ELPHIDIUM EXCAVATUM (TERQUEM): PALEOBIOLOGICAL AND STATISTICAL INVESTIGATIONS OF INFRASPECIFIC VARIATION

by

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ABSTRACT

Detailed study of large sympatric populations and fossil assemblages of the highly variable species Elphidium excavatum (Terquem) collected from 20 widely spaced locations indicates that a variety of morphotypes of Elphidium can be linked to one another in a number of interlocking intergradational series. Ten morphotypes are recognized and grouped as formae (ecophenotypes) of Elphidium excavatum (Terquem); these morphotypes were previously considered as 22 independent taxa by various authors.

To test the hypothesis that these ecophenotypes are distinct morphologically, the ten ecophenotypes were separated into groups based on differences in external morphology; 15 of the characters by which the groups are distinguished were measured and or scored on 721 individuals (11-163 per forma). Discriminant and classification functions were calculated from these character measurements using the SPSS computer program DISCRIMINANT. To illustrate the derivation of these functions, two examples (2 groups and 2 variables; 3 groups and variables), were calculated and explained step by step using the MINITAB interactive statistical package.

Fifteen analyses, using either one sample or split sample approaches, and simultaneous or stepwise analytic methods, classify 84-90% of the specimens into the subjectively defined formae to which they were assigned. Either morphotype (forma) or location was treated as the dependent variable. The analyses showed that there is no strong relationship between formae and geographic location, thus strengthening the subjective conclusion that these are ecophenotypes and not subspecies.

Although all of these formae belong to the same species, it is suggested that the distinction among them should be retained because of their potential as a valuable interpretive tool in paleo-ecological and biostratigraphic studies of Holocene and Pleistocene sediments.

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INTRODUCTION

AN IDENTIFICATION PROBLEM

Applied micropaleontology often views purely taxonomic studies as being of academic interest only. Without a uniform and clearly defined taxonomy, however, it becomes very difficult to compare data from different sources. At the same time, the indicator value of the species is diminished if several different names are applied to the same taxonomic unit (Medioli and Scott 1978). This problem becomes most acute in areas where infraspecific variability is highest (i.e., nearshore and shelf environments).

The species *Elphidium excavatum* (Terquem), which is extremely important for the interpretation of post-glacial events, has been plagued by a myriad of synonyms. The first to recognize the real nature of the problem was Feyling-Hanssen (1972), who grouped several common species as ecophenotypes of *E. excavatum*. The variations within this species have been interpreted either as ecophenotypic (Bartlett 1965b, Feyling-Hanssen 1972, Cronin 1979, Poag 1978) or as a subspecific (Wilkinson 1979). It has been noted, but not illustrated, that *E. excavatum* (= *E. clavatum* of many workers) appears to grade into a number of different species (e.g. Parker 1952b, Weiss 1954, Brodniewicz 1965, Bartlett 1965b, Buzas 1965b, Cronin 1979).

During a geochemical study of *E. excavatum* tests from a Labrador Shelf sediment core (Miller 1979), it became apparent that specimens of two different *Elphidium* species could be arranged into an intergradational series covering their spectrum of morphological variability. Miller et al. (1982) continued this investigation and arranged five distinct "species" in three similar intergradational series. Thus, the biologic principle of conspecificity of specimens arranged in an intergradational series, as enunciated by Mayr et al. (1953) and applied to foraminifera by Medioli and Scott (1978), was used in an attempt to solve the taxonomic problems of the E. excavatum group.

Demonstration of an intergradational series between taxonomic units previously defined as species is a useful tool for illustrating the range of variation that may be encompassed by different samples of a taxon which is probably a single biological species in the sense of Mayr et al. (1953). When morphological variants of the species appear to convey important information about the environment, however, it becomes necessary to delimit the range of morphology encompassed by the different environmental indicators, and to assign infraspecific names to these morphotypes.

When two or more morphotypes are linked through an intergradational series, there are no set limits to each morphotype and the "morphological boundaries" are arbitrary and artificial. As pointed out by Scott (1974), subjective assessment of variation is alone inadequate, in principle and practice, for scientific communication. The problem becomes that of where to draw boundaries along the morphological gradient in order to produce workable, identifiable, taxonomic units, and how to classify these units within the species.

AIMS OF THIS WORK

1) The overall aims of this work are to investigate the polytypic nature of the foraminiferal species Elphidium excavatum (Terquem) using both conventional biological criteria and multivariate statistical methods; and to compare the results of the two methods of analysing variation within a species. 2) Within the Linnean hierarchy (as best as possible) the species is first "split" into morphotypes and the intergradation between morphotypes is investigated and documented. The taxonomic (and apparent biological) relationships among the morphotypes are also investigated and their corresponding ecological and geographical ranges noted.

3) Once the patterns of infraspecific variation have been noted and the presence or absence of intermediate forms documented, the kind of biological variation present can be determined and an appropriate classification adopted.

4) These same morphotypes are then analysed statistically using the multivariate technique of discriminant analysis. This is to determine if the morphotypes are statistically distinct and to determine, using the classification phase of the analyses, how well these morphotypes are delineated based on the information (morphological characteristics) included in the analysis. How well these morphotypes are delineated is also a test on the placement of the arbitrary boundaries between morphotypes, which split the morphologic range of the species into more rigid discrete units.

5) Finally, three other species are included in the statistical analysis to determine how well this E. excavatum group is delineated

within a larger framework.

In general, then, the purpose of this work is to develop a classification scheme for the species _E. excavatum_ (Terquem) which meets the following criteria: (1) fits into both the biologic and paleontologic frameworks (the Linnean hierarchy) and consequently is acceptable to workers in both fields; (2) is statistically valid; (3) is repeatable by other workers; and consequently objectively solves the taxonomic problems of the group.

Only when there are standard taxonomic units can an accurate description of patterns of infraspecific variation be formulated. Clear definition of taxonomic variants in turn is a prerequisite for the explanation of the species variation in terms of geographical and ecologic isolation.

ELPHIDIUM EXCAVATUM (TERQUEM): ECOPHENOTYPIC VERSUS SUBSPECIFIC VARIATION

METHODS OF STUDY

Different standard methods of preparation and preservation were employed, due to the various types of samples under study. None of them is sufficiently unusual to warrant description.

Samples from various localities (Table 1) were made available by numerous colleagues. Most of these samples were dry residues, except those collected by Scott and Medioli, which had been stained with Rose Bengal and stored in a mixture of denatured ethanol and water.

All samples studied contained large assemblages or populations of *E. excavatum*. In this study, a distinction is made between populations of stained individuals (i.e., individuals stained by Rose Bengal, hence alive at the moment of collection) and assemblages of empty tests. Stained individuals of the same species in the same sample clearly represent a "population", i.e., potentially interbreeding individuals. An assemblage of empty tests could contain reworked individuals and does not contain anything that could be potentially interbreeding; as such it does not constitute a "population".

The principle of intergradation is normally affixed to "populations", but that is mainly for lack of consideration of fossil assemblages. Thus, the individuals of populations are *potentially* interbreeding but, in the vast majority of cases, no one has bothered to check if, in fact, they do interbreed. Usually, a visual appraisal

Location	Latitude	Longitude	Collected By	Age	Formae Identified	Sample No. Reference	Type of Environment
Beaufort Sea Canada	60°56'50''N	134° 33'00''W	Vilks, 1970	recent assemblage	clavata, excavata magna selseyensis	853 Vilks et al. 1979	arctic nearshore with estuarine influence. salinity: 28-31% water depth: 10m
Beauford Sea Canada	?	?	?	Holocene assemblage	clavata, excavata	F2255, made available by Bartlett; no reference	arctic nearshore
Hirtshals Denmark	57°36'N	9°58'W	Vilks, 1979	Late Pleistocene assemblage 14,000-35,000 Y.B.P.	clavata, excavata	Zone C of the older Yoldia clay, Andersen 1971	arctic shallow water
Labrador Sea **	54°36'30''N	56°15'00''W	Vilks, 1977	Late Pleistocene (Wisconsinian) assemblage > 22,000 Y.B.P.	clavata, excavata	Core 12 826-831cm Vilks and Mudie 1978; Miller 1979; Vilks 1980; Miller et al. 1982	melting ice margin (?) basin environment; no modern analogue
Champlain Sea, Quebec (St. Aime Guillaume Quebec)	45°53'N	72°55'W	Guilbault, 1980 (Service de Geotechniquee Resources, Quebec)	Late Pleistocene assemblage 11,500 Y.B.P.	magna, clavata excavata, lidoensis	YAM-F13-80A > 106A 24.5m in boring. Guilbault 1980	Facies B cold bottom water Salinity 25-35% Guilbault suggests the deeper part of the Baltic Sea as a modern analogue (i.e. Lutze, 1974.)
Bay of Chaleur Gulf of St. Lawrence Canada	1) 47°54'29''N 2) 48°00'12''N 3) 48°04' N	65°50'20''W 65°21'19''W 66°19' W	Shafer and Cole, May 1971	recent population	excavata, clavata williamsoni, magna lidoensis, cuvillier	1) SRA-52 2) SQA-52 3) SRQ-53 Schafer and Cole 1978	Shallow water, nearshore, estuarine.
Miramichi Estuary, N.B., Canada	47°07'05''N	65°06'05''W	Scott, 1976	recent population	clavata, lidoensis excavata, magna	station 6; Scott, Schafer and Medioli 1977, 1980	open bay zone of estuary Salinity: 20-25%; water depth 5-10m.
Baie Verte, Northumberland Strait, Canada	46°02'20''N	63°42'80''W	Medioli, 1979	Holocene assemblage 4,000-5,000 Y.B.P.	selseyensis, clavata lidoensis, gunteri magna, excavata cuvillieri, galvestonesis	Navicula core 2, 60-62cm Prime 1980	mid-Holocene hypsithermal (?) warm, temperate to sub-tropical, water depth < 5m, this fauna does not exist there today.
Annapolis Basin, N.S. Canada	1) 45°40'19''N 2) 44°38'09''N	65°38'53''W 65°45'08''W	Bartlett, 1968	recent population	selseyensis, magna lidoensis, clavata excavata	1) BQ-68-AB-8 2) BQ-68-AB-16 no reference	shallow, partially restricted estuary. Tidal range > 12m salinity probably 25-32%
Chezzetcook Inlet, N.S.	44°41'N	63°14'W	Scott and Medioli, 1977	recent population	magna, selseyensis clavata, lidoensis excavata, williamsoni cuvillieri	stations 49-55; Scott 1977, Scott Medioli 1980, Scott, Schafer and Medioli, 1980	nearshore turbulent zone subtidal; salinity: 25-32% water depth: 3-5m

Table 1: Listing of samples studied. The listing under "Formae Identified" is given in order of abundance, at the time of collection. **Illustrated in Miller et al. (1982).

Maine-New Brunswick Estuary (near Eastport, Maine) 44°45'N (approx.)	67° W (approx.)	no reference	recent population	*williamsoni*, *clavata* *lidoensis*	B-I-71 Schafer 1971	shallow water, nearshore estuarine
Scotian Shelf (off Liverpool, N.S.) Canada 43°59'N	64°39'W	Medioli and Scott, 1978	recent population	*magna*, *clavata*	Station 134 Miller, Scott and Medioli, unpub. data	nearshore turbulent zone 40m deep normal marine conditions
Long Island Sound, N.Y. U.S.A. 40°57'N	73°30'W	Schafer, 1965	recent population	*selseyensis*, *lidoensis* *excavata*, *clavata*	Field No. 722 Schafer 1968, 1970.	outer estuary, temperate salinity 17-20‰ water depth: 10-20m.
San Francisco Bay, CA U.S.A. 37°36'N	122°21'W	1969 (borehole transect across San Francisco Bay)	pre-Wisconsinian, ? Sangamonian assemblage 80,000-100,000 Y.B.P. oxegen isotope stage 5	*lidoensis*, *excavata* *gunteri*, *selseyensis*, *clavata*	230-11 43m below present sea level	Unit B. subtidal mudflat and channel environments. salinity: 20-32‰ temperature: 8-20° annually
San Diego Bay, CA, U.S.A. 33°34'N	117°11'W	Bradshaw, 1972	recent population	*lidoensis*, *tumidum* *clavata*, *selseyensis* *gunteri*	IX-1, IX-2 Scott et al. 1976	inner bay assemblage. salinity: 31-35‰ water depth: 3-5m
San Antonio Bay, Gulf of Mexico, TX U.S.A. 28°26'N	96°53'W	Poag, 1972	recent population	*gunteri*, *lidoensis*, *galvestonensis*, *cuvillieri*, *clavata*	sample 13 Poag 1976, 1978	mudflat; salinity 5-15‰ (over sampling period) water temperature: 12-23°C
Wadden Sea, The Netherlands ?	?	Hofker, 1975, 1976	recent or Holocene assemblage	*williamsoni*, *gunteri*	no sample number; made available by A. Fortuin. Hofker 1977	probably tidal flat.
Venice Lagoon, Italy 45°30'N	12°26'E	Petrucci, 1981	recent population	*gunteri*, *cuvillieri*, *lidoensis*.	Sample 1	Albani and Serandrei Barbero 1982, water temperature: 6-25°C salinity: 32-35‰ in lagoon itself
Bay of Izmir Turkey 38°44'06''N	26°33'00''E	Piper and Aksu, 1979	late Pleistocene (Wurm) assemblage oxygen isotope upper stage 2	*cuvillieri*, *lidoensis*, *excavata*, ?*williamsoni*	core 79-Iz-2 sample 4 30-32cm sample 10 92-94cm Piper and Aksu 1981	current water depth: 110m Pleistocene pro-delta slope sea level lowered 110m.

Table 1: continued.

of morphological similarities is considered more than adequate to make the assumption that two individuals do or do not interbreed. Similarily, a visual appraisal of a fossil assemblage should be more than adequate and equally valid to decide whether or not two individuals would have been capable of interbreeding had they existed at the same time. However, to be prudent, the assemblages studied in this thesis were carefully chosen from those lacking evidence of reworking.

Representative specimens covering all aspects of morphological variation of the species were selected from each sample and prepared for standard scanning electron microscope (SEM) observation. A total of 1057 SEM photos of 810 E. excavatum specimens were taken either at Dalhousie University (Bausch and Lomb Nanolab 2000) or the Bedford Institute (Cambridge 180) using both Polaroid NP/52 and NP/55 film.

Samples were collected from a wide variety of environments as well as geographical range (Table 1): Beaufort Sea, Labrador Shelf, Champlain Sea, Bay of Chaleur, Miramichi Estuary, Baie Verte, Annapolis Basin, Chezzetcook Inlet, and the Scotian Shelf, Canada; a Maine-New Brunswick Estuary, Long Island Sound, San Francisco Bay, San Diego Bay, and San Antonio Bay, U.S.A.; Hirtshals, Denmark; Wadden Sea, Netherlands; Venice, Italy; and Bay of Izmir, Turkey. The age range of the samples is late Pleistocene to recent.

HISTORICAL REVIEW

Before proceeding with the observations of this study, it is necessary to examine the complex history of Elphidium excavatum

(Terquem) in some detail, in order to place this study in proper perspective. A schematic outline of the history is illustrated in Figure 1 (back pocket). As far as possible, the following review is presented in chronological order. The letters in parenthesis indicate the position of the information on the schematic diagram (Figure 1).

D'Orbigny described three species relevant to this study: *Polystomella oceanensis* (1826, p. 285) (A on Figure 1) a recent species from the French coast; (C) *P. poeyana* (1839a, p. 55, Pl. 6:25-26) from Cuba; and (B) *P. articulata* (1839b, p. 30, Pl. 3:9,10) from recent material from the Falkland Islands. It appears that d'Orbigny did not figure or choose a holotype of *P. oceanensis*, so it remained a *nomen nudum* until figured by Fornasini (1904, p. 13, Pl. 3:10). The remaining two species were figured; but the type of *P. articulata* is lost (if it was ever designated) and a lectotype of *P. poeyana* was designated by Loeblich and Tappan in 1964 (CC).

In England in 1858, Williamson described a species (D) *Polystomella umbilicatula* (Walker and Jacob), (1858, p. 42-44, Pl. 3:81-82), a species later shown to be quite distinct from Walker and Jacob's. In the same publication, Williamson also described a variety of this species. Williamson called this species *P. umbilicatula* var. *incerta*, and it has become known as *Elphidium incertum* (Williamson).

Terquem (1876) described *Polystomella excavata* (E) from the shore of Dunkerque, French south coast.

Heron-Allen and Earland (1909) identified a species as *Polystomella striatopunctata* (Fichtel and Moll) variety (p. 695, Pl.

21:2); in 1911 the same authors designated this species as P. striatopunctata var. selseyensis (p. 488), from the shore sands of southeast England (F).

Cushman (1930, p. 18, Pl. 7:8-9) described and figured a large white opaque Elphidium, which he referred to as E. incertum (Williamson) (G). In the same paper, he described and figured a variety, E. incertum var. clavatum (p. 20, Pl. 7:10) which was smaller, translucent orange-brown and often, but not always, with a knobby boss or bosses occupying the umbilicus (H). Unfortunately, in the writer's opinion, Cushman (1930, p. 21, Pl. 8:4-7) also appears to have mistaken Williamson's species (P. umbilicatula - D) for E. excavatum, even while displaying Terquem's original figures (I) of E. excavatum (Cushman, 1930, p. 21, Pl. 8:1-3). This apparent error has persisted and may have confused workers in Europe, the eastern U.S., and Canada up until the 1970's (e.g. Todd and Low 1961, Richter 1961, 1964a, 1967, Haake 1962, 1967, Feyling-Hanssen 1964, Murray 1965a, 1968, Scott et al. 1977).

Compounding this, Heron-Allen and Earland (1932) described E. (Polystomella) excavatum (Terquem) (p. 439, Pl. 16:22-23) from the Falkland Islands (J) and placed it in synonymy (K) with the E. excavatum (Terquem) of Cushman, 1930 (Pl. 8:4-7) i.e. Williamson's species. Heron-Allen and Earland (1932) clearly did not place these specimens in synonymy with their P. striatopunctata var. selseyensis.

In the next 10 years (1930-1940) five species were described by North American workers which have become widely reported in the literature. These were: (L) Elphidium gunteri Cole, 1931 (p. 34, Pl.

4:9-10) from Pliocene (later shown to be Pleistocene by Poag 1978) deposits in Florida; (M) a variety of this, E. gunteri var. galvestonense (= E. galvestonensis) Kornfeld 1931 (p. 87, Pl. 15:1a-b) from Texas and Louisiana; (N) E. lidoense Cushman, 1936 (p. 86, Pl. 15:6a-b) from beach sands in Venice, Italy, and two species described by Natland (1938) from the California coast: (O) E. transluscens (p. 144, Pl. 5:3,4) and (P) E. tumidum (p. 144, Pl. 5:5,6).

In addition, nine other species were described from 1930 to 1951. Two were described by Shupack (1934): (Q) E. brooklynense (p. 10, opp. p. 9, Figs. 7a-b) and (R) E. florentinae (p. 9, opp. p. 9, Figs. 5a-b) from Long Island Sound and New York Harbour. Five were described by Cushman and Brönnimann (1948) from Trinidad: (S) Cribroelphidium trinitatense (p. 20, Pl. 4:8), (T) C. limnosum (p. 19, Pl. 4:7), (U) C. vadescens (p. 18, Pl. 4:5), (V) C. salsum (p. 19, Pl. 4:6) and (W) C. kugleri (p. 18-19, Pl. 4:4). The remaining two were (X) E. littorale Le Calvez and Le Calvez, 1951 (p. 251, Fig. 5:a-b) and (Y) E. guntheri (sic) var. waddense van Voorthuysen 1951 (p. 25, Pl. 2:16a-b).

In 1966, Levy described a common shallow water Mediterranean form he called (Z) E. cuvillieri (p. 5-6, Pl. 1:6a-c, Pl. 2:2).

Thus, from 1930-1970, 11 different species which the writer assigns to the E. excavatum group were described and figured in North American literature. 1) Elphidium excavatum of Cushman's concept (i.e. the species of Williamson)(I), was reported by Cushman (1930, 1939, 1949), Todd and Low, (1961), and Adams and Frampton (1965); 2) E. incertum of Cushman (not Williamson's taxon) (G) was described by

Cushman (1930, 1939, 1944, 1949), Parker (1948, 1952a, 1952b), Todd and Low (1961), and Bartlett (1965b); 3) _E_. _clavatum_ Cushman (AA), and _E_. _incertum_ var. _clavatum_ (H) were described by Cushman (1930, 1939, 1948), Loeblich and Tappan (1953), Todd and Low (1961), Cooper (1964), and Buzas (1965b, 1966). 4) _E_. _poeyana_ (d'Orbigny) (CC) was described by Cushman (1930), Parker et al. (1953), Todd and Brönninann (1957), Todd and Low (1961), and Loeblich and Tappan (1964); 5) _E_. _gunteri_ Cole (DD) was described by Cushman (1939), Parker et al. (1953), Phleger (1954, 1960a, 1960b), Bandy (1956), Lehmann (1957), and Lankford (1959); 6) _E_. _galvestonense_ Kornfeld (EE) was described by Parker et al. (1953), Phleger (1954, 1960a), Lehmann, (1957), Parker and Athearn (1959), and Todd and Low, (1961); 7) _E_. _oceanense_ (d'Orbigny) (FF) was reported by Cushman (1939); 8) _E_. _selsevense_ (Heron-Allen and Earland) (GG) was described by Cushman (1939) and Parker (1952b); 9) _E_. _lidoense_ was described by Cushman (1936, 1939) (N); 10) _E_. _transluscens_ Natland (HH) was reported by Bandy (1953), Parker et al. (1953), Phleger (1954, 1964), Todd and Bronnimann (1957), Todd and Low (1961); and 11) _E_. _tumidum_ Natland (II) was reported by Parker et al. (1953), Todd and Bronnimann (1957), Lehmann (1957), and Phleger (1960b).

In addition, seven of the nine other species mentioned previously were also reported in the literature. Shupack's two species were referred to by Weiss (1954) and Cushman and Bronnimann's five species were referred to by Todd and Brönnimann (1957).

Loeblich and Tappan (1953) elevated _E_. _incertum_ var. _clavatum_ Cushman to the specific rank _E_. _clavatum_ Cushman (AA); and showed that the *E. incertum* of Cushman was quite distinct from that of Williamson's taxon, *Polystomella umabilicatula* variety *incerta* Williamson (1858). Buzas (1966) proved, through statistical analysis and wall structure investigation, that *E. clavatum* Cushman, and *E. incertum* of Cushman could not be separated into distinct species (JJ); a view shared by Parker (1952b) and Bartlett (1965b) based solely on external morphology. Buzas (1966) initiated the investigation because he had observed morphological gradation from one species to the other (Buzas 1965b, 1966). In addition to other differences, Buzas (1966) showed that Williamson's *E. incertum* had an optically granular wall structure, instead of the optically radial wall structure of Cushman's specimens. Thus, Buzas (1966) concluded that both of Cushman's forms did belong to *E. clavatum* Cushman (AA).

At the same time, European workers were describing and figuring seven species under six names: 1) *E. excavatum* (Terquem) of Cushman's concept (i.e. Williamson's species) (I) was recorded by Rottgardt (1952), van Voorthuysen (1957, 1960), Jarke (1961) Richter (1961, 1964a, 1967), Haake (1962, 1967), Feyling-Hanssen (1964), Brodniewicz (1965) and Murray, (1965a, 1968, 1970); 2) *E. excavatum* (Terquem) (sensu stricto) (KK) was discussed by Lutze (1965, 1968), Lévy (1966), Haake (1967), Lévy et al. (1969, 1975), Murray (1971) and Knudsen (1973b); 3) *E. articulatum* (d'Orbigny) (BB) was recorded by Lutze (1968), Murray (1971), Rosset-Moulinier (1972) and Knudsen (1973a, 1973b); 4) *E. gunteri* Cole (DD) was discussed by van Voorthuysen (1957, 1960), Haake (1962), Richter (1964a), Lévy (1966) and Lévy et al. (1969); 5) *E. selseyense* (Heron-Allen and Earland) (LL) was discussed by Brand (1941), van Voorthuysen (1957, 1960), Richter (1961, 1964a) and Haake (1962); 6) E. clavatum Cushman (NN) was discussed by Hansen (1965) and Knudsen (1971a, 1971b); and 7) E. lidoense Cushman (MM) by Accordi and Socin (1951), Lévy (1966), Cita and Premoli-Silva (1967) and Lévy et al. (1969).

During the 1960's, a few workers started grouping some of these species. Haake (1962) was one of the first to place E. selseyense (Heron-Allen and Earland) (LL) and E. clavatum (AA) Cushman in synonymy (OO); Haake used the name E. selseyense because he considered E. clavatum to be a junior synonym. Both Hansen (1965) and Knudsen (1971b) could not separate E. clavatum and E. selseyense (PP). In 1965 Lutze studied topotype material of E. excavatum and concluded that E. excatavum (Terquem) and E. clavatum Cushman were the same species (QQ). However, Lutze (1965) did differentiate the two at a subspecific level (E. excavatum excavatum, E. excavatum clavatum).

By 1970 then, various workers had combined E. selseyense and E. clavatum (PP) (Hansen 1965, Knudsen 1971); or E. clavatum and E. excavatum (QQ) (Lutze 1965), or E. excavatum and E. selseyense (RR) (Haake 1967, Lévy et al. 1969, 1975, and [later] Feyling-Hanssen 1972 and Banner and Culver 1978). Lévy et al. (1975) reported that Terquem's holotype had been lost; they redescribed E. excavatum (Terquem) and erected a neotype. Haake (1967), and von Daniels (1970) had also placed E. (Cribrononion) lidoense in synonymy with E. excavatum (SS).

In addition, van Voorthuysen (1957) placed his E. gunteri var. waddense back into E. gunteri (TT); Lévy (1966), and later Hansen and

Lykke-Andersen (1976) and Poag (1978) put E. oceanense and E. littorale into E. gunteri (UU) because they considered the former to be a nomen nudum, and Murray placed E. gunteri into E. oceanense (VV).

In 1972 Feyling-Hanssen completed a comprehensive study of these species and concluded that there was only one highly variable species: E. excavatum (Terquem) (WW). Feyling-Hanssen's species is comprised of E. excavatum (Terquem), E. clavatum Cushman, E. incertum var. clavatum Cushman (not Williamson), E. selseyense (Heron-Allen and Earland) and E. lidoense Cushman. Feyling-Hanssen (1972) noted a pattern to the variablility and concluded that there are four ecophenotypes of this one species. He differentiated these ecophenotypes on a "forma" level, so that earlier specific names were retained as formae names of E. excavatum. He suggested that the distribution of these ecophenotypes was environmentally controlled but also implied some geographical restrictions. The four formae designated by Feyling-Hanssen (1972) are: (1) E. excavatum forma clavata Cushman, for the small translucent orange-brown form with (or without) the knobby bosses, which he observed dominating assemblages in arctic environments; (2) E. excavatum (Terquem) and E. selseyense (Heron-Allen and Earland) which he placed in synonymy as E. excavatum forma selseyensis (Heron-Allen and Earland) and defined as a larger, orange-brown to white form found in boreal environments (North Sea region and western Baltic); (3) E. excavatum forma lidoensis Cushman which was described as a strongly ornamented, knobby form found in the Lusitanian regions (the west coasts of France and Portugal); and (4) for the white form, which he believed Cushman identified as E.

incertum (Williamson), he suggested the name E. excavatum forma alba. The same author found E. excavatum forma alba in foraminiferal zone E of early Holocene sediments in the Oslo Fjord area.

In 1969, Lévy et al. reported on Cushman's error (in mistaking Williamson's species for E. excavatum) and they returned to Terquem's original definition of the species. For the form that Cushman and subsequent workers had identified as E. excavatum, Lévy et al. returned to Williamson's specific epithet umbilicatula (XX). However, Haynes (1973) pointed out that this name is invalid because it is occupied by Walker and Jacob's species, so Haynes suggested the name E. williamsoni (YY) for Williamson's species.

Haynes (1973) also commented on the differences between specimens of E. selseyense (Heron-Allen and Earland) in the British Museum and E. excavatum (Terquem's type figure). He stated that E. selseyense (ZZ) can be distinguished, and should remain distinct from E. excavatum (Terquem) (KK) as redefined by Lévy et al. (1969, 1975). Both Haynes (1973) and Lévy et al. (1969, 1975) state that the sutures are non-granular, but the topotype illustrated (Lévy et al. 1975, p. 176, Pl. 3:5-6) shows granular material in the sutures. This discrepancy was pointed out by Wilkinson (1979) who placed the neotype of Lévy et al. (1975, p. 176, Pl. 3:1-2) in E. excavatum (Terquem), and referred their topotype to E. clavatum selseyense (Wilkinson, 1979). Wilkinson (1979) studied E. excavatum (Terquem) and E. clavatum Cushman; and his results differ markedly from those of Feyling-Hanssen (1972). Wilkinson (1979) concluded that he was dealing with Cushman's E. clavatum, a species distinct from E.

excavatum. He also defined eight subspecies of E. clavatum (AAA) which, Wilkinson states, form a gradational sequence based on umbilical characteristics. One of these subspecies is E. clavatum selseyense, which is an invalid name (as pointed out by Haynes, 1982 pers. comm., as selseyense takes priority).

Other workers were beginning to recognize ecophenotypy within the genus Elphidium. Poag (1978) recognized four ecophenotypes of two species, E. gunteri (BBB and CCC) and E. galvestonense (DDD). In 1981 Haynes recognized the polymorphic nature of E. excavatum (EEE). He pointed out that the species could be regarded as a "superspecies", including E. clavatum and E. selseyense and related forms which he referred to as "siblings" of Elphidium. ex gr. excavatum. Haynes (1981) also states that E. excavatum (Terquem) can be regarded as one polytypic species (sensu Beckner 1959) which he called the E. excavatum subsp. gr. Haynes includes E. incertum (Williamson), E. clavatum Cushman, E. selseyense (Heron-Allen and Earland), E. williamsoni Haynes and E. cf. advenum sensu Todd and Low in the group, but he did not include Cushman's E. lidoense.

In 1982 Rodrigues and Hooper voiced the opinion that Terquem's original concept of E. excavatum included E. williamsoni Haynes. They also followed Wilkinson's (1979) lead in distinguishing among the species E. excavatum, E. selseyense, E. lidoense and E. clavatum. Rodrigues and Hooper based this decision on the fact that since (1982, p. 415) "...no morphological series relating modern specimens of E. clavatum to either E. selseyense or E. lidoense has been adequately documented in the literature, we choose to regard E. clavatum as distinct from *E. selseyense* and *E. lidoense*.". A month later, intergradation of these four species in material from eight locations was reported and illustrated by Miller et al. (1982) (FFF). Miller et al. (1982) designated five ecophenotypes of *E. excavatum*. Two of these formae are the same as Feyling-Hanssen's (*E. excavatum* f. *clavata* and f. *lidoensis*), two formae (*E. excavatum* f. *excavata* and f. *selseyensis*) result from the splitting of Feyling-Hanssen's *E. excavatum* forma *selseyensis*; and one is a new ecophenotype previously undescribed (*E. excavatum* forma *magna*).

OBSERVATIONS

MORPHOTYPIC VARIATION

The study of this material has allowed delineation of ten morphotypes, nine of which are interpreted as being conspecific with *E. excavatum* as documented by the intergradational series illustrated in the plates.

These morphotypes, which are considered here as "formae", are easily recognised under low power microscopy. Photoplates 20-28 illustrate these formae. For the sake of clarity the formae are designated such that they correspond to conventional species previously described in the literature as much as possible and take their names from the "species" they represent. The salient characteristics of the formae are outlined below.

E. excavatum forma *excavata* (pl. 20) has lobate chambers, and straight sutures extending unconstricted into the umbilicus. The pore density is greater in this forma than in forma clavata, giving the test a hazy appearance. Ponticuli are typically strongly developed.

E. excavatum forma williamsoni (pl. 21) is an inflated, rotund form, with smooth peripheral outline and rounded periphery. It has a flat umbilicus, with the chambers extending completely into the umbilicus. The ponticuli are very regular and well developed, covering up to half the chamber width. The test walls are finely and densely perforate.

E. excavatum forma selseyensis (pl. 22) is recognised by its large size; smooth to lobate peripheral outline; sub-acute periphery; and greatly convex walls, giving the umbilicus a raised appearance. The sutures are slightly backwards curved to straight, with irregular, indistinct to strongly developed ponticuli, and often with papillae filling the sutures. The umbilicus contains granular material, or bosses, or both.

E. excavatum forma clavata (pl. 23) is small, disc-shaped, orange-brown, translucent, often with an umbilical boss; and always with an imperforate (complete or incomplete) collar surrounding the umbilicus. The sutures are generally backwards curved, with a few narrow, often incomplete ponticuli.

E. excavatum forma gunteri (pl. 24) is a small to medium sized form, rather rotund, with a coarsely perforate wall. The sutures are straight, not depressed, and marked by many regular, raised rectangular shaped ponticuli, often longer than the chambers are wide. The umbilicus contains papillae/irregular bosses (irregular lateral extensions of the ponticuli and chambers).

E. excavatum forma *galvestonensis* (pl. 25) is a large, many chambered (13-18) form with a large, very raised umbo (boss or bosses) in the umbilicus and many regular distinct ponticuli. There may be a ring of papillae surrounding the boss or in the sutures. The wall is heavily calcified and very finely perforate giving the test a porcelanous appearance. The periphery is sub-acute.

E. excavatum forma *lidoensis* (pl. 26) is a small form, with a large open umbilicus filled with papillae/bosses. The sutures are backwards curved, distinctly broadening towards the umbilicus, and also filled with papillae; ponticuli are not generally well developed. Within this forma, two "subforma" are observed, a phenomenon that will be detailed in both the Discussion (p. 30) and Systematic Paleontology (p. 155).

E. excavatum forma *tumidum* (pl. 27), is a large, ornamented form resembling forma *selseyensis*. However, the ornamentation and ponticuli are much more regular on forma *tumidum*. The umbilicus is large, circular, depressed and filled with papillae/bosses. The chamber extensions into the umbilicus are truncated sharply. The periphery is usually rounded and the chambers inflated.

E. excavatum forma *cuvillieri* (pl. 28), is a smooth, round disc shaped *Elphidium* about the same size as forma *clavata*. The peripheral outline can range from smooth to very lobate. The sutures are straight or gently backwards curved, and characterized by very regular rows of sutural pores.

E. excavatum forma *magna* (pl. 27) is recognised by its larger size, smooth peripheral outline, sub-acute periphery; and strongly convex walls, which give the umbilicus a raised appearance. The umbilicus is usually large and filled with one knobby boss. The sutures are backwards curved, and some (or all) may be constricted before reaching the umbilicus.

ECOPHENOTYPIC VARIATION

Having delineated the ten distinct morphotypes, analysis of their distribution in the study areas is necessary to ascertain if they are ecophenotypes or subspecies. This information is also important for the study of paleo-ecology and biostratigraphy of Pleistocene and Holocene deposits.

Beaufort Sea: Two series of morphotypes are illustrated, one from a Holocene surface sample (pl. 2:1-8) and one from a Holocene core sample (pl. 3:1-12). Both samples are assemblages of empty non-living tests. The first assemblage is almost entirely E. excavatum forma clavata. However, the second contains four formae: clavata, excavata, magna and selseyensis.

Hirtshals Denmark: Two formae were recognized in this late Pleistocene assemblage: E. excavatum forma clavata (pl. 2:9-17, pl. 23:1) and forma excavata (pl. 2:18-20). E. excavatum forma clavata comprised greater than 95% of the E. excavatum population.

Champlain Sea: Four formae are recognized from this late Pleistocene assemblage: f. clavata (pl. 4:1,6-9; pl. 23:2-3), f. excavata (pl. 4:10-11), f. magna (pl. 4:2-5, pl. 27:9-10) and f. lidoensis (pl. 4:12). Specimens of three of the formae (magna, clavata, and excavata) can be assembled into an intergradational series. Forma lidoensis appears to be rare and no link was observed joining this forma to the series. This sample exhibits more variability and contains more formae than any other post-glacial/arctic sample studied.

Scotian Shelf: Two formae, E. excavatum forma clavata (pl. 4:13-16) and magna (pl. 4:17-20; pl. 27:5-8,11) were observed and assembled into an intergradational series from this recent sample of live specimens (a population). Forma magna exhibits more variability here than observed elsewhere. Intermediate specimens, linking the two formae (i.e. pl. 4:15-17) were also observed.

Miramichi Estuary: Three formae have been recognised and assembled into an intergradational series from a live population from Miramichi Estuary: E. excavatum forma clavata (pl. 5:1-7; pl. 23:4-7), forma lidoensis (pl. 5:8-12; pl. 26:7-9) and forma excavata (pl. 5:13-16). The specimens from Miramichi exhibited a wider ranged of variability than seen in the previous post-glacial/arctic samples and a larger number of the specimens could be considered to be morphologically intermediate between formae. Specimens of E. excavatum forma excavata from Miramichi were more irregular than those seen previously. These specimens greatly resemble the neotype illustrated by Lévy et al. (1975, Pl. 3:5-6).

Bay of Chaleur: An intergradational series was assembled from three live populations. Six formae are present, and this sample exhibits, on the whole, more ornamentation than any other sample studied, especially specimens of E. excavatum forma excavata (pl. 6:8-16,19). These specimens have many regular ponticuli and granular material in the sutures and umbilici. E. excavatum forma excavata is linked through intermediate specimens to forma lidoensis (pl. 6:7), forma williamsoni (pl. 6:17-18; pl. 21:10-11) and forma cuvillieri (pl. 6:20). E. excavatum forma clavata (pl. 6:3-6; pl. 23:13) and forma magna (pl. 6:1-2) are also present, grading into one another, and forma clavata is linked to forma lidoensis (pl. 6:6-7).

Annapolis Basin: An intergradational series was assembled with specimens from two recent assemblages collected in the Annapolis Basin. The E. excavatum population exhibits a wide range of morphological variation in these samples, with many intermediate specimens.

Elphidium excavatum forma excavata (pl. 7:13-16; pl. 20:3) in these samples closely resembles the neotype described by Lévy et al. (1975, Pl. 3:5-6). E. excavatum forma selseyensis (pl. 7:1), forma magna (pl. 7:2-3), forma clavata (pl. 7:4-9; pl. 23:12) and forma lidoensis (pl. 7:10-12; pl. 26:1-2) were also observed.

Chezzetcook Inlet: An intergradational series was assembled from seven live populations collected from the mouth of Chezzetcook Inlet. Seven formae were recognized, five displaying a wide range of variability. Elphidium excavatum forma clavata (pl. 8:4-8), was present throughout the estuary in very low numbers. E. excavatum forma selseyensis (pl. 8:10-13) was also present throughout in low numbers, but became more prominent in the outer estuary. These specimens were the most irregular of the group; each with a large umbilicus, filled with bosses and papillae. The representative specimen bears a marked resemblance to specimens of E. selseyense collected by Heron-Allen and Earland and illustrated by Banner and Culver (1978, Pl. 9:12-14).

E. excavatum forma *magna* (pl. 8:1-3; pl. 27:1-4) was first observed at this location (=*Cribrononion excavatum incertum* (Cushman, [not Williamson]) of Scott 1977, Scott et al. 1980) and is dominant in the nearshore turbulent zone. This forma best exhibits its characteristics in this area which is hereby designated the type area for *E. excavatum* f. *magna*.

Elphidium excavatum forma *excavata* (pl. 8:14-16; pl. 20:12) became more prominent in the intertidal zone; and *E. excavatum* forma *lidoensis* (pl. 8:9; pl. 26:3) was also present in low numbers throughout the area.

Isolated specimens of *E. excavatum* forma *cuvillieri* (pl. 28:23) were also observed. *E. excavatum* forma *williamsoni* (pl. 21:5-6) is rare in these particular samples but it is the dominant form in intertidal areas of the marsh (=*Cribrononion umbilicatula* (Williamson) of Scott 1977, and *C. williamsoni* (Haynes) of Scott and Medioli 1980).

A Maine-New Brunswick Estuary: Three formae were observed from a live population at this location and no intermediate specimens were observed. *E. excavatum* forma *williamsoni* was the dominant form (pl. 9:1-16; pl. 21:1-3) and some specimens with fewer chambers may be juveniles of this forma. Isolated specimens of *E. excavatum* forma *lidoensis* (pl. 9:17) and *E. excavatum* forma *clavata* (pl. 9:18) were also observed.

Long Island Sound: This live population contained an abundant (greater than 75%) *E. excavatum* with four intergradational formae present, the dominant one being *E. excavatum* forma *selseyensis* (pl. 6,10:9-13; pl. 22:1-13). These specimens were large and irregular, and closely resemble specimens of *E. selseyense* from the Dovey Marshes illustrated by Haynes (1973, Pl. 22:3-4; Pl. 24:11; Pl. 26:4,7,9).

Elphidium excavatum forma *excavata* (pl. 10:6-8,14; pl. 20:4-7), forma *lidoensis* (pl. 10:15-16; pl. 26:3-5,10-11) and forma *clavata* (pl. 6:1-2) are present as minor constituents of the population.

San Diego Bay: Six formae were observed from a live population at this location. One of the dominant forms was *E. excavatum* forma *tumidum* (pl. 11:1-4, 15-16; pl. 27:13-19). Forma *tumidum* was linked by intermediate specimens to *E. excavatum* forma *selseyensis* (pl. 11:5), forma *lidoensis* (pl. 11:9-13, pl. 26:20-22,27) and forma *clavata* (pl. 11:6-8; pl. 23:20-21). The specimens of forma *clavata* are more irregular and ornamented than those found in colder environments.

Two other formae were also observed. *E. excavatum* forma *gunteri* (pl. 11:17-18; pl. 24:13) was present but no intermediate specimens linking them to the remainder of the group were found. Three other specimens, tentatively identified as *E. excavatum* forma *galvestonensis* (pl. 11:19-21; pl. 25:15-16) (identifications based on enlargements, pl. 25:15-16) were also observed. No intermediate specimens linking these to the remainder of the group were found.

San Francisco Bay: Seven formae were recognized from a Pleistocene core assemblage from San Francisco Bay. The dominant forms were *E. excavatum* forma *excavata* (pl. 12:1-3,12; pl. 20:8-10) and forma *lidoensis* (pl. 12:4-5,7-10; pl. 26: 21-24) which were linked to forma *clavata* (pl. 12:11) and forma *selseyensis* (pl. 12:14-15). One specimen was tentatively identified as *E. excavatum* forma *tumidum* (pl. 12:6), and another as *E. excavatum* forma *williamsoni* (pl. 12:19).

E. excavatum forma *gunteri* was also observed in this sample (pl. 12:16-18; pl. 24:21). As with the San Diego Bay sample, no intermediate specimens were observed here linking this forma to other members of the *E. excavatum* group.

Baie Verte, Northumberland Strait: This assemblage was the most unusual and interesting studied in terms of the *E. excavatum* fauna. Eight formae were observed and all could be assembled into an intergradational series (two series were assembled and illustrated here). Many intermediate specimens were observed; this coupled with the fact that some specimens were badly etched made identifying many of them to the forma level difficult and very subjective.

Elphidium excavatum forma *gunteri* (pl. 13:1-2; pl. 14:1-3; pl. 24:14-20) and *E. excavatum* forma *galvestonensis* (pl. 13:17-20; pl. 14:19-20; pl. 25: 11-14) were observed, with intermediate specimens (pl.14:3 and pl. 13:17) linking these two formae to the remainder of the group.

E. excavatum forma *clavata* (pl. 13:3-5,8-9,16; pl. 14:4-5,13-14) was the most dominant form present, and exhibited considerable variability. Specimens of forma *selseyensis* (pl. 13:12-15; pl. 14:8-9,18) were similar to those seen in Long Island Sound. *E. excavatum* forma *excavata* (pl. 13:10; pl. 14:11-12), forma *lidoensis* (pl. 13:11; pl. 14:10; pl. 26:12-13) forma *magna* (pl. 14:15-17) and forma *cuvillieri* (pl. 13:6-7; pl. 14:6-7) were also observed.

San Antonio Bay: Four formae were identified from this live population and the two dominant formae were assembled into an intergradational series. E. excavatum forma gunteri (pl. 15:8-15; pl. 24:1-12) and forma lidoensis (pl. 15:1-7,16-20; pl. 26:14-19) were linked through numerous intermediate specimens. Both formae exhibit more variability than observed in specimens (of the same formae) from other locations. Some specimens of forma gunteri exhibit extreme variability in the development of the ponticuli (i.e. pl. 15:9; pl. 24:1-3); some ponticuli are not really as well developed on the ultimate and penultimate sutures. The specimens of forma lidoensis exhibit the key characteristics of the forma, but they resemble more those specimens found along the west coast of North America and the Mediterranean. The wall perforations are coarser, the peripheral outline more lobate, the sutures more depressed, and the papillae/bosses in the sutures and umbilicus are larger and more variable in these "Lusitanian" specimens versus the "boreal" environment specimens from maritime Canada and New England.

Two other formae were observed from this location, but they are morphologically isolated from the remainder of the group. E. excavatum forma galvestonensis (pl. 16:1-8; pl. 25:1-10) was observed to be more common from this location than from any other, and these specimens best exhibited the characteristics of the forma. E. excavatum forma cuvillieri was also observed, (pl. 16:9-14; pl. 28:22) more common at this location than at any other North American location. These specimens resemble those observed in the European samples. An unidentified species of Elphidium (pl. 16:15) was also observed.

Wadden Sea: Two formae of *E. excavatum* were observed from this Wadden Sea Holocene assemblage. *E. excavatum* forma *williamsoni* (pl.17:1-12; pl. 21:7-9,12-24) comprised over 95% of the *E. excavatum* population and was very variable. *E. excavatum* forma *gunteri* (pl. 17:13-15) was also observed. No intermediate specimens were observed.

Venice Lagoon: Four formae were identified (and one other tentatively identified) from a Venice Lagoon live population; two formae were assembled into an intergradational series. This sample contained *E. excavatum* forma *gunteri* (pl. 18:1-4, pl. 24:22-24) and forma *lidoensis* (pl. 18:5-7, pl. 26:23-25) which are similar morphologically to those specimens observed from San Antonio Bay, particularily the specimens of forma *lidoensis*, and the intermediate forms present (i.e. pl. 18:4). *E. excavtum* forma *cuvillieri* (pl. 18:8-15; pl. 28:11,13-14,16-21) and forma *williamsoni* (pl. 18:17) were also identified. The specimens of forma *cuvillieri* are extremely variable, particularily the sutures, ponticuli, and umbilical regions. Two specimens were observed that may be *E. excavatum* forma *galvestonensis* (pl. 18:16,18). These were identified by comparison with specimens from San Diego Bay.

Bay of Izmir, Turkey: Three formae were observed from a late Pleistocene assemblage from this location. All three are mophologically isolated and no intermediate specimens were observed. *E. excavatum* forma *lidoensis* (pl. 19:1-7; pl. 26:28-32), forma *cuvillieri* (pl. 19:8-15; pl. 28:1-10,12,15) and forma *williamsoni* (pl. 19:16-17) were found. The specimens of forma *lidoensis* are the

"Lusitanian" form; and specimens of forma cuvillieri are similar to those found living in Venice Lagoon.

DISCUSSION

The observations presented above suggest patterns in the degree of variablity within the range of the *E*. *excavatum* group. Samples from colder waters display less variablility than their counterparts from more temperate environments. Samples from nearshore estuarine locations display a wider range of variability and contain a larger number of intermediate forms than samples from more stable environments.

The range of variability observed in the three samples from Europe is much narrower. The formae are quite isolated and distinct at two of the locations (Wadden Sea and Bay of Izmir), no intermediate specimens linking any of the formae have been observed. At the third European location, Venice Lagoon, only *E*. *excavatum* forma *gunteri* and forma *lidoensis* can be linked, all other formae are isolated, as is the case with the sample from San Antonio Bay. These four samples come from locations where the annual climatic ranges are not extreme. The specimens displaying the widest range of variation are those from eastern North American temperate estuaries which are subject to extremes in climate and environmental conditions. It is only in this particular region that *E*. *excavatum* forma *gunteri*, *galvestonensis*, *williamsoni* and *cuvillieri* can be linked to the core formae (i.e. formae *clavata* and *excavata*) of the group. This apparent lack of intermediate forms may be one reason why some European workers (i.e.

Haynes 1973, 1982 pers. comm.; Murray 1979, 1982 pers. comm.) have not grouped some of these morphotypes (i.e. forma *gunteri*, *williamsoni*, or *cuvillieri*) with the remainder of the group. Another reason for not grouping may be the variation within the forma. For example *E. excavatum* forma *lidoensis* can be split into two "subforma": a "boreal" environment form from areas with extremes in climatic variation, i.e. Miramichi Estuary, Annapolis Basin and Long Island Sound; and a "Lusitanian" environment form, from areas with a narrower climatic range, i.e. San Diego Bay, San Antonio Bay, Venice Lagoon and Bay of Izmir. Both forms exhibit the key characteristic of the forma: sutures filled with papillae, broadening towards the umbilicus, giving the umbilicus a star shaped appearance. The "boreal" form found along the North Atlantic seaboard resembles, and can be linked to *E. excavatum* forma *excavata*; the wall perforations are fine and the papillae small. The ponticuli are more strongly developed on this form. The "Lusitanian" form resembles, and can be linked to *E. excavatum* forma *gunteri*; the periphery is rounded, wall perforations coarse, papillae more variable in size and a larger number of bosses present in the umbilicus. This "Lusitanian" form is the one most often seen by European workers, and in the European samples examined, the link to the core of the *E. excavatum* group is not apparent.

It is difficult to draw definite conclusions about the environmental preferences of some of the morphotypes. As Myers (1943) pointed out, there are many ecological parameters acting simultaneously upon several phases of the life cycle of foraminifera, making it difficult to estimate the possible effect of a single variable while comparable changes in magnitude are taking place in other conditions. As noted by Raup and Stanley (1971), the same morphological variables may be under genetic control, or under control of the environment, making separation of genetic and non-genetic factors especially difficult. Separation of such factors is impossible in a situation suggested by Jardine and Sibson (1971), when the extent to which variables are environmentally modifiable is in itself under genetic control.

In very general terms, however, the following useful observations can be emphasized: 1) *Elphidium excavatum* forma *clavata*, the dominant member of the group and cosmopolitan form, is found in cold, normal marine waters or slightly reduced salinities; 2) forma *excavata* (a cosmopolitan form) is found as a minor constituent of the population in the intertidal zone; 3) forma *williamsoni* a very cosmopolitan form, is the dominant intertidal/marsh form where there is little wave action; 4) forma *selseyensis* is a temperate to polar water (1-16°C) estuarine form on both sides of the Atlantic; 5) forma *lidoensis*, also present on both Atlantic seaboards and the Pacific coast, is a warm to temperate water estuarine and lagoon form; 6) forma *gunteri* a cosmopolitan form, appears to replace forma *clavata* in temperate to tropcial waters; 7) forma *galvestonensis*, a tropical, nearshore, lagoon form preferring normal to hyper-salinities, appears to be geographically isolated, being present mainly along eastern North America; a tropical, nearshore, lagoon form preferring normal to hyper-salinities; 8) forma *cuvillieri* appears to be a subtidal temperate to tropical normal marine form, common in the Mediterranean and along the European (Atlantic) coast but occurring in the Gulf of Mexico too; 9) forma tumidum is observed only along the western North American coastline and 10) forma magna appears to be an arctic to temperate water nearshore turbulent zone form.

Feyling-Hanssen (1972) reported the following occurrences: 1) Elphidium excavatum forma clavata in arctic and subarctic waters from moderate depths; 2) forma selseyensis (= forma excavata) in the boreal environment; and 3) forma lidoensis in the Lusitanian regions. He noted that (1972 p. 339): "In all environments, variation in shape and sculpture of this species occur, but a certain pattern in the distribution of different forms is recognizable..... This pattern must also be of paleo-ecological significance, and for these reasons it must be considered of some importance to maintain a taxonomic separation between the major variations within the species".

Similar observations were made earlier by Bartlett (1963, 1964, 1965a, 1965b). Bartlett studied the occurrence of Elphidium incertum "complex" (=E. excavatum) of Tracadie Bay, Prince Edward Island (1965a) and the Scotian Shelf (1963, 1964); observing that differences in external morphology were apparently related to environmental parameters (Bartlett, 1965b). Bartlett found large opaque forms (forma magna) associated with turbulent nearshore environments (as did Scott 1977, Scott et al. 1980) or the outer shelf. In normal marine environments, such as inner shelves and open bays, Bartlett (1965b) observed translucent biumbonate forms with one or more umbilical bosses and translucent biumbilicate specimens (=forma clavata?). Back-bay and lagoonal specimens appeared to be smaller, extremely variable in external morphology and often the umbilicus had a depressed, slit-like appearance (=forma *excavata*).

Wilkinson (1979) was of the opinion that he was dealing with two distinct species when he pointed out that the type descriptions of *Elphidium excavatum* and *E. clavatum* differ markedly. He compared the type figure of *Polystomella excavata* Terquem (1876), and the neotype described by Lévy et al. (1975) with Cushman's *E. clavatum*, and concluded that the morphological differences between the two were taxonomic and sufficient to justify specific separation.

Wilkinson (1979) reported the geographical distribution of the different morphological variants as having very little or no overlap and consequently designated them as subspecies. According to Mayr et al. (1953, p. 30): "Subspecies are geographically defined aggregates of local populations which differ taxonomically from other such subdivisions of a species. Not more than one subspecies of any one polytypic species can exist in breeding condition in any one area". In the populations studied, seven morphological variants of *E. excavatum*, including those that Wilkinson would regard as subspecies, are found concurrently living in Bay of Chaleur; six are present in San Diego Bay; five were observed in the Annapolis Basin, Chezzetcook Inlet, and San Antonio Bay; four were present in Long Island Sound and Miramichi Estuary; three were observed in the Maine-New Brunswick Estuary and Venice Lagoon; two were observed in the Beaufort Sea and off Liverpool, Nova Scotia. In addition, of the assemblages studied eight morphotypes were noted in the Baie Verte core sample; seven were present in San Francisco Bay core; four were observed in the Champlain

Sea sample; three were present in the Bay of Izmir core sample; and two formae were present in the Labrador Shelf core, and in the Hirtshals, Denmark and Wadden Sea samples.

Hence these distributions provide strong evidence that the morphotypes examined in this study do not fulfill Mayr's definition of subspecies . These morphotypes appear to be ecophenotypes, which are the result of non-genetic modification of the phenotype to specific ecologic conditions (Mayr et al. 1953). A similar interpretation was proposed by Feyling-Hanssen in 1972.

Wilkinson (1979) noted that *E. excavatum* (Terquem) and *E. clavatum* Cushman were morphologically distinct. Rodrigues and Hooper (1982, p. 415) also stated: "because no morphological series relating modern specimens of *E. clavatum* to either *E. selseyensis* or *E. lidoense* have been adequately documented in the literature, we choose to regard *E. clavatum* as distinct from *E. selseyense* and *E. lidoense*". As shown in this thesis however, these four "species" and six other often reported taxonomic units (*E. williamsoni*, *E. gunteri*, *E. galvestonense*, *E. cuvillieri*, *E. tumidum* and *E. excavatum* forma *magna*) as well as numerous other "species", can be accommodated into various intergradational series, which indicates only one highly variable species is present, *E. excavatum* (Terquem), which includes at least 10 ecophenotypes. Since the ecophenotypes of *E. excavatum* have paleo-ecological rather than taxonomic significance, it is suggested that Feyling-Hanssen's (1972) trinomial terminology, inclusive of an epithet for the forma, be retained.

Poag (1978) has studied ecophenotypy in the genera *Ammonia*, Elphidium, Palmerinella, and Ammotium from San Antonio Bay, Texas. (The San Antonio Bay samples studied here are some of the same samples, kindly made available by Dr. Poag). Poag's conclusions about ecophenotypy in Elphidium are different than those drawn here, probably for two reasons. One is the subjectivity of the methods used to delimit the ecophenotypes. When two or more morphotypes can be linked through an intergradational series, there is no set limits to each morphotype and the "morphological boundary" between two morphotypes is up to the author's discretion. The other reason may be the limited range of variability present in Poag's sample relative to the scope of the variability observed in the twenty samples described in this work. No one sample contains the whole spectrum of the species (indeed, neither does twenty samples) but the range of variability in twenty is usually greater than that observed in one. Consequently, the boundaries between morphotypes fall in different places. Arnold (1968) has emphasized that large natural populations must be studied throughout as much of the geographic range as possible to determine the incidence of each suspect variant.

Haynes (1981, p. 61-62) states that E. excavatum can be regarded as a "superspecies" comprising E. clavatum and E. selseyense and their allies as siblings of E. ex gr. excavatum. Alternatively, this group may be viewed as one polytypic species, E. excavatum subsp. gr. Haynes states that intermediates do exist and that the distribution patterns he has observed suggest (p. 62): "a morphological continuum with distinctive 'end members' in different geographical areas that are conveniently regarded as separate species.". Haynes (1981) continues: "... it is difficult, if not impossible to distinguish between 'subspecies' and 'ecophenotypes' which in any case are potential if not actual subspecies."

The observations made in this study contradict those of Haynes; they indicate that eight of the formae studied are not geographically isolated (a hypothesis that will be further investigated in the statistical study). Only two formae, tumidum and galvestonensis do not have a widespread occurence throughout both Europe and North America. As stated previously, the presence of intergradational series makes it highly unlikely that these morphotypes are subspecies.

It has been suggested (see Haynes 1981) that live cultures are the only definite method of solving genetic vs. non-genetic variation problems. For some groups, this method has been successful (e.g. Ammonia beccarii, Schnitker 1974). However, the intergradational series technique applied to live populations is also effective because, in a sense, an "in situ" culture is being investigated. This technique has the advantage of examining a population from a natural environment rather than the artificial environment provided by laboratory cultures. It is difficult to duplicate all the conditions of the natural environment, and with so many variables, Myers (1943) considers it is virtually impossible to determine which one or combination of influences determines morphological variation. Hence, it is felt that the intergradational series techniques for this kind of taxonomic study is a useful and valid tool.

CONCLUSIONS

1) Information from the literature and observations here indicate that Elphidium excavatum (Terquem) is a highly variable species comprising at least nine (possibly ten) distinct ecophenotypes (formae). No definite conclusions are drawn at this time about the tumidum form; though it is treated as a forma of E. excavatum, no definite conclusions can be based on 11 specimens from two locations.
2) Distribution patterns of the formae suggest association with environmental variables rather than simple geographic locality (many formae can live in one area at times). These observations lead to the rejection of the subspecies ranks proposed by Wilkinson (1979) and Haynes (1981).
3) The designation of "forma" has been retained from Feyling-Hanssen (1972) and ten formae can be recognised with the binocular microscope:
1) E. excavatum forma excavata (= forma selseyensis of Feyling-Hanssen) found as a constituent of populations in intertidal zones; 2) forma williamsoni is the dominant intertidal/marsh form where there is little wave action; 3) forma clavata, the dominant member of the group found in cold normal marine waters or slightly reduced salinities; 4) forma selseyensis (not sensu Feyling-Hanssen), a temperate to polar water estuarine morphotype; 5) forma gunteri, which appears to replace forma clavata in temperate to tropical waters; 6) forma galvestonensis, possibly geographically isolated along the eastern North American coast, a tropical, nearshore lagoon form, preferring normal to hyper-salinities; 7) forma lidoensis, a warm to temperate water estuarine and lagoon form; 8) forma cuvillieri appears to be a subtidal temperate to tropical normal marine form; 9)

forma _tumidum_ which has been observed only along the western North American coast and 10) forma _magna_ a nearshore, turbulent zone morphotype.

Variability in the _E. excavatum_ group (number of formae and the percentage of intermediate forms present) appears to increase when each, or a combination of, the following variables is increased: water temperature, proximity to shore, estuarine influence and the range of annual climatic variation.

STATISTICAL INVESTIGATION OF INFRASPECIFIC VARIATION

PREVIOUS WORK

The earliest attempts to apply numerical methods to taxonomy date from the rise of biometrics in the last century (Sokal and Sneath 1963). As early as 1898 Heinke used a measure of phenetic distance to distinguish between races of herring. It was realized early on that biometrics could be applied to systematics (Sokal and Sneath 1963).

Foraminiferal taxonomy is based almost exclusively on characters of the shell, and foraminiferal shell structures have been most commonly analysed by univariate methods. These include linear measurements, enumerator data, ratios, and relative variability, all of which are explained by Scott (1974). Bivariate analysis, usually pairs of shell measurements analysed by linear regression, have also been used. Scott (1974) cites many examples of both univariate and bivariate methods (as applied to foraminifera); a good example is described by Gradstein (1974).

However, a form as complex as the foraminiferal shell requires many variates for its quantitative representation. The shell is an integrated structure and variates need to be considered simultaneously rather than in pairs. Multivariate methods are capable of doing this, and the development of electronic computational methods and equipment, makes multivariate analysis possible.

The many variates quantitatively representing the foraminiferal test can often be envisaged as a cluster of points in a multidimensional space. New variables "canonical variates" (plotted on canonical axes), are computed which are linear combinations of the original variables, and are so oriented that the sample means are now at maximum distances apart (Scott 1974). Buzas (1966) computed three canonical variates based on invariant characters of four species of *Elphidium*; these canonical variates graphically represent a large proportion of intersample variance. Buzas (1966) proved that these four species were only three species statistically; two species, *Elphidium clavatum* Cushman and *E. incertum* Cushman (not Williamson) were not statistically separable.

To differentiate infraspecific populations exhibiting ecologic or geographic patterns to their distribution, various techniques of discriminant analysis (Fisher 1936) may be used to test the hypothesis that they can be differentiated (Jardine and Sibson 1971). Discriminant analysis constructs canonical variates from multivariate normal populations with common variances and covariances and allocates individuals among known populations. These new variates are linear and the populations are at maximum distances apart. Discriminant analysis is particularily applicable if the specimens to be allocated belong to one of the populations represented in the computation of the function; there is no provision for a specimen not belonging to one of the populations in question (Scott 1974).

Another advantage of discriminant analysis is that it has been successfully used previously in similar cases, where there is no convenient breaks in the sequence to allow the delineation of distinct morphotypes. Ashton et al. (1957) and Pritchard (1960) have applied discriminant analysis to infraspecific variation in anthropology and botany respectively; and Reyment (1973) in paleontology.

DISCRIMINANT ANALYSIS

WHAT IS IT?

Discriminant analysis is a statistical method for deriving one or more discriminant functions, each of which is a linear combination of two or more independent variables that will discriminate best between the *a priori* defined groups. This derivation is achieved by using a statistical decision rule to determine the maximum between-group variance relative to the within-group variance, i.e. to obtain the largest ratio of the between-group to within-group variance (Hair et al. 1979).

The general equation of a discriminant function is:

$$Z = w_1x_1 + w_2x_2 + w_3x_3 + \dots w_px_p \qquad \text{(equation 1)}$$

or

$$Z = \underline{x}'\underline{w} \qquad \text{(equation 2)}$$

where:

Z is the value of the discriminant function or discriminant score, for a defined group

w_p is the coefficient for the p^{th} variable, x_p

$\underline{x} = (x_1, x_2, x_3, \dots, x_p)'$ is the independent variables vector, and

$\underline{w} = (w_1, w_2, w_3, \dots, w_p)'$ is the coefficients vector.

To obtain the discriminant function, each independent variable is multiplied by its corresponding weight and these products are added together. If there are more than two groups, more than one discriminant function is needed to separate the groups. In general, there are a maximum of g-1 functions (where g is the number of groups). The result is a single composite discriminant score for each function for each individual in the analysis. The discriminant function tests the hypothesis that the means of the two (or more) groups are equal. By averaging the discriminant scores for all the individuals within a particular group, the group mean, called the group centroid, is obtained. The test for statistical significance of the discriminant function is a generalized measure of the distance between the group centroids, and is computed by comparing the statistical distribution of the discriminant scores in each group. If the overlap in the distributions is small, the discriminant function separates the groups well. If the overlap is large, the function is a poor discriminator between the groups (Hair et al. 1979).

A good mathematical description of discriminant analysis is given in Sneath and Sokal (1973).

There are a few assumptions made in the application of discriminant analysis. One is that there is multivariate normality of the distributions and equal dispersion and covariance structures for the groups. Scott (1974) says that the assumption of equal covariance matrices seldom holds for foraminiferal data; causes and reasons for non-homogeneity are discussed by Reyment (1962, 1969). Another assumption is that there are equal *a priori* group probabilities. However, discriminant analysis is not overly sensitive to violations of these assumptions unless the violations are extreme (Hair et al. 1979). The assumption that there is equal probability of an unknown sample belonging to any group is the most difficult to justify when taxonomic data are used (Davis 1973), but tests for this probability are beyond the scope of this work.

GEOMETRIC REPRESENTATION

A graphical illustration of a two-group analysis may help elucidate the procedure just described. Figure 2 represents a scatter diagram and the projection resulting from computation of a discriminant function.

There are two groups, a and b, and two variables, x_1 and x_2, measured for each specimen of the two groups. The x_1, x_2 values are plotted for each specimen. By finding a linear combination of the original variables x_1 and x_2, the result can be projected onto a new axis, representing the discriminant function, Z, drawing a straight line through the two points where the ellipses encircling the data for each group interesect. When the data points for groups a and b are projected onto the new Z axis, they condense the information about group differences into a set of points on a single axis (Hair et al. 1979). The overlap between the univariate distribution a' and b' is smaller than that obtained by any other line drawn through the scatter plots (Green and Tull 1975).

PROCEDURE

The application of discriminant analysis can be divided into three major stages: (1) derivation, (2) validation and (3) interpretation (Hair et al. 1979). The derivation stage involves determining whether or not a discriminant function which is statistically significant can be derived to separate the groups. The validation stage involves developing a classification matrix to further evaluate the predictive accuracy of the discriminant function. The interpretation stage involves determining which of the independent variables contribute the most toward discriminating between the groups

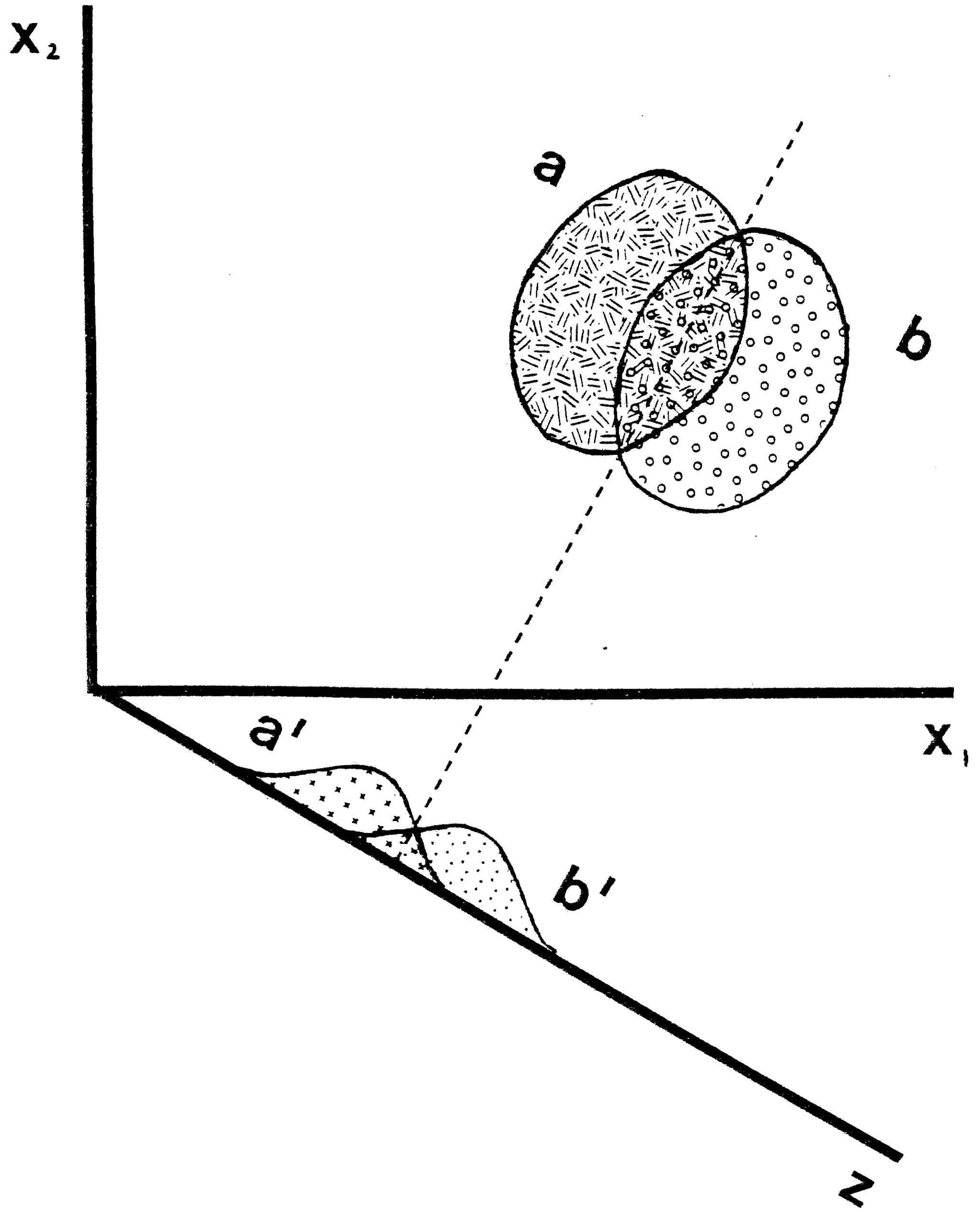


Figure 2: A two group analysis. A scatter diagram for characters x_1 and x_2, obtained for all the individuals in groups a and b; and the projection resulting from the computation of a discriminant function (from Hair et al. 1979).

(Hair et al. 1979).

DERIVATION

This stage consists of several steps: a) variable selection, b) sample division, c) computational methods, and d) statistical significance (Hair et al. 1979).

Variable selection: To apply discriminant analysis, the analyst must first specify which variables are to be independent variables and which is to be the dependent variable. The dependent variable should be chosen first. There can be two or more categories or groups of the dependent variable but these groups must be mutually exclusive and exhaustive. The independent variables must then be chosen. These variables can be selected in two ways. Variables identified from previous research or from a theoretical model (which is the underlying basis of the research question) can be employed. The second method of choosing variables is intuitive, based on trying to extend the researcher's knowledge. In both methods, those variables are selected which logically might be related to predicting the groups for the dependent variable (Hair et al. 1979).

Sample division: The discriminant function (or functions) must be tested for statistical validity. One procedure (the split sample method) involves developing the discriminant function(s) on one data set and then testing it (them) on another (Frank et al. 1965). The first data set, the analysis sample, is used to develop the discriminant function. The second set, the holdout sample, is used to test the discriminant function.

Frank et al. (1965) point out that an upward bias will occur in the prediction accuracy of the discriminant function if the same individuals are used in developing the classification matrix as were employed in computing the discriminant function. If the split sample method is not used, then the classification accuracy will be higher than is valid for the discriminant function.

There are no definite rules for dividing the data into analysis and holdout samples. One can employ a 50 - 50, 60 - 40, or 75 - 25 split between the two groups, respectively. However, when selecting individuals for the two samples, a proportionally stratified sampling procedure is usually followed. If the categorical groups of the dependent variable are not equally represented in the total sample, then the size of the groups within the holdout sample should be proportional to that group's representation within the total sample (Hair et al. 1979).

The most frequent procedure utilized in validating the discriminant function is to divide the groups randomly and run the analysis only once. Frank et al. (1965) suggest that greater confidence could be placed on the validity of the function(s) if the above procedure were followed several times.

There are other more sophisticated methods for validating discriminant functions, a summary of these methods can be found in Crask and Perreault (1977).

Computational method: There are two computational methods that can be utilized in deriving the discriminant functions: the simultaneous (direct) method, and the stepwise method (Hair et al. 1979).

The simultaneous method involves computing the discriminant function so that all of the independent variables are considered concurrently. The discrimanant function(s) is computed using the entire set of independent variables, regardless of the discriminating power of each. The simultaneous method is appropiate for the initial analysis, when the function(s) is derived. Once the discriminating power of the function(s) is ascertained, the stepwise method might be employed to see the intermediate results based on only the most discriminating variables (Nie et al. 1975).

The stepwise method involves entering the independent variables into the discriminant function(s) one at a time, based on their discriminant power. The first step is for the computer to determine the single best discriminating variable. This initial variable is then paired with each remaining variable until a second variable is chosen that best improves the discriminating power of the function in combination with the first variable. The third and subsequent variables are selected in a similar manner. As additional variables are included, some previously selected variables may be removed if the information they contain about group differences is available in some combination of other included variables. Eventually, all variables will have been included in the function(s), or excluded if they do not contribute significantly to the discriminating power of the function(s) (Nie et al. 1975).

The mathematical derivation of the discriminant function(s) (as derived from first principles) is given in Appendix B.

Statistical significance: After the discriminant function has been derived, its level of significance must be assessed. If the function is not significant at or beyond the 0.05 level, there is little justification for continuing to the validation and interpretation stages because there is little likelihood that the function will classify accurately (Hair et al. 1979).

VALIDATION

Once the discriminant function(s) have been developed, the statistical significance of the function(s) must be determined. In the SPSS program, the statistic used is a chi-square, χ^2 (Nie et al. 1975). However, the level of significance of this statistic is a poor indication of the function's ability to discriminate between the groups (Hair et al. 1979). With large sample sizes, the group means (centroids) could be almost identical and there would still be a statistically significant difference with the χ^2 test. With sufficiently large sample size, there could be a significant (χ^2) difference between two (or more) groups and yet, for example, only 53 percent would be correctly classified (when chance is 50 percent for two equal sized groups) (Morrison 1969). For reliable classification the classification matrices should be developed to provide a more accurate assessment of the discriminating power of the function (Hair et al. 1979).

The validation stage involves several steps. These include: a) construction of classification matrices, b) using chance models to determine the expected percent of correctly classified specimens and c) assessing the classification accuracy relative to the chance of random group assignment (Hair et al. 1979).

Construction of classification matrices: To validate the discriminant functions, classification functions are developed and evaluated. As mentioned earlier the analysis sample was used to compute the discriminant function(s). The holdout or validation sample was retained for use in developing the classification matrix. The general equation for a classification function is:

$$\ln \frac{1}{g} + (\underline{x} - \frac{\underline{\bar{x}}_i}{2})' W^{-1} \underline{\bar{x}}_i \qquad \text{(equation 3)}$$

where:

g is the number of groups

$\underline{x}$ is the independent variable vector (for the specimen being tested)

$\underline{\bar{x}}_i$ is the mean vector for the independent variables of the ith group, and

W is the within groups variance-covariance matrix.

Derivation of the general equation is given in Appendix B. The classification rule is to evaluate these g functions for each specimen, and classify the specimen with independent variables $\underline{x}$ into the group which gives the largest function value. The g x g classification matrix tabulates for each group the number of specimens classified into each group (correctly classified when assigned to its own group and incorrectly classified when assigned to another group). The hit ratio, which is the proportion correctly classified, is the sum of the diagonal entries on this matrix divided by the sample size. For a two group case, it can be shown that the classification functions and discriminant functions are essentially the same (Appendix B).

Chance models: Another factor that must be considered is the percentage of specimens that would be correctly classified by chance. When the sample sizes of the groups are equal, the determination of the chance classification statistic (c) is simply obtained by dividing

1.0 by the number of groups (ie: $c=1/g$). For the case where the group sizes are unequal, c can be based on the sample size of the largest group, referred to as the maximum chance criterion (Hair et al. 1979). When the sample sizes are unequal and all specimens are to be classified, the discriminant function defies the odds when classifying a specimen into a smaller group; a factor which should be taken into account (Morrison 1969).

If the percentage of correct classifications is significantly larger than would be expected by chance, an attempt can be made to interpret the discriminant functions. Hair et al. (1979) suggest that as a rough estimate, the classification accuracy should be at least 25 percent greater than by chance; this criterion is easy to apply to equal sized groups (Hair et al. 1979).

INTERPRETATION

If the discriminant function is statistically significant and the classification accuracy acceptable, then the results can be interpreted. The discriminant functions should be examined to determine the relative importance of each of the independent variables in discriminating between groups. Three methods have been suggested for determining the relative importance of these variables: a) standardized discriminant weights, b) discriminant structure correlations, and c) partial F-values (Hair et al. 1979).

Discriminant weights: The traditional approach to interpreting discriminant functions involves examining the sign and magnitude of the standardized discriminant weights (or function coefficients), calculated for each variable in computing the discriminant functions.

Independent variables with relatively larger weights contribute more to the discriminating power of the function than do variables with smaller weights regardless of the sign (+ or -) Hair et al. 1979). There are two drawbacks associated with emphasizing discriminant weights. A small weight may either mean that its corresponding variable is irrelevant in determining a relationship; or that the variable has been partialled out of the relationship because of a high degree of multicolinearity (Hair et al. 1979).

Discriminant loadings: Discriminant loadings (or structure correlations) measure the simple linear correlation between each independent variable and the discriminant function(s). The discriminant loadings reflect the variance the independent variables share with the discriminant function, and can be interpreted like factor loadings in assessing the relative contribution of each independent variable to the discriminant function (Hair et al. 1979).

Partial F-values: As discussed earlier, there are two computational approaches that can be utilized in deriving the discriminant function(s) - simultaneous and stepwise. When the stepwise method is selected, the relative discriminating power of the independent variables is measured through the use of partial F - values. Large F-values would indicate greater discriminating power.

ANALYSIS OF FORAMINIFERA DATA

COMPUTER PROGRAMS

The statistical analysis was completed using a FORTRAN language computer program from SPSS - "Statistical Package for the Social Sciences". It is a prepared program that performs a specified set of operations, under the control of a simplified set of instructions (Klecka et al. 1975). The major features of SPSS: data collection, control cards, data and system files, etc., are explained in the SPSS Primer (Klecka et al. 1975). A complete description of the SPSS system including the subprogram DISCRIMINANT is given in "the SPSS manual", "SPSS: Statistical Package for the Social Sciences" (Nie et al. 1975).

To aid in understanding the SPSS output, an illustrative example was devised (see Illustrative Example - TEST) and most of the SPSS computations for this TEST example were duplicated using another statistical package, MINITAB. MINITAB is a step-by-step interactive package (Ryan et al. 1981). The computations reproduced from the SPSS output using MINITAB will be outlined in detail later (see Appendix C: TEST Calculations).

The computing was done on the CDC Cyber 170 computer at Dalhousie University.

DATA COLLECTION

There are many comprehensive textbooks on numerical taxonomy (among them Sokal and Sneath 1963, Jardine and Sibson 1971, and Sneath and Sokal 1973). These all discuss the philosophy behind numerical taxonomy and the theoretical considerations of data collection, and character selection, measurements, coding and ranking, etc. which will not be discussed here. Scott (1974) discusses character selection and measurement in detail for foraminiferal biometric studies and the reader wishing to pursue the matter is referred to these works or those of his choice.

The first step was to choose the dependent variable and it was decided, based on the observations and subjective taxonomy to make "morphotype" the dependent variable (group) for most of the analyses. However, morphotype was treated as an independent variable in two of the analyses, and for these two analyses, location was the dependent variable (otherwise location was treated as an independent variable). Selection and measurement of the independent variables will be described in detail in the following section.

There were two alternatives available for the actual measurement of the independent variables. One was to take the measurements directly from the specimens observed under a microscope, a method employed by Buzas and Culver (Buzas 1966, Buzas and Culver 1981 pers. comm.). The other method was to obtain scanning electron microscope (SEM) photographs of each specimen and make the measurements from those photographs. Scott (1974) discusses the advantages of this method and lists authors who have had success completing biometric studies with the aid of the SEM. This second method was chosen because it is easier to return to a photograph to verify measurements than to relocate a specimen under a microscope. However, the disadvantage of photographs is that photos are often distorted, because the specimen was not centered, or because the specimen was damaged during the preparation for or during photographing. (In this study, phots of 89 specimens were rejected for these reasons.) If the first method had been employed, the measurements may have been more accurate, but also more difficult to make and reproduce.

VARIABLE SELECTION and MEASUREMENT

In this study, the dependent variable is usually the "morphotype" or group, to which specimen belongs. As described in the first part of the thesis, ten morphotypes (ecophenotypes) of Elphdium excavatum were recognized using a subjective method. Even without exact knowledge of the degree of overlap between the typological units and those to be generated in the analysis, the practice of Gradstein (1974) was followed, that of retaining the ten epithets, of the "subjectively" defined morphotypes and using these names for the "statistically" defined morphotypes. This has the advantage that a set of labels is already available (Gradstein 1974).

Each specimen was assigned to one of these ten morphotypes (1-10) as outlined on Table 2. In addition, for three of the analyses, three other species were added (11-13, Table 2). These were Elphidium bartletti, E. subarcticum and Haynesina orbiculare. The group codes for these species are also given on Table 2.

Throughout the remainder of the statistical investigation, the morphotypes will be referred to as groups, and the groups will usually be referred to by code number only. The Fortran code for group is FORM (from 'forma'). All other variables were also assigned a code name. Sixteen independent variables were chosen, in consultation with Dr. S.J. Culver, Dr. M.A. Buzas (Culver and Buzas 1981 pers. comm.), and Dr. C.T. Schafer (Schafer 1982 pers. comm.). In addition, variables were chosen with reference to previous work by Buzas (Buzas 1966). The data were measured (ranked/scored) so they could be utilized directly in the SPSS system .

Number (FORM)	Morphotype or Group
1	clavata
2	excavata
3	selseyensis
4	lidoensis
5	magna
6	gunteri
7	galvestonensis
8	cuvillieri
9	williamsoni
10	tumidum
11	H. orbiculare
12	E. subarcticum
13	E. bartletti

Table 2: Code numbers used for each of the ten morphotypes (or groups) of *Elphidium excavatum* and three other Elphidiidae species in the analysis.

Ten of the independent variables are qualitative, six are quantitative. Kendall and Stuart (1966) state that a set of mixed variables (some qualitative, some quantitative) can't be processed satisfactorily by discriminant functions, but Nie et al. (1975) make no mention of these restrictions; in fact, their examples contain both.

The first qualitative variable is the location (LOC) the specimen was collected from. Specimens were from 20 samples from 19 different locations (see Table 1) and were assigned code numbers for the purpose of the analyses, as outlined on Table 3.

The remainder of the qualitative variables were observations made from the SEM photographs, and were given arbitrary scores or ranks, as explained below. Table 4 lists all the variables, their codes, and possible ranks or scores. Table 5 refers to illustrations of the variables.

PAP denotes the presence (scored as 1) or absence (scored as 0) of papillae anywhere on the test surface other than directly within the suture. UMCO denotes the presence (1) or absence (0) of an imperforate collar of test material surrounding the umbilicus.

Seven variables were given arbitrary rankings. The depression of the umbilicus (DEUM), was measured as depressed (1), flush with the test wall (2), or raised (3). The density of the wall pores (POR) was ranked as very fine (4-barely seen in photo), fine (3), medium (2), and coarse (1). The angle of the margin (AOMA) was ranked as acute (1) or subacute (2). The peripheral outline (PERO) was ranked as completely smooth (1); slightly lobate or the last few chambers lobate (2); or markedly lobate or more than one half the chambers in the

Number (LOC)	Location
1	Beaufort Sea - Vilks
2	Beaufort Sea - Bartlett
3	Hirtshals, Denmark
4	Labrador Shelf
5	Labrador Shelf
6	Miramichi Estuary
7	Northumberland Strait
8	Annapolis Basin
9	Chezzetcook Inlet
10	Long Island Sound
11	Bay of Chaleur
12	San Diego Bay
13	Bay of Izmir (Turkey)
14	Champlain Sea
15	Wadden Sea
16	Venice Lagoon
17	Maine-New Brunswick Estuary
18	San Antonio Bay (Texas)
19	Liverpool, Nova Scotia
20	San Francisco Bay

Table 3: Code numbers for the variable locations. Location 4 refers to a gradational sequence from a Labrador Shelf core, Location 5 is an intergradational series from the same core. Both of these are discussed and illustrated elsewhere (Miller 1979, Miller et al. 1982).

dependent or independent	discrete or continuous	qualitative or quantitative	code	possible scores or rankings
dependent	discrete	qualitative	FORM	1 - 10
independent	discrete	qualitative	LOC	1 - 20
			PAP	0, 1
			UMCO	0, 1
			AOMA	1, 2
			SUT	1, 2
			DEUM	1, 2, 3
			PERO	1, 2, 3
			DEPO	0, 1, 2, 3
			REPO	0, 1, 2, 3, 4
			POR	1, 2, 3, 4
		quantitative	CHAM	count
			PONT	count
			NOBO	count, then classed 0, 1, 2, 3, 4
			POSU	ratio, then classed
				0, 1, 2, 3, 4
	continuous	quantitative	GSD	measurement
			GS90	measurement

Table 4: Summary of variables used in the analysis.

Table 5: Listing of specimens illustrating possible independent variable ranks or scores. Plate and figure listings refer to this work.

Variable and code	Rank/Score	Illustration
Forma (FORM)	1-10	See Table 2
Location (LOC)	1-20	See Table 3
Papillae (PAP)	0	pl. 24: 11,13; pl. 29: 1,8,22;
	1	pl. 24: 12,15; pl. 27: 3,13,32
Imperforate (UMCO) Collar	0	pl. 21: 2,4,6; pl. 27: 5,17
	1	pl. 24: 2,6,13,16,19
Depression of (DEUM) Umbilicus	1	pl. 21: 1,4; pl. 24: 1,3
	2	pl. 24: 6,14; pl. 29: 6,9,20
	3	pl. 25: 9,11; pl. 28: 3,7,11
Wall Pore (POR) density	1	pl. 25: 5,13; pl. 27: 14,17
	2	pl. 24: 2,21; pl. 29: 6,9,22
	3	pl. 24: 11,14; pl. 28: 14,15
	4	pl. 22: 3,6,14,20
Angle of (AOMA) Margin	1	pl. 21: 5,9; pl. 24: 2,13,15
	2	pl. 25: 9,11; pl. 28: 3,4,7
Peripheral (PERO) Outline	1	pl. 24: 2,11; pl. 28: 1,10
	2	pl. 27: 5,23; pl. 29: 8,15
	3	pl. 23: 1,3; pl. 29: 16
Curvature of (SUT) Sutures	1	pl. 24: 4,8,19; pl. 28: 2,5
	2	pl. 27: 12,13; pl. 29: 16,22
Development of (DEPO) ponticuli	0	pl. 27: 21,23,26
	1	pl. 23: 14; pl. 27: 5,7,13
	2	pl. 21: 1,2; pl. 24: 12,13
	3	pl. 24: 8,15; pl. 29: 8,10,20
Regularity of (REPO) ponticuli	0	pl. 24: 2; pl. 27: 21,23
	1	pl. 21: 12; pl. 24: 3; pl. 27: 19
	2	pl. 25: 13,22; pl. 28: 5,7,14
	3	pl. 25: 23; pl. 28: 12,17
	4	pl. 22: 5,8,16; pl. 29: 12
Number of (NOBO) bosses (classed)	0	pl. 27: 3,8; pl. 29: 8,10,22
	1	pl. 24: 2,4,8; pl. 26: 4,13
	2	pl. 24: 11; pl. 27: 19, 32
	3	pl. 25: 11; pl. 27: 14; pl. 28: 12,16
	4	pl. 27: 24,28; pl. 28:14
Number of ponticuli/ (POSU) suture	0	pl. 24: 2; pl. 27: 26
	1	pl. 21: 12; pl. 24: 3; pl. 27: 21
	2	pl. 23: 2,13; pl. 27:19
	3	pl. 25: 11,14; pl. 28: 7,17
	4	pl. 22:6,11,14; pl. 25: 9

final whorl lobate (3). The sutures (SUT) were ranked as straight or with more than one half the sutures straight (1) or more than one half the sutures curved (2). The ponticuli (DEPO) were ranked as absent (0), poorly developed or indistinct (1), distinct but not completely spanning the suture (2) or more completely developed and extending all the way across the suture (3). The regularity of the ponticuli (REPO) were ranked as absent (0), very irregular (with some sutures having ponticuli absent, others having many ponticuli) (1), medium regular (2), very regular (3), and extremely regular (4).

Four of the quantitative variables were actual counts or measurements taken from the photographs. Two were discrete counts: the number of chambers (CHAM) and the number of ponticuli observed on the final whorl (PONT). Two variables were size measurement readings, the greatest spiral diameter (GSD - the largest diameter measured through the umbilicus and usually through the final chamber), and the diameter measured 90° to the greatest spiral diameter (GS90).

Finally, there were two measurements used that were highly variable, and in some cases difficult to measure. For these two variables, classes were erected. One variable was the number of bosses (NOBO). It was often difficult to distinguish between an umbilical boss and papillae in the umbilicus. Consequently the number of bosses per specimen was counted and classed accordingly: 0 bosses = 0; 0 - 2 bosses = 1; 2 - 4 bosses = 2; 4 - 8 bosses = 3; and 8 - 16 bosses = 4. This same class system was applied to the ratio POSU (= number ponticuli / suture). In effect, this is a measurement of REPO, and might make REPO redundant. If the ratio was less than 1, the class is 0, 1 to 2 = 1; 2 - 4 = 2; 4 - 8 = 3; and 8 - 16 = 4.

This system of classing variables, and of classing these variables in particular has been employed by Buzas (1966).

For five of the analyses indicator or dummy variables were created; dummies were created for location in four analyses and for forma in one analysis. In this instance each location (or forma) was represented by a new independent variable with value one if the specimen was from that particular location (or of that forma), and with value zero otherwise. When location was coded as dummy variables (DUM1 to DUM20) each with score one, LOC was not included in the analysis. Similarily when forma was treated as dummy variables, there were 10 additional independent variables (DUM21 to DUM30) in the analysis and FORM was not included.

VARIABLE TRANSFORMATIONS

The quantitative independent variables were tested for constant variance by plotting each group mean (for each variable) against its standard deviation. PONT, did not have a constant variance. However, the square root transformation of PONT, POSQ did have a constant variance and was used in place of PONT in all analyses.

There is a general tendency in biological populations for variance to be a function of the mean (Scott 1974).

Some of the quantitative variables are related to ontogenetic development, or the growth stage of the organism. These include CHAM, GSD and GS90. The measurements of the continous variables depend on the ultimate growth stage which the individual attained (Gradstein 1974). CHAM, GSD, and GS90 become greater with increasing test size, preventing general conclusions from being drawn from the comparison of means based on the raw data. If possible, the effects of ontogenetic development should be removed (Gould 1970). Because only adult specimens were chosen for this study (based on Buzas's [1966] criteria for designating a specimen "adult"), the effects of age were minimized in this work. The two variables measuring size, GSD and GS90 were highly correlated so a new variable GSR, the ratio GS90/GSD was computed and used in all analyses, in place of GSD and GS90. None of the other variables (qualitative or quantitative) correlated highly with one another.

ANALYTICAL FEATURES OF SUBPROGRAM 'DISCRIMINANT'

For each analysis a set of basic or core operations were performed. Some of these operations are referred to as "statistics", others are referred to as "options". The statistics and options calculated are given on Table 6.

Subrogram DISCRIMINANT always prints the standardized discriminant function coefficents. They are used to compute the discriminant score for a case in which the original discriminating variables are in standard form (Z scores). The coefficents have been derived in such a way that the discriminant scores produced are in standard form (Nie et al. 1975). For each function the overall mean is zero and the standard deviation is one. Discriminating variables are not coded in standard form, and standardized function coefficents may not be very useful for computational purposes. Option 11 prints unstandardized function coefficients, which when multiplied by the raw values of the independent variables give the unstandardized

Table 6: Statistics and options calculated/performed in the analyses (from Nie et al. 1975).

Statistics/options calculated in all analyses	
Statistic/Option	Operation/calculation performed.
Statistic 1	Group means - means of all values of the dependent variable and for the total set of cases.
Statistic 2	Standard deviations for each group and the total set of cases.
Statistic 3	Pooled within - groups covariance matrix.
Statistic 6	Univariate F ratios. One-way analysis of variance test for equality of group means on a single discriminating variable. An F is printed for each variable.
Option 1	All missing value declarations are ignored. All cases included during the stepwise and analysis phases, provided they satisfy the GROUPS specification. All cases are classified regardless of their group assignment.
Option 5	Print classification results table indicating for each group the number of cases classified into each of the groups and the percent correct classifications for the known groups.
Option 6	Print discriminant scores and classification information for each case. This includes case identification (subfile name and sequence number); group number of the group the case actually belongs to; group number (G) of the closest group; the probability of a case in group G being that far from the group centroid denoted by P(X/G); the probability of the case being in group P(G/X); if the probability of membership in the second closest group is greater than .0005, that probability and the number of the second closest group is provided; and the discriminant scores.
Option 7	Print a single plot of cases. For one function, this plot is a histogram of the distribution of cases along the function. For two or more functions, a scatter plot of the first two discriminant functions is printed.
Option 8	Print a separate plot for each group
Option 10	Print territorial map. Again for more than two functions, a plot for the first two discriminant functions is printed.
Option 11	Print unstandardized discriminant function coefficients. These are the coefficients to be used in computing the discriminant scores from raw data. The constant to be added as an adjustment for the variable means is also printed.
Option 12	Print classification functions. These produce classification scores when used with raw data from the discriminating variables. The constant to be added as an adjustment for the variable means is also printed.
Option 17	Output discriminant scores.
Option 18	Output membership probabilities for all groups.
Statistics and Options used in some of the analyses	
Statistic 7	Test for equality of group covariance matrices. This is Box's M and its associated F test This statistic is computed for the covariance matrices based on the discriminating variables. If Option 14 is in effect this statistic is also computed for the covariance matrices based on the discriminant functions.
Option 14	Use individual group covariance matrices for classification, instead of the pooled within groups covariance matrix in computing the probabilities of group membership.

discriminant score. When the overall mean is adjusted to zero (by addition of a constant) the standardized score is obtained.

It is not necessary that all variables be included in all analyses. Those variables included are given on the the VARIABLES LIST. All the independent variables were included in the analyses except where specified.

Using the DIRECT method all the variables specified are entered concurrently into the analysis.

In the STEPWISE procedure, the independent variables are selected for entry into the analysis on the basis of their discriminating power, either by the subprogram itself, or by specifying the order (by inclusion levels) with the ANALYSIS card.

For most of the STEPWISE analyses the ANALYSIS card was not used. The analyses where the entry order was specified will be discussed later.

There are five stepwise selection criteria. Only one method, the Wilks' lambda was used for stepwise analysis, because this method was the most similar to the DIRECT method. When METHOD = WILKS, the criterion is the overall multivariate F ratio for the test of differences among the group centroids. The variable which maximized the F ratio also minimized Wilks' lambda, a measure of group discrimination (Nie et al. 1975).

When a STEPWISE analysis is perfomed it is necessary to specify six other parameters or allow them to default. For all of the STEPWISE analyses four of the parameters were allowed to default. These were: TOLERANCE (tolerance level for stepwise selection, default value .001); MAXSTEPS (maximum steps for the stepwise procedure (default is twice the number of variables in the analysis); FIN (minimum F to enter, default value 1.0); and FOUT (minimum F to avoid removal, default is 1.0). Two other parameters, PIN (maximum significance level of F-to-enter, default value 1.0) and POUT (maximum significance level of F-to-remove to avoid removal, default is 1.0) were allowed to default on some analyses, and specified on others (which will be discussed later). All of these parameters are explained fully in Nie et al. 1975.

There are additional controls which can be imposed on the analysis. Two parameters which must be specified are the number of discriminant functions to be derived and the percentage of variation that these functions must account for. These are specified under FUNCTIONS.

The maximum number of discriminant functions to be derived is either one less than the number of groups (i.e. g-1) or equal to the number of variables, whichever is smaller. The dependence on the number of original variables is due to the mathematical impossibility of creating more new variables. The importance of the number of groups stems from geometric principles, that the maximum number of dimensions needed to completely describe a set of points is one less than the number of points (Nie et al. 1975). In all the analyses, the maximum number of functions were allowed.

The subprogram DISCRIMINANT provides two measures for judging the importance of the discriminant functions. One is through the eigenvalue computed in the process of deriving the discriminant functions. The sum of the eigenvalues is a measure of the total variance existing in the discriminating variables. A single eigenvalue expressed as a percentage of the total sum of the eigenvalues is a measure of the relative importance of the associated function. Discriminant functions are derived in order of importance, and the process can be stopped when the relative importance is judged too small (Nie et al. 1975). In these analyses the program was instructed to account for all the variance, i.e. no function was judged too small.

A second criterion for eliminating discriminant functions is to test for the significance of discriminating information not yet accounted for in the derived functions. As each function is derived, starting with zero functions, Wilks' lambda is an inverse measure of the discriminating power in the original variables which has not yet been removed by the discriminant functions - the larger lambda is, the less information remaining. Lambda can be transformed into a chi-square statistic for an easy test of statistical significance. Functions that are not statistically significant can be removed. However, if the number of functions are specified, that number of functions is computed regardless of the values for the relative percentage and the significance level (Nie et al. 1975).

In the classification phase of the analysis, there is one parameter to be specified, and this is the PRIORS specification. This refers to the _a priori_ estimate of group membership. There are three ways of inputting the _a prior_ probabilities. When PRIORS = EQUAL (or PRIORS not included) the _a priori_ probabilities are considered equal and no adjustments made. When PRIORS = SIZE, adjustments are made on the basis of prior probabilities being proportional to the number of cases in each group, i.e. more cases will be assigned to a larger group. Alternatively, a set of prior probabilities can be provided. PRIORS was allowed to default (to EQUAL) for all of the analyses.

ILLUSTRATIVE EXAMPLE - TEST

It was realized fairly early on that a massive data set, consisting of 15 independent variables (plus the two dependent/independent variables, location and forma) for each specimen, and specimens representing 10 different morphotypes (groups) would produce very complicated calculations that may be difficult to validate and interpret. Validation and interpretation of the results would not be complete without understanding the derivation and calculation of the discriminant and classification function(s). However, understanding and duplicating the calculation of up to nine functions each containing up to 15 independent variables is a major undertaking in itself. Instead, an illustrative example was designed, one that was representative of the population data set, but was simple enough so that the discriminant and classification functions could be derived, understood, and the calculations duplicated. This illustrative example is called TEST. The objectives of TEST were to concentrate on the first stage, the derivation stage of the discriminant analysis, and to explain and duplicate the calculation of the various discriminant and classification functions on the SPSS output, using MINITAB.

TEST CALCULATIONS

A sample population (TEST) was set up consisting of 190 specimens (114 of group one [Elphidium excavatum forma clavata], 29 of group three [forma selseyensis], and 47 of group four [forma lidoensis]). The selection of these three groups was arbitrary. Three independent variables were chosen, two qualitative (NOBO and POSQ) and one quantitative (GSD). There were four TEST analyses, which are outlined in Table 7. All TEST data are given in Appendix A, Table A1.

Test Case	Groups	Variables
TEST 1	1, 3	NOBO, GSD
TEST 2	1, 3	NOBO, GSD, POSQ
TEST 3	1, 3, 4	NOBO, GSD
TEST 4	1, 3, 4	NOBO, GSD, POSQ

Table 7: Summary of TEST analyses.

One of the objectives was to understand and duplicate, using MINITAB, the calculation of the various functions and matrices given on the SPSS output. These included: the pooled within groups variance-covariance matrix (W); the two sets of discriminant functions referred to as unstandardized (Z standardized only) and standardized (Z and independent variable standardized); the Z values for the group centroids ($\bar{Z}$ for a group), the critical Z values; the classification functions; the discriminant scores (for the two group analyses); and the classification scores (for the three group analyses).

The analyses were carried out using the simultaneous rather than the stepwise method because at this stage the relative importance of each variable in the analysis was not relevant. The split sample approach was not taken because it was not necessary to test the validity of the functions at this stage but merely to determine how the functions were calculated. The statistical significance of the functions was calculated and observed to be significant in all TEST analyses; therefore, this aspect was pursued no further at this time. The classification due to chance and classification accuracy were not examined at this time because most of these aspects fall under stage two, validation of the analysis. The emphasis of the TEST section is on stage one, derivation. In the analysis of the *Elphidium* data stages two and three are also discussed.

All four TEST analyses were completed, but for the sake of brevity only TEST One and TEST Four are described in Appendix C. TEST Two and TEST Three contained no information not illustrated in TEST One and TEST Four.

ANALYSIS OF ELPHIDIUM EXCAVATUM POPULATION

METHODS

Of the 810 *Elphidium excavatum* specimens photographed, 721 were used in the analysis. The number of specimens of each forma from each location used in the analyses is given in Table 8. The complete data set is given in Appendix A, in Table A2. There are only a few specimens of forma *galvestonensis* (7) and forma *tumidum* (11) for the analyses but no more specimens of these two formae were available. The data for the three additional species is given in Appendix A, in

FORMA	1	2	3	4	5	6	7	8	9	10	TOTAL
LOCATION											
1	9	-	-	-	-	-	-	-	-	-	9
2	10	2	-	-	-	-	-	-	-	-	12
3	10	3	-	-	-	-	-	-	-	-	13
4	10	2	-	-	-	-	-	-	-	-	12
5	14	1	-	-	-	-	-	-	-	-	15
6	12	4	-	12	1	-	-	-	-	-	29
7	39	5	15	9	10	11	9	6	-	-	104
8	9	3	2	8	2	-	-	-	-	-	24
9	8	3	5	6	8	-	-	1	3	-	34
10	8	20	20	10	-	-	-	-	-	-	58
11	8	10	1	2	2	-	-	1	4	-	28
12	7	1	6	15	-	2	-	-	-	10	41
13	-	1	-	25	-	-	-	39	-	-	65
14	14	1	-	1	16	-	-	-	-	-	32
15	-	-	-	-	-	3	-	-	44	-	47
16	-	-	-	8	-	16	-	12	-	-	36
17	1	-	-	1	-	-	-	-	48	-	50
18	1	-	-	24	-	34	11	8	-	-	79
19	2	-	-	-	7	-	-	-	-	-	9
20	1	5	2	12	-	3	-	-	1	1	25
	163	61	51	134	46	69	20	67	100	11	721

Table 8: Number of specimens of each forma from each location used in the analyses.

Table A3.

Thirty-two analyses were completed. Twelve were preliminary analyses on a data set of approximately 300 specimens and these cases were classified to see how effective the discriminating variables are and to decide the value of continuing the work. Based on these preliminary results 20 other analyses were completed. Some of these analyses proved redundant or did not produce information relevant to the study. Consequently, only the results of 15 analyses will be discussed. One 'core' or 'basic' analysis will be discussed in detail. Then the options/statistics/features of the other analysis will be listed and explained as needed.

ANALYSES COMPLETED

The 15 analyses can be divided into five groups as outlined on Table 9.

Group A analyses: Four analyses were completed in this group. FORM was the dependent variable and the data contained in one data set; this one data set was both analysed and classified. The DIRECT (or simultaneous) method was used. The main purposes of this group of analyses were to determine the importance or effect of location, and to compare the subjective classification results to those generated by the computer. In analysis A-1 LOC was not included and in A-3 it was included as dummy variables.

Statistic 7 was added to analysis A-1, and indicated that four of the group covariance matrices were not equal.

Consequently, in analysis A-2 option 14 was exercised, and the classifications were based on the separate group covariance matrices,

Table 9: Summary of analyses, and overall percent correctly classified in each analysis.

Group of Analyses	Analyses Name	Description	Percent correctly classified
A		- FORM as dependent variable - one (complete) data set - 721 specimens -DIRECT (simultaneous) methods	
	A-1	LOC not included addition of statistic 7	84.88%
	A-2	addition of option 14	89.99%
	A-3	LOC coded as dummy variables and included as independent variables	85.66%
B		-LOC as dependent variable -one (complete) data set -DIRECT (simultaneous) method	
	B-1	FORM not included	55.05%
	B-2	FORM coded as dummy variables and included as independent variables	54.79%
C		-FORM as dependent variable -one (complete) data set -STEPWISE method-WILKS LAMBDA	
	C-1	LOC not included	85.16%
	C-2	LOC included	85.30%
	C-3	LOC coded as dummy variables and included as independent variables. ANALYSIS feature exercised DUM1 to DUM20 out at step 7	87.66%
D		-FORM as dependent variable -SPLIT-SAMPLE approach (two data sets, ANALYSIS and HOLDOUT	
	D-1	LOC not included DIRECT method	A-83.76 H-83.80
	D-2	LOC not included DIRECT method addition of Option 14	A-89.43 H-86.19
	D-3	LOC coded as dummy variables, and included as independent variables. DIRECT method	A-87.28% H-88.09%
	D-4	LOC coded as dummy variables and included as independent variables. Addition of Option 14. STEPWISE method WILKS LAMBDA. PIN,POUT specified at .05.	A-87.28% H-89.04%
E		-FORM as dependent variable -one data set with addition of three Elphidiidae species (90 specimens, total 811)	
	E-1	DIRECT method	85.70%
	E-2	DIRECT method addition of Option 14	90.60%
	E-3	STEPWISE method-WILKS LAMBDA addition of Option 14.	90.60%

rather than the pooled matrix. The importance of the assumption that these matrices are equal can be determined by comparing the classification results with and without exercising option 14, as well as exercising statistic 7.

Group B analyses: To further test the influence or effect of location, LOC was treated as the dependent variable. The data was contained in one set which was both analysed and classified. In analysis B-1, FORM was not included and in B-2 it was included as dummy variables.

Group C analyses: FORM was the dependent variable and the one data set analysed and classified. The main feature of these three analyses was that the STEPWISE method of Wilks' lambda was used to determine the order of importance of the independent variables. Analysis C-1 did not include LOC. Another analysis, C-2, was completed with LOC, to determine the relative importance of location (i.e. at what step LOC was removed). Then analysis C-3 was completed with location coded as dummy variables; these dummies were removed simultaneously (using the ANALYSIS feature) at step 7 (the step where LOC was removed in analysis C-2).

Group D analyses: In this group FORM was again the dependent variable but the split-sample approach was taken. The one data set was randomly split into the analysis sample (511 specimens) and holdout sample (210 specimens) to test the classification accuracy of the functions. (No specimens of groups 7 and 10 were placed in the hold out sample because of their low numbers in the analysis sample).

The DIRECT method was used for three of the analyses. Analyses D-1 and D-2 did not include LOC. Option 14 was added to D-2. In analyses D-3 and D-4 location was included as dummy variables. In D-4 a STEPWISE analysis was completed, option 14 added, and PIN and POUT specified at .05.

Group E analyses: Three analyses were completed on a larger data set, which contained 90 specimens of three other species in addition to the other 721 *E. excavatum* specimens. The main objectives here were to see the changes in the classification results when three other species were added. The DIRECT method was used without (E-1) and with (E-2) option 14. A stepwise analysis was computed (E-3) to deterimine if the relative importance of the variables changed when three other species were introduced.

ANALYSIS RESULTS

Group A analyses: Analysis A-1 is treated as a core or basic analysis and the complete results in the form of the computer printout (output) are given in Appendix D. Statistics 1, 2, and 3 are straight forward and do not warrant discussion. Calculation of statistic 3 and option 11, are demonstrated in Appendix C.

Five of the nine discriminant functions account for 95% of the variance (see p. 326). All of the functions are highly significant, though the last four functions don't each account for more than 2% of the variance. The magnitude of the standardized discriminant function coefficients indicate the importance of each independent variable within each function, and those with greatest magnitude are circled on the printout (p. 326). Of the coefficients for the first five functions, AOMA is the most important variable in function 1; UMCO and

POR in function 2; PAP, UMCO and NOBO in function 3; UMCO, POR, CHAM and POS in function 4; and PAP, UNCO, AOMA and DEPO in function 5. Because function 1 accounts for almost 37% of the variance AOMA is the single most discriminating variable. The univariate F-ratios (p. 325) show that AOMA, POR, POSQ, REPO, POSU, and UMCO have large F-values, and are the major group discriminators.

Scatter plots (p. 332-341) of the discriminant scores of the first two functions are given for each group (option 8) and for all cases (option 7) (p. 331); from these plots a territorial map (p. 330) is constructed (option 10). The territorial map is a visual representation of group membership probability based on the two discriminant function scores. The distance (or difference in function scores) between any two group centroids on the map is a measure of the overall difference in morphology between these two groups. The map shows that groups 1, 4, and 8 are closely related (or poorly discriminated by these variables). Group 2 is close to these three groups. Groups 10 and 7 are the next two most closely related groups, followed by groups 10 and 6, and 2 and 3. Group 9 is the most morphologically distinct. All nine discriminant scores, group membership probabilities, and actual group memberships for each case are given (options 6, 17, and 18) on p. 342-367.

The discriminant scores for the group centroids are given on a separate table (p. 327).

The remainder of the output pertains to the classification phase of the analysis. All cases are classified regardless of their group assignment (option 1). As there are 10 groups, there are 10 classification functions (see Appendix B) and these functions (p. 328) are given on the output (option 12). Statistic 7 tests for the equality of the group covariance matrices. Usually the pooled within-groups covariance matrix is used in calculating the classification scores from the classification functions. When option 14 is exercised, the individual group covariance matrices are used for each group, respectively. In this analysis groups 7, 8 and 9 did not have equal matrices and group 10 did not have enough cases to be accurately tested (p. 329).

The analysis does not discriminate group 4 well, it classifies 16.4% of the group 4 cases in group 1, and 15.7% of the cases in group 2. It also places a few specimens of group 5 in groups 3 and 7 (and vice versa). The overall percent of group cases correctly classified is 84.88%. Of the 15.12% incorrectly classified, at least half are group 4 specimens.

In analysis A-2 option 14 was exercised; this uses the individual group covariance matrices for classification, instead of the pooled within group covariance matrix and is employed when the individual matrices are inhomogenous. The overall classfication results are given in Table 10. The overall percent correctly classified has improved to 89.99%. Most of the improvement is from the group 4 cases, 76% of the group 4 cases have been correctly classified, instead of 62% as in analysis A-1.

The A-2 territorial map (Figure 3) is markedly different from the A-1 map;the centroids for groups 1, 2, 4, and 8 are very close together. Group 9 now falls within group 2, group 7 within group 3, group 1 within group 4, and group 8 within groups 2 and 1.

In analysis A-3 location, coded as 20 dummy variables, was

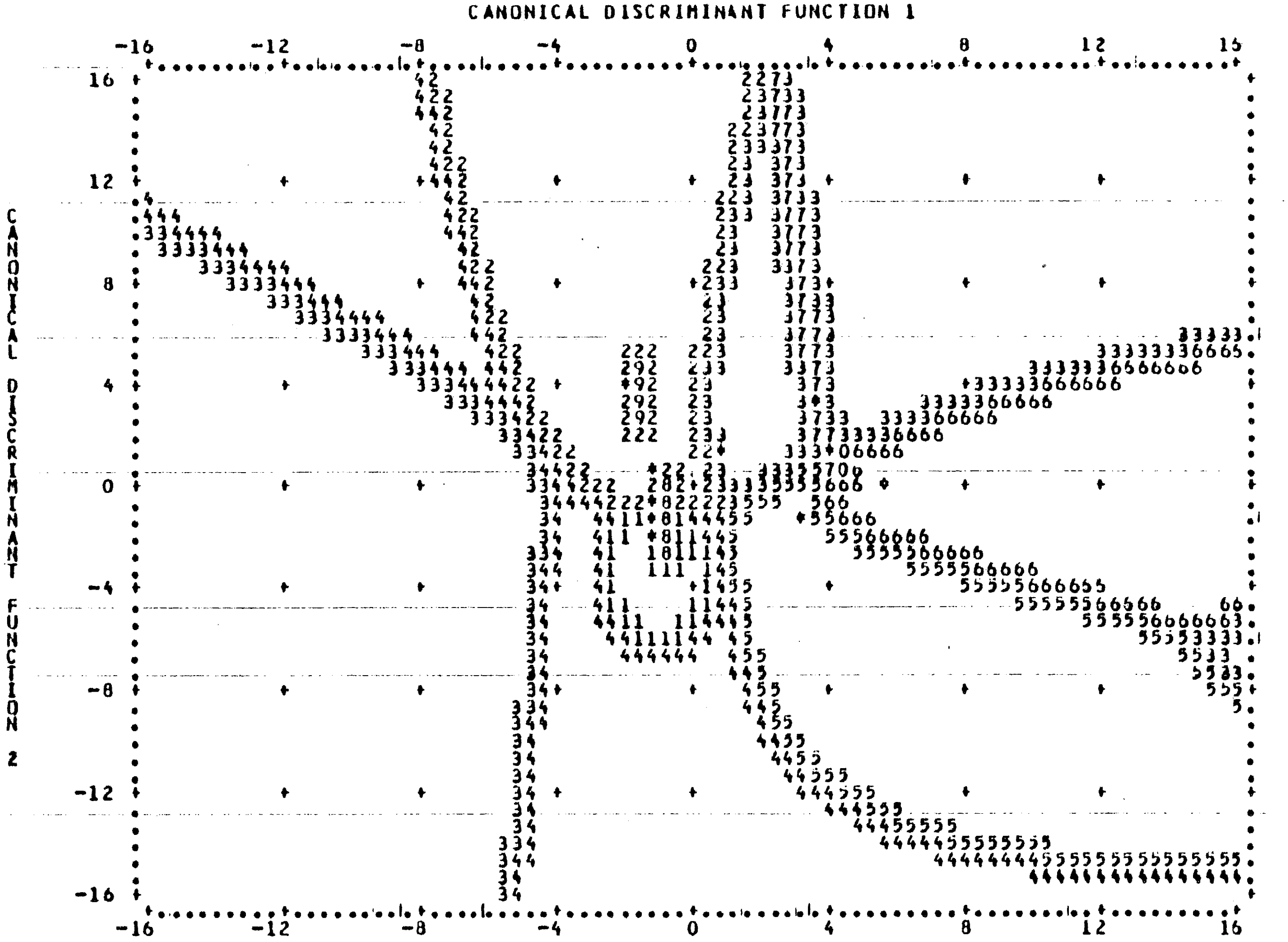


Figure 3: Territorial map, analysis A-2. It is assumed that all functions but the first two are zero. * Indicates a group centroid.

group	no. of specimens	1	2	3	4	5	6	7	8	9	10
1	163	153	3	0	5	1	0	0	1	0	0
		93.9	1.8	0	3.1	.6	0	0	.6	0	0
2	61	3	51	0	5	0	1	0	1	0	0
		4.9	83.6	0	8.2	0	1.6	0	1.6	0	0
3	51	1	3	42	2	1	0	1	0	0	1
		2.0	5.9	82.4	3.9	2.0	0	2.0	0	0	2.0
4	134	8	17	6	103	0	0	0	0	0	0
		6.0	12.7	4.5	76.9	0	0	0	0	0	0
5	46	1	0	1	0	43	0	1	0	0	0
		2.2	0	2.2	0	93.5	0	2.2	0	0	0
6	69	0	0	1	0	0	68	0	0	0	0
		0	0	1.4	0	0	98.6	0	0	0	0
7	20	0	0	0	0	0	0	20	0	0	0
		0	0	0	0	0	0	100	0	0	0
8	67	3	0	0	0	0	0	0	64	0	0
		4.5	0	0	0	0	0	0	95.6	0	0
9	100	1	2	1	0	0	0	0	2	94	0
		1.0	2.0	1.0	0	0	0	0	2.0	94.0	0
10	10	0	0	0	0	0	0	0	0	0	10
		0	0	0	0	0	0	0	0	0	100.0

Table 10: Classification results, analysis A-2. The top number in each square is the actual number of specimens classified in that group, bottom number the percent the above number represents. Overall percent correctly classified - 89.88%

included as an independent variable. Looking at the univariate F ratios (Table 11) some of these dummy variables (i.e., DUM10, DUM12 to DUM15, DUM17 and 18) have significant F-values. However, at some of these locations one group comprises over 80% of the cases and the analysis is in fact discriminating on form. The overall classification results have improved only slightly, to 85.66%.

<u>Group B analyses</u>: To further test the influence of location two analyses were completed with LOC as the dependent variable. FORM was treated as an independent variable. The classification results are quite poor only 55.05% (Table 12). Comparing Tables 8 and 12, it can be seen that the number correctly classified at each location corresponds closely to the dominant group present at each location. Coding FORM as dummy variables (analysis B-2) changes the results only slightly to 54.79%. (In an earlier analysis on LOC, FORM was not included and the results were essentially the same - 54.79%).

<u>Group C analyses</u>: To further determine the relative importance of each independent variable, three analyses were completed on one data set with FORM as the dependent variable but using the STEPWISE method. LOC was not included in analysis C-1. Nine functions were calculated (see Table 13) but the last function was close to not being significant. The univariate F-ratios and Wilks' lambda for each independent variable are given on Table 14. Note that these values are the same as on the bottom of Tables 11 and 16. GSR is the only variable that is not significant at the .01 level. The summary table (Table 15) lists the variables in order in which they were removed. The variables are not removed in order of descending F-values. This is because some of the differences among groups in a variable are

```
WILKS   LAMBDA (U-STATISTIC) AND UNIVARIATE  F-RATIO
WITH    9 AND        711 DEGREES OF FREEDOM

   VARIABLE    WILKS  LAMBDA          F             SIGNIFICANCE
   --------    -------------    -------------      ------------

   DUM1             .95673          3.573               .0002
   DUM2             .95938          3.345               .0005
   DUM3             .95875          3.399               .0004
   DUM4             .95938          3.345               .0005
   DUM5             .93826          5.196                   0
   DUM6             .96135          3.176               .0009
   DUM7             .90707          8.094                   0
   DUM8             .97894          1.699               .0854
   DUM9             .96321          3.018               .0015
   DUM10            .79612          20.23                   0
   DUM11            .95333          3.867               .0001
   DUM12            .73031          29.17                   0
   DUM13            .63608          45.20                   0
   DUM14            .82435          16.83                   0
   DUM15            .62613          47.17                   0
   DUM16            .86726          12.09                   0
   DUM17            .57909          57.42                   0
   DUM18            .71787          31.05                   0
   DUM19            .89003          9.761                   0
   DUM20            .95735          3.519               .0003
   PAP              .44822          97.25                   0
   UMCO             .35113          146.0                   0
   DEUM             .47023          89.00                   0
   P[illegible]R    .25749          227.8                   0
   ADMA             .19494          326.2                   0
   NOBD             .51021          75.84                   0
   PERD             .91139          7.680                   0
   REPO             .29881          185.4                   0
   SUT              .67775          37.56                   0
   CHAM             .51698          73.81                   0
   POSU             .32197          166.4                   0
   D[illegible]PO   .52885          70.38                   0
   POSD             .29697          187.0                   0
   GSR              .97339          2.160               .0230
```

Table 11: Wilks' lambda and univariate F-ratios for the independent variables, analysis A-3.

Table 12: Classification results, analysis B-1. The number to the left of the slash in each square is the actual number of specimens classified into that group. The number to the right of the slash is the percent the actual number represents. Overall percent correctly classified -55.05%.

Group	no. of specimens	1	2	3	4	5	6	7
1	9	8/88.9	0	0	0	0	1/11.1	0
2	12	1/8.3	8/66.7	1/8.3	0	0	1/8.3	0
3	13	2/15.4	0	9/69.2	0	0	0	1/7.7
4	12	3/25.0	0	1/8.3	5/41.7	2/16.7	0	0
5	15	1/6.7	0	1/6.7	2/13.3	10/66.7	1/6.7	0
6	29	2/6.9	1/3.4	1/3.4	1/3.4	1/3.4	11/37.9	1/3.4
7	104	0	5/4.8	1/1.0	3/2.9	6/5.8	6/5.8	33/31.7
8	24	0	1/4.2	0	1/4.2	0	0	1/4.2
9	34	0	2/5.9	1/2.9	1/2.9	0	2/5.9	1/2.9
10	58	0	1/1.7	5/8.6	2/3.4	2/3.4	2/3.4	1/1.7
11	28	0	2/7.1	2/7.1	1/3.6	2/7.1	1/3.6	1/3.6
12	41	2/4.9	0	0	1/2.4	3/7.3	2/4.9	0
13	65	1/1.5	0	0	0	0	0	0
14	32	5/15.6	0	0	2/6.3	1/3.1	3/9.4	1/3.1
15	47	0	0	0	0	0	0	0
16	36	0	0	0	0	0	0	0
17	50	0	0	0	0	0	1/2.0	0
18	78	1/1.3	0	0	0	0	0	3/3.8
19	9	0	0	0	0	0	0	1/11.1
20	25	0	0	0	0	0	2/8.0	0

Group	no. of specimens	8	9	10	11	12	13	14
1	9	0	0	0	0	0	0	0
2	12	0	1/8.3	0	0	0	0	0
3	13	0	0	1/7.7	0	0	0	0
4	12	0	0	0	1/8.3	0	0	0
5	15	0	0	0	0	0	0	0
6	29	0	0	5/17.2	2/6.9	0	0	1/3.4
7	104	6/58	10/9.6	6/5.8	2/1.9	1/1.0	4/3.8	0
8	24	8/33.3	0	1/4.2	5/20.8	0	0	1/4.2
9	34	4/11.8	7/20.6	4/11.8	1/29	0	2/5.9	0
10	58	6/10.8	0	34/58.6	1/1.7	0	0	0
11	28	2/7.1	0	5/17.9	7/25.0	0	2/7.1	0
12	41	4/9.8	0	1/2.4	0	22/53.7	0	0
13	65	0	0	1/1.5	0	4/6.2	53/81.5	0
14	32	0	0	0	0	1/3.1	0	18/56.3
15	47	0	0	0	0	0	0	0
16	36	0	0	0	0	6/16.7	7/19.4	0
17	50	0	0	0	0	0	0	1/2.0
18	78	0	5/6.4	0	1/1.3	1/1.3	7/9.0	1/1.3
19	9	1/11.1	0	0	0	0	0	0
20	25	1/4.0	0	4/16.0	0	1/4.0	0	0

Group	no. of specimens	15	16	17	18	19	20	
1	9	0	0	0	0	0	0	
2	12	0	0	0	0	0	0	
3	13	0	0	0	0	0	0	
4	12	0	0	0	0	0	0	
5	15	0	0	0	0	0	0	
6	29	0	0	0	0	1/3.4	2/6.9	
7	104	0	1/1.0	0	10/9.6	8/7.7	2/1.9	
8	24	0	0	0	0	2/8.3	4/16.7	
9	34	1/2.9	1/2.9	1/2.9	1/2.9	4/11.8	1/2.9	
10	58	0	0	0	0	0	4/6.9	
11	28	1/3.6	0	1/3.6	0	1/3.6	0	
12	41	0	3/7.3	0	1/2.4	0	2/4.9	
13	65	0	3/4.6	0	3/4.6	0	0	
14	32	0	0	0	0	0	1/3.1	
15	47	39/83.0	0	5/10.6	3/6.4	0	0	
16	36	0	16/44.4	0	5/13.9	0	2/5.6	
17	50	9/18.0	0	39/78.0	0	0	0	
18	78	1/1.3	5/6.4	1/1.3	51/65.4	0	1/1.3	
19	9	0	0	0	0	7/77.8	0	
20	25	1/4.0	4/16.0	0	0	0	12/48.0	

```
                                        CANONICAL DISCRIMINANT FUNCTIONS

                       PERCENT OF  CUMULATIVE     CANONICAL   -   AFTER
FUNCTION   EIGENVALUE   VARIANCE    PERCENT      CORRELATION  - FUNCTION  WILKS  LAMBDA  CHI-SQUARED   D.F.  SIGNICANCE

                                                              -    0       .0012499        4736.1      117          0
   1*        5.45389     36.90       36.90       .9192686    -    1       .0080665        3415.0       96          0
   2*        3.85739     26.10       63.00       .8911387    -    2       .0391819        2295.2       77          0
   3*        2.69360     18.22       81.22       .8539678    -    3       .1447222        1369.5       60          0
   4*        1.68264     11.38       92.60       .7919804    -    4       .3882377        670.34       45          0
   5*         .49423      3.34       95.95       .5751154    -    5       .5801153        385.80       32          0
   6*         .29001      1.95       97.91       .4741438    -    6       .7483547        205.38       21          0
   7*         .16270      1.10       99.01       .3740799    -    7       .8701149        98.574       12      .0000
   8*         .12315       .83       99.84       .3311314    -    8       .9772737        16.290        5      .0061
   9*         .02326       .15      100.00       .1507623    -

  * MARKS THE   9 FUNCTION(S) TO BE USED IN THE REMAINING ANALYSIS.
```

Table 13: Statistics for the nine discriminant functions calculated for analysis C-1.

```
WILKS  LAMBDA (U-STATISTIC) AND UNIVARIATE F-RATIO
WITH   9 AND          711 DEGREES OF FREEDOM

  VARIABLE    WILKS  LAMBDA          F            SIGNIFICANCE
  --------    -------------    -------------      ------------

  PAP              .44822           97.25                    0
  UMCO             .35113           146.0                    0
  DEUM             .47023           89.00                    0
  POR              .25749           227.8                    0
  AOMA             .19494           326.2                    0
  NOBO             .51021           75.84                    0
  PERO             .91139           7.680                    0
  REPO             .29881           185.4                    0
  SUT              .67775           37.56                    0
  CHAM             .51698           73.81                    0
  POSU             .32197           156.4                    0
  DEPO             .52885           70.38                    0
  POSQ             .29697           187.0                    0
  GSR              .97339           2.160                .0230
```

Table 14: Univariate F-ratios and Wilks' lambda for the independent variables, analysis C-1.

```
                    ACTION             VARS     WILKS
         STEP  ENTERED  REMOVED         IN      LAMBDA       SIG.

          1    AOMA                      1     .194942          0
          2    POR                       2     .052769          0
          3    REPO                      3     .018151      .0000
          4    UMCO                      4     .006898          0
          5    PAP                       5     .003955          0
          6    NOBO                      6     .002802          0
          7    DEUM                      7     .002237          0
          8    CHAM                      8     .001823          0
          9    SUT                       9     .001560          0
         10    POSU                     10     .001420          0
         11    DEPO                     11     .001322      .0000
         12    POSQ                     12     .001283          0
         13    PERO                     13     .001250      .0000

-------------- VARIABLES NOT IN THE ANALYSIS AFTER STEP  13

                               MINIMUM
VARIABLE     TOLERANCE        TOLERANCE     F TO ENTER     WILKS  LAMBDA

GSR           .9550541        .1342956         .9461           .00123

F LEVEL OR TOLERANCE OR VIN INSUFFICIENT FOR

FURTHER COMPUTATION.
```

Table 15: Summary table for the stepwise analysis C-1.

explained by variables already included in the analysis. GSR was not removed after step 13 (and hence not included in the analysis) because F-to-enter fell below the default value. The classification results have improved only slightly (compared to analysis A-1) and have increased to 85.16% due to the omission of GSR.

In analysis C-2, the relative importance of LOC was examined. Of the 14 variables LOC's F-ratio is twelfth in magnitude (52.16 - see Table 16) but as the variables are removed, the relative values of the F-ratio and Wilks' lambda change; at step 7 LOC had the smallest Wilks' lambda and was removed at this step. At the end of the analysis, after step 14, GSR was the only variable not included (because F-to-enter fell below the default value). Note again that the last variables are exactly the same as on the bottom of Tables 11 and 14. The classification results - 85.30% - improved by only one specimen, (compared to the previous [C-2] analysis).

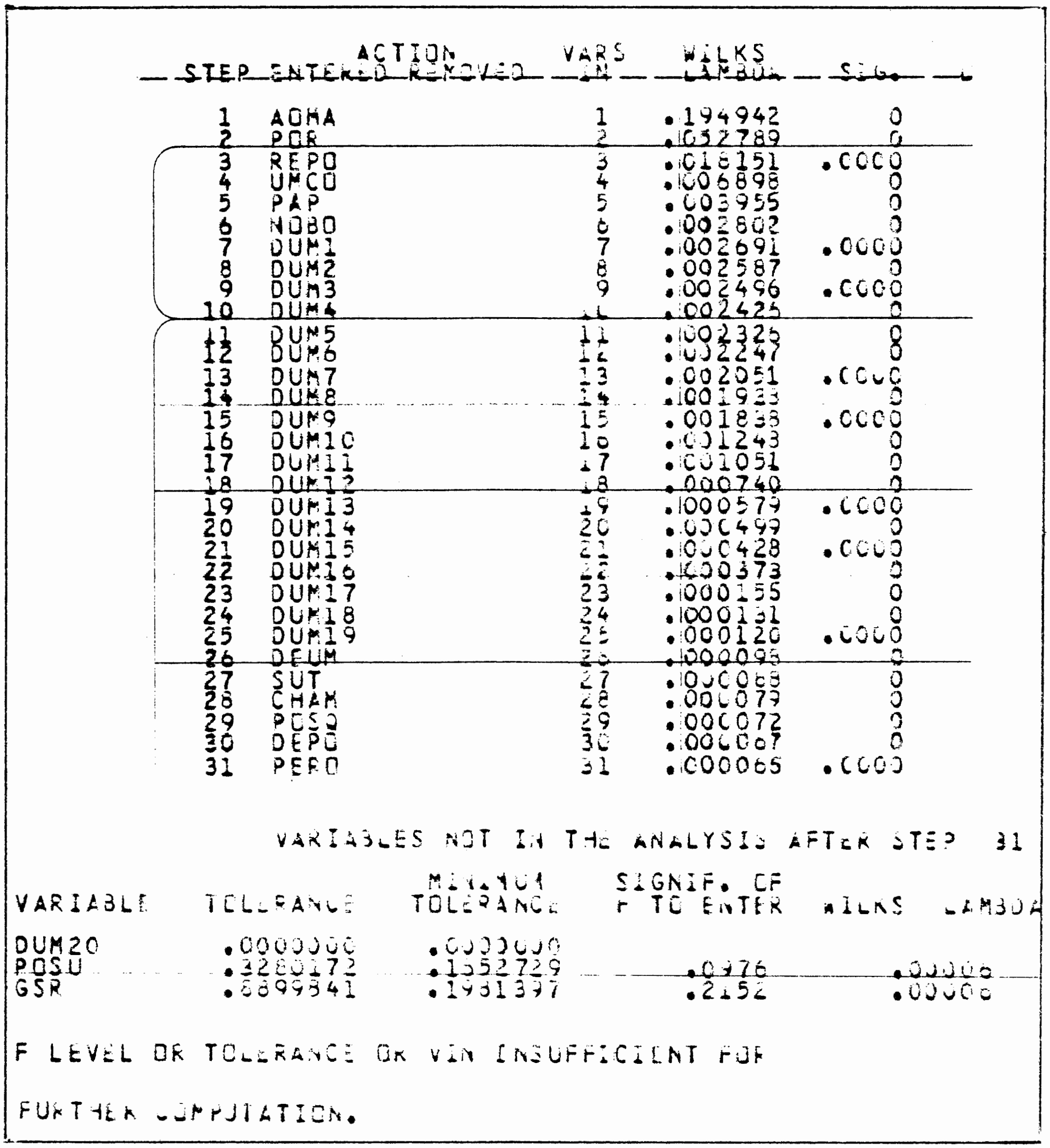
LOC was coded as dummy variables in analysis C-3 and using the ANALYSIS feature, the dummies were removed simultaneously at step 7. The variables removed in steps 1-6 remained the same as in the previous two analyses. The dummy variables were then removed in steps 7 through 26 (DUM1 to DUM19 respectively). DUM20 was not removed, and due to PIN and POUT specifications, DUM20, POSU and GSR were not included in the analyses. A summary is given on Table 17. Coding LOC as dummy variables did improve the classification results by 17 specimens, to 87.66% (see Table 18). Group 4 classification improved the most (16% within that group, followed by group 2 - 9.9% and group 3 - 9.8% within those groups, respectfully).

<u>Group D analysis</u>: The three previous groups of analyses have

WILKS LAMBDA (U-STATISTIC) AND UNIVARIATE F-RATIO
WITH 9 AND 711 DEGREES OF FREEDOM

VARIABLE	WILKS LAMBDA	F	SIGNIFICANCE
LOC	.60233	52.16	0
PAP	.44822	97.25	0
UMCO	.35113	146.0	0
DEUM	.47023	89.00	0
POR	.25749	227.8	0
AOMA	.19494	326.2	0
NOBO	.51023	75.84	0
PERO	.91139	7.680	0
REPO	.29881	185.4	0
SUT	.67775	37.56	0
CHAM	.51698	73.81	0
POSU	.32197	166.4	0
DEPO	.52885	70.38	0
POSQ	.29697	187.0	0
GSR	.97339	2.160	.0230

Table 16: Univarite F-ratio and Wilks' lambda for the independent variables, analysis C-2.



```
                   ACTION               VARS    WILKS
     STEP  ENTERED  REMOVED              IN     LAMBDA      SIG.

       1   ADMA                           1    .194942          0
       2   POR                            2    .032789          0
       3   REPO                           3    .018151      .0000
       4   UMCO                           4    .006898          0
       5   PAP                            5    .003955          0
       6   NOBO                           6    .002802          0
       7   DUM1                           7    .002691      .0000
       8   DUM2                           8    .002587          0
       9   DUM3                           9    .002496      .0000
      10   DUM4                          10    .002425          0
      11   DUM5                          11    .002326          0
      12   DUM6                          12    .002247          0
      13   DUM7                          13    .002051      .0000
      14   DUM8                          14    .001933          0
      15   DUM9                          15    .001838      .0000
      16   DUM10                         16    .001243          0
      17   DUM11                         17    .001051          0
      18   DUM12                         18    .000740          0
      19   DUM13                         19    .000579      .0000
      20   DUM14                         20    .000499          0
      21   DUM15                         21    .000428      .0000
      22   DUM16                         22    .000373          0
      23   DUM17                         23    .000155          0
      24   DUM18                         24    .000131          0
      25   DUM19                         25    .000120      .0000
      26   DEUM                          26    .000095          0
      27   SUT                           27    .000088          0
      28   CHAM                          28    .000079          0
      29   POSO                          29    .000072          0
      30   DEPO                          30    .000067          0
      31   PERO                          31    .000065      .0000

              VARIABLES NOT IN THE ANALYSIS AFTER STEP  31

                               MINIMUM     SIGNIF. OF
VARIABLE    TOLERANCE        TOLERANCE    F TO ENTER   WILKS  LAMBDA

DUM20        .0000000         .0000000
POSU         .3280172         .1552729       .0976          .00006
GSR          .6899841         .1981397       .2152          .00006

F LEVEL OR TOLERANCE OR VIN INSUFFICIENT FOR

FURTHER COMPUTATION.
```

Table 17: Summary table for the stepwise analysis C-3.

group	no. of specimens	1	2	3	4	5	6	7	8	9	10
1	163	153	1	1	5	1	0	0	1	1	0
		93.9	.6	.6	3.1	.6	0	0	.6	.6	0
2	61	4	50	3	3	0	1	0	0	0	0
		6.6	82.0	4.9	4.9	0	1.6	0	0	0	0
3	51	1	2	41	1	3	0	0	0	0	3
		2.0	3.9	80.4	2.0	5.9	0	0	0	0	5.9
4	134	16	15	1	99	1	1	0	0	1	0
		11.9	11.2	.7	73.9	.7	.7	0	0	.7	0
5	46	1	0	0	0	43	1	1	0	0	0
		2.2	0	0	0	93.5	2.2	2.2	0	0	0
6	69	0	0	1	0	0	64	0	1	1	2
		0	0	1.4	0	0	92.8	0	1.4	1.4	2.9
7	20	0	0	0	0	1	1	18	0	0	0
		0	0	0	0	5.0	5.0	90.0	0	0	0
8	67	5	0	0	0	0	0	0	62	0	0
		7.5	0	0	0	0	0	0	92.5	0	0
9	100	1	3	2	0	0	0	0	2	92	0
		1.0	3.0	2.0	0	0	0	0	2.0	92.0	0
10	10	0	0	0	0	0	0	0	0	0	10
		0	0	0	0	0	0	0	0	0	100.0

Table 18: Classification results, analysis C-3. Top number in each square is the actual number of specimens classified in that group, bottom number the percent the above number represents. Overall percent correctly classified, 87.66%.

been performed on only one data set. To test the classification accuracy of the functions the split sample approach was taken. Analysis D-1 was performed to compare the classification results of the two samples. The results of the analysis sample were 83.76% correctly classified. The results of the holdout sample are given on Table 19 - 83.80%. The consistency of the classification results for the two samples indicates that the functions are good discriminators. When option 14 is added (analysis D-2) the percent correctly classified jumps to 89.43% for the analysis sample (comparable to analysis A-2), and to 86.19% for the holdout sample (Table 20). When LOC (as dummy variables) is included as independent variables the results for the analysis sample are 87.28% and for the holdout sample 88.09% (Table 21). Taking this analysis further, using the STEPWISE method, and specifying PIN and POUT at .05 (analysis D-4), the results are 87.28% correctly classified (analysis sample) and 89.04% correctly classified (Table 22-holdout sample). On Table 23, the first 6 variables removed are the same as for analysis C-3. In this instance, DUM20 was not removed from the analysis (unlike analysis C-3) but DUM1 to DUM5 were removed in addition to PERO, POSQ, and GSR (Table 23). Comparing Tables 19 and 22, the improvements in the correctly classified are largest for groups 3, 4 and 6.

Group E analyses: The last three analyses were completed on one data set, containing the 721 *Elphidium excavatum* specimens plus 90 other specimens, comprising of 30 specimens each of *Elphidium subarcticum*, *E. bartletti*, and *Haynesina orbiculare*. Analysis E-1 was completed using the DIRECT method. There are now 12 (i.e. 13-1) discriminant functions, of which the first five account for 95% of the

group	no. of specimens	1	2	3	4	5	6	7	8	9	10
1	48	47	0	0	0	0	0	0	1	0	0
		97.9	0	0	0	0	0	0	2.1	0	0
2	19	2	16	5.3	0	0	0	0	0	0	0
		10.5	84.2	5.3	0	0	0	0	0	0	0
3	16	0	3	8	2	2	0	1	0	0	0
		0	18.8	50	12.5	12.5	0	6.2	0	0	0
4	41	7	7	2	24	0	0	0	0	0	1
		17.1	17.1	4.8	58.5	0	0	0	0	0	2.4
5	13	0	0	0	0	13	0	0	0	0	0
		0	0	0	0	100	0	0	0	0	0
6	22	0	0	0	0	0	19	0	0	0	3
		0	0	0	0	0	86.4	0	0	0	13.6
8	21	1	0	0	0	0	0	0	19	1	0
		5	0	0	0	0	0	0	90	5	0
9	70	0	0	0	0	0	0	0	0	70	0
		0	0	0	0	0	0	0	0	100	0

Table 19: Classification results of the holdout sample, analysis D-1. Top number in each square is the actual number of specimens classified in that group, bottom number the percent the above number represents. Overall percent correctly classified: 83.80%.

group	no. of specimens	1	2	3	4	5	6	7	8	9	10
1	48	45	2	0	1	0	0	0	0	0	0
		93.8	4.2	0	2.0	0	0	0	0	0	0
2	19	1	18	0	0	0	0	0	0	0	0
		5.3	94.7	0	0	0	0	0	0	0	0
3	16	0	4	8	3	1	0	0	0	0	0
		0	25.0	60.0	18.8	6.2	0	0	0	0	0
4	41	1	5	3	32	0	0	0	0	0	0
		2.4	12.2	7.4	78.0	0	0	0	0	0	0
5	13	0	0	0	0	11	2	0	0	0	0
		0	0	0	0	84.6	15.4	0	0	0	0
6	22	0	0	2	0	0	20	0	0	0	0
		0	0	9.1	0	0	90.9	0	0	0	0
8	21	3	0	0	0	0	0	0	18	0	0
		14.3	0	0	0	0	0	0	85.7	0	0
9	70	0	0	1	0	0	0	0	0	69	0
		0	0	1.4	0	0	0	0	0	98.6	0

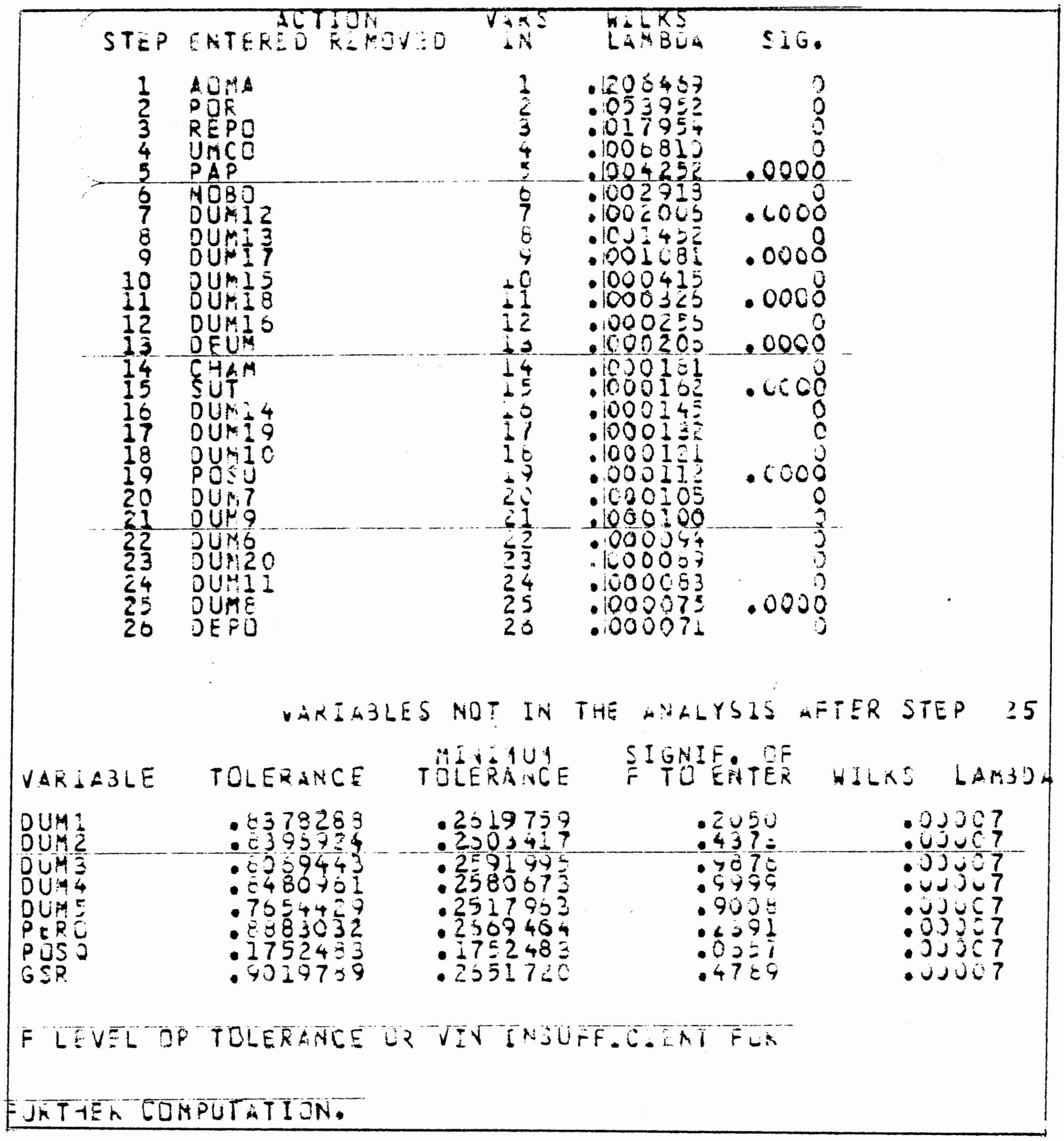
Table 20: Classification results of the holdout sample, analysis D-2. The top number in each square is the actual number of specimens classified in that group, bottom number the percent the above number represents. Overall percent correctly classified: 181/210=86.19%.

group	no. of specimens	1	2	3	4	5	6	7	8	9	10
1	48	46	0	0	1	1	0	0	0	0	0
		95.8	0	0	2.1	2.1	0	0	0	0	0
2	19	1	16	1	1	0	0	0	0	0	0
		5.3	84.1	5.3	5.3	0	0	0	0	0	0
3	16	0	2	12	1	1	0	0	0	0	0
		0	12.5	75	6.2	6.2	0	0	0	0	0
4	41	5	6	1	29	0	0	0	0	0	0
		12.3	14.6	2.4	70.7	0	0	0	0	0	0
5	13	0	0	0	0	13	0	0	0	0	0
		0	0	0	0	100	0	0	0	0	0
6	22	0	0	0	0	0	21	0	0	1	0
		0	0	0	0	0	95.5	0	0	4.5	0
8	21	2	0	0	0	0	0	0	19	0	0
		10	0	0	0	0	0	0	90	0	0
9	70	0	1	1	0	0	0	0	0	68	0
		0	1.4	1.4	0	0	0	0	0	97.2	0

Table 21: Classification results of the holdout sample, analysis D-3. The top number in each square is the actual number of specimens classified in that group, bottom number the percent the above number represents. Overall percent correctly classified: 185/210 = 88.09%.

group	no. of specimens	1	2	3	4	5	6	7	8	9	10
1	48	46	0	0	1	1	0	0	0	0	0
		95.8	0	0	2.2	2.2	0	0	0	0	0
2	19	1	16	1	1	0	0	0	0	0	0
		5.2	84.2	5.2	5.2	0	0	0	0	0	0
3	16	0	2	12	1	1	0	0	0	0	0
		0	12.5	75.0	6.2	6.2	0	0	0	0	0
4	41	6	3	1	31	0	0	0	0	0	0
		14.6	7.3	2.5	75.6	0	0	0	0	0	0
5	13	0	0	0	0	13	0	0	0	0	0
		0	0	0	0	100	0	0	0	0	0
6	22	0	0	0	0	0	22	0	0	0	0
		0	0	0	0	0	100	0	0	0	0
8	21	2	0	0	0	0	0	0	19	0	0
		9.5	0	0	0	0	0	0	90.5	0	0
9	70	0	1	1	0	0	0	0	0	68	0
		0	1.4	1.4	0	0	0	0	0	97.1	0

Table 22: Classification results of the holdout sample, analysis D-4. Top number in each square is the actual number of specimens classified in that group, bottom number the percent the above number represents. Overall percent correctly classified, 193/210 = 89.04%.



```
                ACTION              VARS      WILKS
STEP  ENTERED REMOVED                IN       LAMBDA      SIG.

  1   AOMA                            1      .206469          0
  2   POR                             2      .053952          0
  3   REPO                            3      .017954          0
  4   UMCO                            4      .006810          0
  5   PAP                             5      .004252      .0000
  6   NOBO                            6      .002913          0
  7   DUM12                           7      .002005      .0000
  8   DUM13                           8      .001452          0
  9   DUM17                           9      .001081      .0000
 10   DUM15                          10      .000415          0
 11   DUM18                          11      .000325      .0000
 12   DUM16                          12      .000255          0
 13   DEUM                           13      .000205      .0000
 14   CHAM                           14      .000181          0
 15   SUT                            15      .000162      .0000
 16   DUM14                          16      .000145          0
 17   DUM19                          17      .000132          0
 18   DUM10                          18      .000121          0
 19   POSU                           19      .000112      .0000
 20   DUM7                           20      .000105          0
 21   DUM9                           21      .000100          0
 22   DUM6                           22      .000094          0
 23   DUM20                          23      .000089          0
 24   DUM11                          24      .000083          0
 25   DUME                           25      .000075      .0000
 26   DEPO                           26      .000071          0


                  VARIABLES NOT IN THE ANALYSIS AFTER STEP  25

                             MINIMUM     SIGNIF. OF
VARIABLE     TOLERANCE      TOLERANCE   F TO ENTER    WILKS  LAMBDA

DUM1          .6378268      .2619759       .2050         .00007
DUM2          .6395924      .2503417       .4372         .00007
DUM3          .6069443      .2591995       .9876         .00007
DUM4          .6480961      .2580673       .9999         .00007
DUM5          .7654429      .2517953       .9008         .00007
PERO          .8883032      .2569464       .2391         .00007
POSO          .1752483      .1752483       .0557         .00007
GSR           .9019759      .2651720       .4789         .00007

F LEVEL OP TOLERANCE OR VIN INSUFFICIENT FOR

FURTHER COMPUTATION.
```

Table 23: Summary table for the stepwise analysis D-4.

variance (Table 24). The last function is not significant. The univariate F-ratios and Wilks' lambda are given for each independent variable (Table 25); comparing Table 25 with the same table for analysis A-1 (in Appendix D p. 329) the relative importance of each variable has not changed.

The territorial map for this analysis (Figure 4) is quite different than that for analysis A-1 (see p. 330). The group centroids for B (E. subarcticum) and C (E. bartletti) appear to be superimposed. The centroids for the formae of E. excavatum are spatially, closer together. The maximum distance between any two morphotype centroids is less than from any morphotype centroid to that for the two other Elphidiidae species. The farthest distance is from the Haynesina orbiculare (A) centroid to any morphotype centroid.

The overall classification results (percent correctly classified) are 85.70% (Table 26). The functions have placed one group 2 (E. excavatum f. excavata) and two group 4 (E. excavatum f. lidoensis) specimens into E. subarcticum and one group 4 specimen into E. bartletti. One E. subarcticum specimen has been classed as E. bartletti and three specimens vice versa. All Haynesina specimens have been correctly classified and no specimens incorrectly classed as Haynesina.

Exercising option 14 improved the classification results (analysis E-2, 90.60%).

A STEPWISE analysis was completed to further determine the importance of each independent variable. The variables were removed in the same order (Table 27) as in analysis C-1 (Table 15) except that the importance of REPO decreased, (it came out at step 12 instead of

```
                                   CANONICAL DISCRIMINANT FUNCTIONS

                         PERCENT OF  CUMULATIVE     CANONICAL   -   AFTER
FUNCTION   EIGENVALUE     VARIANCE     PERCENT     CORRELATION  - FUNCTION  WILKS  LAMBDA  CHI-SQUARED   D.F.  SIGNICANCE

                                                                -     0       .0002977      6467.4       168          0
   1*       7.24046        35.89        35.89       .9373620    -     1       .0024532      4787.3       143          0
   2*       5.21434        25.85        61.74       .9160141    -     2       .0152449      3332.2       120          0
   3*       3.51735        17.44        79.17       .8824010    -     3       .0688565      2131.1        99          0
   4*       2.35553        11.73        90.90       .8383734    -     4       .2317723      1164.5        80          0
   5*        .97720         4.84        95.74       .7033189    -     5       .4582614      621.52        63          0
   6*        .31404         1.55        97.30       .4888629    -     6       .6021729      403.99        48          0
   7*        .23638         1.17        98.47       .4372463    -     7       .7445119      234.99        33          0
   8*        .12511          .63        99.10       .3346456    -     8       .8384327      140.39        24      .0000
   9*        .09759          .48        99.58       .2981880    -     9       .9202255      66.218        15      .0000
  10*        .04270          .21        99.79       .2023737    -    10       .9595229      32.911         8      .0001
  11*        .04200          .21       100.00       .2007659    -    11       .9998227      .14125         3      .9865
  12*        .00010          .00       100.00       .0133161    -

     * MARKS THE  12 FUNCTION(S) TO BE USED IN THE REMAINING ANALYSIS.
```

Table 24: Statistics for the 12 discriminant functions calculated for analysis E-1.

```
WILKS  LAMBDA (U-STATISTIC) AND UNIVARIATE F-RATIO
WITH  12 AND          798 DEGREES OF FREEDOM

 VARIABLE     WILKS  LAMBDA          F            SIGNIFICANCE
 --------     -------------     -------------     ------------

 PAP               .45027            81.19             .0000
 UMCO              .32271            139.6             .0000
 DEUM              .41106            95.28             .0000
 POR               .19771            259.9             .0000
 AOMA              .15540            333.1             .0000
 NOBO              .45795            78.71             .0000
 PERO              .85120            11.63             .0000
 REPO              .22609            227.6             .0000
 SUT               .57538            31.96             .0000
 CHAM              .50200            65.97             .0000
 POSU              .24661            203.2             .0000
 DEPO              .35321            121.8             .0000
 POSQ              .22599            227.8             .0000
 GSR               .94089            4.178             .0000
```

Table 25: Wilks' lambda and univariate F-ratios for the independent variables, analysis E-1.

```
          ACTION          VARS     WILKS
STEP ENTERED REMOVED       IN      LAMBDA     SIG.

  1   AOMA                  1    .156397        0
  2   POR                   2    .033531        0
  3   POSQ                  3    .007013        0
  4   UMCO                  4    .002559        0
  5   PAP                   5    .001395        0
  6   NOBO                  6    .000929        0
  7   DEUM                  7    .000654        0
  8   CHAM                  8    .000522        0
  9   SUT                   9    .000445        0
 10   DEPO                 10    .000395        0
 11   PERO                 11    .000357        0
 12   REPO                 12    .000323        0
 13   POSU                 13    .000312        0
 14   GSR                  14    .000295        0
```

Table 27: Summary table for the stepwise analysis E-3.

group	no. of specimens	1	2	3	4	5	6	7	8	9	10	11	12	13
1	163	156	1	0	1	1	0	0	4	0	0	0	0	0
		95.7	.6	0	.6	.6	0	0	2.5	0	0	0	0	0
2	61	7	43	3	3	0	1	0	1	1	0	0	1	0
		11.5	70.5	4.9	4.9	0	1.6	0	1.6	1.6	0	0	1.6	0
3	51	1	3	36	1	4	0	4	0	0	2	0	0	0
		2.0	5.9	70.6	2.0	7.8	0	7.8	0	0	3.9	0	0	0
4	134	22	20	5	80	1	0	0	0	0	2	0	3	1
		16.4	14.9	3.7	59.7	.7	0	0	0	0	1.5	0	2.2	.7
5	46	1	0	0	0	43	0	2	0	0	0	0	0	0
		2.2	0	0	0	93.5	0	4.3	0	0	0	0	0	0
6	69	0	2	1	0	0	63	0	1	0	2	0	0	0
		0	2.9	1.4	0	0	91.3	0	1.4	0	2.9	0	0	0
7	20	0	0	0	0	2	0	18	0	0	0	0	0	0
		0	0	0	0	10.0	0	90.0	0	0	0	0	0	0
8	67	2	0	0	0	0	0	0	64	0	1	0	0	0
		3.0	0	0	0	0	0	0	95.5	0	1.5	0	0	0
9	100	0	0	1	0	0	0	0	3	96	0	0	0	0
		0	0	1.0	0	0	0	0	3.0	96.0	0	0	0	0
10	10	0	0	0	0	0	0	0	0	0	10	0	0	0
		0	0	0	0	0	0	0	0	0	100	0	0	0
11	30	0	0	0	0	0	0	0	0	0	0	27	3	0
		0	0	0	0	0	0	0	0	0	0	90.0	10.0	0
12	30	0	0	0	0	0	0	0	0	0	0	1	29	0
		0	0	0	0	0	0	0	0	0	0	3.3	96.7	0
13	30	0	0	0	0	0	0	0	0	0	0	0	0	30
		0	0	0	0	0	0	0	0	0	0	0	0	100

Table 26: Classification results, analysis E-1. The top number in each square is the actual number of specimens classified in that group, bottom number the percent the above number represents. Overall percent correctly classified: 85.70%.

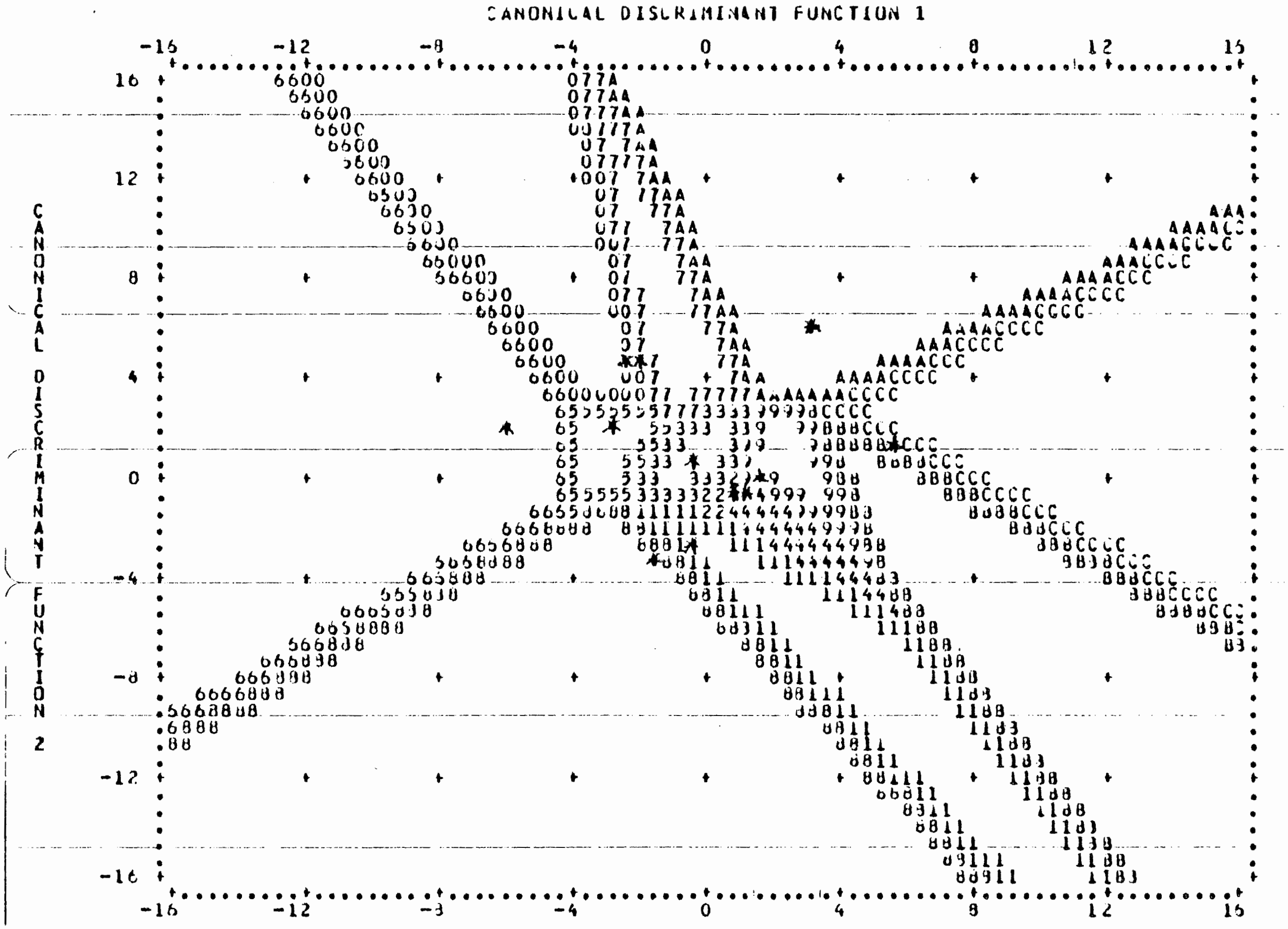


Figure 4: Territorial map, analysis E-1. It is assumed that all functions but the first two are zero. *Indicates a group centroid.

step 3). Reciprocally, POSQ came out at step 3 instead of step 12. GSR was included in the analysis, at the final step, step 14. The classification results (overall percent correctly) remained at 90.60%.

DISCUSSION OF ANALYSIS RESULTS

The overall percent of correctly classified specimens, that is, specimens classified into the group to which they were subjectively assigned, is a measure of how well the functions discriminate the groups based on the information (morphological characteristics, independent variables) supplied. The consistency of these results plus the high percentage of correctly classified specimens for all analysis (84-91%) indicates that the functions are good discriminators, and the independent variables included are good group discriminators.

Group 4, forma *lidoensis*, is not as well defined as the other formae. Many group 4 specimens are incorrectly classified as belonging to groups 1 or 2 in particular. Only 62% of the group 4 specimens are correctly classified in analysis A-1. Of the variables measured, there is no unique combination that exclusively defines group 4. Subsequent observation shows that the feature of the sutures broadening towards the umbilicus is exclusively present in this form and not included in the analysis. Including this feature would probably increase the discriminating power of the functions in relation to group 4.

There are also other patterns to group misclassification. The functions do not discriminate well between groups 1 and 2, groups 3 and 5, and groups 5 and 7. Groups 1 and 2, forma *clavata* and forma excavata are the two most similar formae. The only variable generally present in clavata and absent in excavata is UMCO. The formae are also similar in size and shape. Groups 3 and 5, forma selsevensis and forma magna both have a subacute periphery and a raised umbilicus, as well as similar shape and sizes. They are discriminated on development and regularity of the ponticuli and the umbilical ornamentation. There are similar problems with groups 5 and 7, forma magna and forma galvestonensis. In terms of size and shape they are very similar, only POR and PAP are consistently different, the pores being much denser and finer on galvestonensis and papillae being present more often on this form.

Option 14 was exercised due to non-homogeneity of the individual variance-covariance matrices. The SPSS program test for homogeneity is calculating statistic 7; a test is outlined by Reyment (1962) and some examples given there. The main reason for non-homogeneous variance-covariance matrices in this case is that many of the independent variables are binary or categorical. For a binary variable the mean and standard deviation are directly related. The mean is the proportion of specimens in one of the two categories and the standard deviation is a direct function of this proportion. Unfortunately it is not possible to correct this problem using a simple transformation, but using individual variance-covariance matrices in the classification functions effectively compensates for this. Non-homogeneity is not uncommon for biologic data (Reyment 1962, Scott 1974). Reyment (1962) does point out that non-homogeneity of these matrices, calculated from a sample of microfossils from a single layer of sediment may represent a homogeneous fraction in the development of the species, or it may be a mixture of thousands of generations, depending on the rate of sedimentation incidence of reworking or whether or not the species burrows into the sediment. These causes are unlikely in this case as only samples carefully examined and found lacking evidence of reworking were chosen for inclusion; and all the populations studied were from surface samples and would not represent a large time span paleontologically. The assemblages studied possibly representing a longer time span contained very few specimens from those groups with non-homogeneous matrices.

Another cause of non-homogeneity may be growth invariance (Burnaby 1966, Reyment 1969). Growth invariance is a major factor to be dealt with in multivariate analysis of paleontologic data, particularily for analysis of organisms which do not have a terminal growth size (Burnaby 1966). Though an effort was made to minimize the influence of growth stages by not including variables dependent on growth stage and by choosing only adult specimens. As best as could be ascertained only two variables related to growth, CHAM and GSR, were included in the analysis and these two variables are not solely dependent on growth. Neither CHAM or GSR had significant F values GSR was not included in the STEPWISE analysis.

The importance of LOC (location) as an independent variable was investigated in the group A and B analyses; and the results indicate that LOC is not a factor in correctly classifying specimens. The results improve only very slightly from 84.88% (A-1) to 85.66% (A-3) when LOC, as dummy variables, is included. When LOC is treated as the dependent variable (B-1, B-3) the results are very poor, only 55% correctly classified. There are no patterns between formae present and location, which further strengthens the conclusion drawn from the subjective investigation, that these are not subspecies.

The variables with large partial F-values are the variables which are almost exclusively present or absent within each forma (as determined using the STEPWISE method, group C analyses). These included AOMA (angle of margin), UMCO (presence of an imperforate umbilical collar), POR (density of the porosity) and NOBO (number of bosses). Generally, at least five functions are required to account for 95% of the variance. This indicates that no one variable (or variables) alone discriminate the groups, but various unique combinations of these variables are the best discriminators.

When the split sample approach was used, (group D analyses) the classification results were very consistent, varying no more than 3.5% for the two samples (analysis and holdout) for the four split-sample analyses. This further indicates that the functions are good discriminators.

The Group E analyses investigated the changes in the functions when the taxonomic framework was enlarged by including three other species of Elphidiidae. The results are represented graphically by the territorial map (Figure 4). The group centroids of the E. excavatum morphotypes are spatially closer together than the distance from any morphotype centroid to that for the two other Elphidium species. The farthest distance is from the Haynesina orbiculare centroid to any morphotype centroid. The group centroids for E. subarcticum and E. bartletti appear to be superimposed. These results graphically represent the classification hierarchy derived from subjective taxonomy. Infraspecific distances are smaller than specific ones, which in turn are smaller than generic ones. However the spatially close relationship between E. bartletti and E. subarcticum is probably due to the variables the discrimination is based on; the variables were chosen within the context of E. excavatum and are not good discriminators for these two species. These results do indicate that distances in terms of discriminant function scores may represent distances within the conventional classification hierarchy.

CONCLUSIONS

1) The consistent high value of the overall percent correctly classified indicates the functions calculated are good discriminators; which in turn indicates that the morphological characters observed and included in the analysis are those characteristic of each morphotype and those necessary for defining each form. This is strengthened by the consistency of the split-sample analyses results.

2) Location is not a factor in determining morphotype and there is no pattern between morphotype occurances and geographical location. This strengthens the conclusion from the subjective investigation that these morphotypes are not subspecies but are ecophenotypes (formae).

3) Adding three species to the analysis indicates that the spatial distance (represented graphically) between the group mean scores (centroids) of the first two discriminant functions for any two groups is related to their taxonomic relationship. The infraspecific distance is less than an ecophenotype - species (to E. bartletti or E. subarcticum) distance which is less than an ecophenotype - genera distance (to H. orbiculare). Refinement of the system may make it

possible to determine taxonomic relationships from mean function score differences and graphical distances. This would be a help particularily in determining if variants are species or infraspecific variants; or in determining if variants are local (isolated and unique) versus cosmopolitan.

SUMMARY OF RESULTS

The biological and statistical investigations indicate that *Elphidium excavatum* (Terquem) is a polytypic species comprising at least nine (possibly ten) distinct ecophenotypes (formae). These formae are first subjectively defined and then statistically tested using discriminant analysis. The results show that 84-91% of the specimens are classified into the groups to which they were subjectively assigned. The functions and the morphological characteristics on which the functions are based are good discriminators.

The presence of intergradation, and the lack of a pattern between morphotype occurrences and geographical location indicates that these are ecophenotypes rather than subspecies. The distribution patterns of the formae, however, suggest association with environmental variables rather than simple geographic locality (many formae can live in one area at times). These observations lead to the rejection of the subspecies ranks proposed by Wilkinson (1979) and Haynes (1981). The designation of "forma" has been retained from Feyling-Hanssen (1972) and ten formae can be recognized with the binocular microscope: 1) *E. excavatum* forma *excavata* (= forma *selseyensis* of Feyling-Hanssen) found as a constituent of populations in intertidal zones; 2) forma *williamsoni* is the dominant intertidal/marsh form where there is little wave action; 3) forma *selseyensis* (not sensu Feyling-Hanssen) a temperate to polar water estuarine morphotype; 4) forma *clavata*, the dominant member of the group found in cold normal marine waters or slightly reduced salinities; 5) forma *gunteri*, which appears to replace forma *clavata* in temperate to tropical waters; 6) forma galvestonensis, appearing to be geographically isolated along eastern North America, a tropical, nearshore lagoon form, preferring normal to hyper-salinities; 7) forma lidoensis, a warm to temperate water estuarine and lagoon form; 8) forma cuvillieri appears to be a subtidal temperate to tropical normal marine form; 9) forma tumidum which has been observed only along the western North American coast and 10) forma magna a nearshore, turbulent zone morphotype.

Variablity in the E. excavatum group (number of formae and the percentage of intermediate forms present) appears to increase when each, or a combination of, the following variables is increased: water temperature, proximity to shore, estuarine influence, and the range of annual climatic variation.

The classification results indicate that it is possible to recognize, objectively and consistently, morphotypes within species, and to draw artificial but practical morphological boundaries between morphotypes, in order to identify and classify them, and create workable taxonomic units. With a clearly objectively defined taxonomy, it is possible to compare data from different sources and to draw more concise conclusions about the paleo-ecological implications and significance of the ecophenotypes.

The statistical analysis completed here is a simple procedure with the aid of computational facilities, but the data collection techniques time consuming, elementary, crude, and they introduce operator error. These methods will become obsolete as more sophisticated equipment is developed capable of more complex analyses. Biometry on foraminifera is heavily constrained by inadequate data on shape, particularily chamber shape (Scott 1974). The solution to these problems may be micro-analysers - microcomputer based image analysis systems such as the one described by Granlund and Hermelin (1983). These systems eliminate operator error, minimize the time required for data collection and provide a vastly superior system for collection, storage, and retrieval of morphological data (Granlund and Hermelin 1983).

SYSTEMATIC PALAEONTOLOGY

Identified material was supplied to the author by Prof. G. Lutze, Prof. R. Feyling-Hanssen, Prof. J. R. Haynes, Prof. J. W. Murray, Prof. D. Sloan, Dr. M. A. Buzas, Dr. S. W. Snyder, and Miss R. Todd. Dr. G. Vilks, Dr. C. Schafer, Dr. G. Bartlett and Dr. C. W. Poag assisted the authors with some of the identifications. The primary and secondary specimens of a new forma have been deposited at the Smithsonian Institution together with representative specimens of other formae. In addition, representative collections have been deposited with various persons/departments; a listing is given in Appendix E.

The following collections were examined: primary and secondary types of *Elphidium* and related genera housed at the Smithsonian Institution (including identified material from Dr. A. Lévy and Dr. F. W. Haake); specimens of Natland's at Scripps Institute of Oceanography; and Heron-Allen and Earland's specimens from the shores of Selsey Bill, Sussex, at the British Museum of Natural History.

Listed below, for each forma, is a synonymic list, selected from available references with clear illustrations. Original references are cited, regardless of the clarity of the illustrations.

It must be emphasized that the formae are here described using the conventional format for species, although they all belong to the same species.

In two instances the term "ab" is used (i.e. *Elphidium excavatum* forma *williamsoni* Haynes ab Williamson and *E. excavatum* forma *oceanensis* Fornasini ab d'Orbigny). The term was first used in this sense by Medioli and Scott (in press) and designates a binomen that was first published in a way that did not make it available (e.g. a *nomen nudum*) and only a later work made it available. The author preceeding "ab" is the legal author of the species, but the author following "ab" published the binomen first.

In the synonymies below, figured specimens of one species, recorded in the reference cited may be placed in more than one forma. This has been designated as such: *E. excavatum* forma *clavata*: *E. clavatum* Cushman. BUZAS, 1966, (part), p. 591, pl. 71:1-2; *E. excavatum* forma *selseyensis*: *E. clavatum* Cushman. BUZAS, 1966, (part), p. 591, pl. 71:3-4.

Order FORAMINIFERA	Eichwald, 1830
Suborder ROTALINA	Delage and Herouard, 1896
Superfamily ROTALIACEA	Ehrenburg, 1839
Family ELPHIDIIDAE	Galloway, 1933
Genus ELPHIDIUM	de Montfort, 1808
Type species *Elphidium macellum*	Fichtel and Moll, 1798

Genus *Elphidium*

de Montfort, 1808.

The genus description as published and cited by Loeblich and

Tappan (1964) does not warrent repeating (see also Hansen and Lykke-Andersen [1976], and Rosset-Moulinier [1976]).

However, some debate has arisen as to which genus (*Elphidium*, *Cribroelphidium*, *Cribrononion*) the species *Elphidium excavatum* (Terquem) belongs. The majority of workers have retained it in the genus *Elphidium* (Feyling-Hanssen 1972, Lévy et al. 1975, Hansen and Lykke-Andersen 1976, Rosset-Moulinier 1976). *Elphidium* and *Cribroelphidium* have an areal aperture (which is absent in *Cribrononion*); all three genera have a row of pores at the base of the apertural face. Loeblich and Tappan (1964) differentiate the genera on the presence (in *Elphidium*) or absence (in *Cribroelphidium* and *Cribrononion*) of retral processes; Lévy et al. (1975), Hansen and Lykke-Andersen (1976) and Rosset-Moulinier (1976) report finding retral processes and consequently retain the species in the genus *Elphidium*. There is also the genus *Elphidiononion* described by Hofker (1951) based on *Polystomella poevana* d'Orbigny, in which this author has also placed Heron-Allen and Earlands' species *P. selseyense* (Hofker 1977). Hansen and Lykke-Andersen (1976) consider the three genera *Cellanthus*, *Cribroelphidium* and *Cribrononion* synonymous with *Elphidium*.

Scott and Medioli (1980) have discussed the validity of using the apertures for generic differentiation; they have placed *Cribroelphidium* in synonymy with *Cribrononion*, and have retained the species *E. excavatum* as part of the genus *Cribrononion*, based on differences with the type species of *Elphidium* (also Haman 1973).

As Hansen and Lykke-Andersen (1976) point out, in the past the term "retral process" has had varied definitions. Hansen and Lykke-Andersen (1976) follow Wade's (1957) terminology: returning to Carpenter's (1862, p. 278-279) definition of a retral process as an extention of the chamber lumen found on the inside of the chambers. Often, the term retral process has been applied to include the surrounding wall that spans the suture. Hansen and Lykke-Andersen (1976, p. 4) suggest the term "ponticulus" (Latin: small bridge) to characterize the "sutural bridge" or prolongation of the wall that spans the suture. Thus, a ponticulus may be hollow (if it delineates a retral process), or it may be solid.

Carpenter's (1862) definition of a retral process, and Hansen and Lykke-Andersen's (1976) definition of a ponticulus apply in this work.

Elphidium excavatum (Terquem) forma excavata
Terquem, 1876

pl. 1:1:1; pl. 2:18-20; pl. 3:7-8; pl. 4:10-11; pl. 5: 13-16; pl. 6:8-16, 19; pl. 7:13-16; pl. 8:15-16; pl. 10:6-8,14; pl.12:12; pl.13 :10; pl.14:11-12; ?pl.16: 15; pl. 20:1-12

Polystomella excavata. TERQUEM, 1875, p. 20, pl.2:20f (Non vide, not available). TERQUEM, 1876, p. 429, pl. 2:2a-f. (fide Cushman 1930, 1939; Lévy et al. 1969, 1975; Feyling-Hanssen 1972).

Elphidium excavatum (Terquem). Cushman, 1930, (part), p. 21, pl. 8:1-3. (figures after Terquem). CUSHMAN, 1939, p. 58, pl. 16:7-9 (figures after Terquem). CUSHMAN, 1944, p. 26, pl. 3:40. PARKER, 1952a, p. 412, pl. 5:8. PARKER, 1952b, p. 448, pl. 3:13. LÉVY, 1966, p. 4, pl. 1:8a-b. MURRAY, 1971, p. 159, pl. 66:1, 2, 4, 6, 7. KNUDSEN, 1973b, p. 279, pl. 2:3. LÉVY ET AL., 1975, p. 176-178, text-fig. 9 (figures after Terquem), pl. 3:1, 2, 5, 6. ROSSET-MOULINIER, 1976, (part), p.38, pl. 2:14-15. KNUDSEN, 1979, (part), p. 208-209, pl. 1:15-18; pl. 5:1-2.

Elphidium transluscens. NATLAND, 1938, p. 144, pl. 5:3-4. CUSHMAN, 1939, p. 65, pl. 20:7a-b. BANDY, 1953, p. 176, pl. 22:9a-b. PARKER ET AL., 1953, p. 9, pl. 3:27. PHLEGER, 1954, p. 639, pl. 2:10. TODD and BRONNIMAN, 1957, p. 39, pl. 7:6a-b. TODD and LOW, 1961, p. 20, pl. 2:4. PHLEGER and EWING, 1962, p. 178, pl. 4:7. PHLEGER, 1964, p. 388, pl. 2:1.

Elphidium incertum (Williamson). PHLEGER and WALTON, 1950, (part), p. 277, pl. 2:17, 18.

Elphidium incertum (Williamson) var. clavatum Cushman. PHLEGER, 1952b, p. 83, pl. 14:10.

Elphidium hispidulum Cushman. TODD and BRÖNNIMANN, 1957, p. 39, pl. 2:1.

Elphidium poeyana (d'Orbigny). LANKFORD, 1959, p. 2083, pl. II:5a-b.

Elphidium spinatum Cushman and Valentine var. transluscens Natland. UCHIO, 1960, p. 62, pl. 4:23, 24.

Elphidium selseyense (Heron-Allen and Earland). HAAKE, 1962 (part), p. 49, pl. 6:1. JONES and ROSS, 1979, text-fig. 7:A-B.

Elphidium clavatum Cushman. LOEBLICH and TAPPAN, 1953, (part), p. 98, pl. 19:9-10. HANSEN, 1965, p. 325, text-figs. 5:6. BRODNIEWICZ, 1965, (part), p. 210-213, pl. 10:3. KNUDSEN, 1971b, p. 273, pl. 20:5-6

Elphidium cf. clavatum Cushman. MICHELSEN, 1967, p. 237-238, pl. 4:7a-b.

Cribrononion excavatum (Terquem). HAAKE, 1967, (part), p. 13-27, pl. 1:4-5. LÉVY ET AL., 1969, p. 93, pl. 1:1-3 (figures after Terquem); pl. 1:4.

Elphidium incertum (Williamson) variant. MURRAY, 1968, p. 83-96, pl. 1:7a-b.

Cribrononion incertum (Williamson). VON DANIELS, 1970, p.88, pl. 7:12.

Elphidium excavatum (Terquem) forma selseyensis (Heron-Allen and Earland). FEYLING-HANSSEN, 1972, p. 341, pl. 5:1-4. KNUDSEN, 1976, p. 431-449. FEYLING-HANSSEN, 1976b, p. 177. FEYLING-HANSSEN, 1976c, p. 355. MILLER, 1979, p. 33, pl. 1:1-2, pl. 2:1-2, pl. 3:1, pl. 4:4-5, pl. 5:4-5. SNYDER and KATROSH, 1979, p. 254, pl. 1:1-2. SLOAN, 1981, p. 275, pl. 1:5. KNUDSEN, 1982, p. 170, fig. 14:14:5-6.

Cribroelphidium spinatum var. transluscens (Natland). SCOTT, 1976, p. 170. SCOTT ET AL., 1976, p.74.

Cribroelphidium excavatum selseyensis (Heron-Allen and Earland). SCOTT, 1977, p. 170, pl. 6:3. SCOTT ET AL., 1977, p. 1579, pl. 5:3.

Elphidium excavatum forma clavata Cushman. KNUDSEN, 1978, (part) p. 34, pl. 5:4.

Elphidium clavatum nudum. WILKINSON, 1979, p. 638, pl. 1:6, pl. 2:8.

Cribrononion excavatum forma selseyensis (Heron-Allen and Earland). SCOTT and MEDIOLI, 1980, p. 35, pl. 5:6. SCOTT ET AL., 1980, p. 228.

Elphidium ex gr. excavatum (Terquem). Elphidium excavatum (Terquem) sensu stricto. HAYNES, 1981, p. 61-62, pl. 8:9.

Elphidium sp. group B. CANN and DE DEKKER, 1981, (part), p. 663-664, pl. 1:3-5, 17.

Elphidium excavatum forma excavata (Terquem). MILLER ET AL., 1982, p. 128-130, pl. 1:9-12, pl. 2:1-2, pl. 3:1-2, pl. 4:13-16, pl. 5:15-16, pl. 6:6-8, 14.

Elphidium excavatum (Terquem) forma alba Feyling-Hanssen. KNUDSEN, 1982, p. 170, fig. 14:12:5, fig. 14:14:8-9.

Types:

Holotype: Polystomella excavata (specimen lost) Terquem, 1875, p. 20, pl. 2:2a-f, (not available, private publication of the author; fide Ellis and Messina, 1940). Terquem, 1876, p. 429, pl. 2:2a-f (repeat of the 1875 MS).

Deposited in: Musee de Dunkerque, France.

Neotype: Elphidium excavatum (Terquem). Lévy et al., 1975, p. 176-178, pl. 3:1-2 No. FG 447.

Neoparatypes: No. FG 448.

Deposited in: l'Institute de Paleotologie du Museum National d'Historie Naturelle de Paris.

Topotype: Elphidium excavatum (Terquem). Levy et al., 1975, p. 176-178, pl. 3:5-6, also topotypes deposited at the Smithsonian Institution, USNM No. 343319.

Types of junior synonyms:

Elphidium transluscens:

Holotype: Natland, 1938, p. 144, pl. 5:3-4, USNM No. 22549.

Paratype: USNM No. 23332.

Deposited in: Smithsonian Institution.

Representative plesiotype: Miller, 1979, pl. 4:4, pl. 5:4; Miller et al. 1982, pl. 1:10; USNM No. 312511.

Diagnostic characteristics: Generally small, though larger than forma clavata, and with chambers more lobate and sutures straighter, extending unconstricted into the umbilicus. Elphidium excavatum forma excavata generally has a greater pore density than E. excavatum forma clavata; giving the test a hazy appearance. The pore perforations extend to the umbilicus. It is interesting to note that Terquem used for this species the epithet excavata (excavated umbilicus?).

Description: As described by Feyling-Hanssen in 1972 (E. excavatum forma selseyensis), and Lévy et al. in 1975 (E. excavatum).

Maximum Diameters: 0.35 mm - 0.55 mm (Terquem 1876, p. 429); 0.25 mm - 0.65 mm (Lutze, 1965, text-fig. 8); 0.38 mm - 0.66 mm (Bartlett, 1965b, p. 17).

Remarks: Elphidium excavatum forma excavata (Terquem) is the name retained for the original specimens described by Terquem (Polystomella excavata) and the neotype of Lévy et al., 1975.

Feyling-Hanssen (1972) indicates that many European workers (among them van Voorthuysen 1960, Brodniewicz 1965, Hansen 1965, Lutze 1968) grouped this form E. excavatum forma excavata with E. clavatum (= E. excavatum forma clavata). Some workers included it in synonomy with E. selseyense (= E. excavatum forma selseyensis), among them Brand 1941, Haake 1962, Lévy et al. 1969, Feyling-Hanssen 1972.

Many European workers were following the lead of Cushman's (1930, 1939, 1949) and identifying a form that appears to be the "species" of Williamson, Polystomella umbilicatula 1858 = (E. williamsoni Haynes, 1973) as E. excavatum (i.e. van Voorthuysen 1957, 1960, Richter 1961, 1964a, 1964b, 1967, Jarke 1961, Woszidlo 1962, Haake 1962, 1967, Feyling-Hanssen 1964, Brodniewicz 1965, and Murray 1965a, 1968, 1970). Lutze (1968) Murray (1971) and Haynes (1973) have all commented on the confusion arising from Cushman's work, and they too placed Cushman's E. excavatum in synonymy with Williamson's taxon.

As pointed out by Wilkinson (1979), Terquem's original material was lost, and Lévy et al. (1975) , designated a neotype (E. excavatum of Lévy et al. = E. excavatum forma excavata).

Rodrigues and Hooper (1982) suggest that of the three specimens of Polystomella excavata illustrated by Terquem (1875, 1876), one (Pl. 2:2c-d) was of Polystomella umbilicatula. Of Lévy et al.'s (1975) specimens of E. excavatum Rodrigues and Hooper (1982) refer the neotype (1975, Pl. 3:1-2) and topotype (1975, Pl. 3:5-6) to P. striatopunctata var. selseyense, thus they do not believe E. excavatum sensu Terquem and E. excavatum sensu Lévy et al. to be conspecific. After examining the Heron-Allen and Earland collection at the British Museum, and topotypic material of Lévy's at the Smithsonian Institution, the conclusion is reached that Lévy's material is not P. striatopunctata var. selseyense (sensu Heron-Allen and Earland). Rodrigues and Hooper's (1982) suggestion that Terquem included E.

williamsoni in his species may be correct; but they base this on the observations of an umbilical boss (in one) and ponticuli on the periphery (on both) of Terquem's two illustrations. Some specimens observed here have an umbilical boss and/or ponticuli on the periphery and yet have been attributed to *E. excavatum* forma *excavata*, not *E. excavatum* forma *williamsoni* (i.e. pl.6:12,15, pl. 20: 3,5,6,8; also Miller et al., 1982, Pl. 1:10, Pl.2:2, Pl. 4:14). The other suggestion of Rodrigues and Hooper's (1982), that *E. excavatum* sensu Terquem and *E. williamsoni* Haynes are conspecific, is not a new observation (it was made by van Voorthuysen in 1957). It must be remembered, however, that what van Voorthuysen (1957) identified as *E. excavatum* has been listed in synonymy as *E. williamsoni* by Lutze 1968, Murray 1971 and Haynes 1973. Because Terquem's material has been lost, it is suggested here that 1) the concept of *E. excavatum* s.s. (or forma *excavata*) be based on Lévy et al.'s neotype; 2) the concept of forma *williamsoni* be based on Williamson's and Haynes' "species", and 3) the concept of forma *selseyensis* be based on Heron-Allen and Earland's "species".

Here, *Elphidium transluscens* Natland is considered a junior synonym.

Distribution: The form as described here has often been placed in synonymy with either *E. excavatum* forma *clavata* or forma *selseyensis*, or confused with *E. excavatum* forma *williamsoni* (=*E. williamsoni* Haynes ab Williamson), and consequently the distribution of this form is difficult to determine. It appears to be a nearshore form becoming slightly more common in intertidal and shallow subtidal environments.

Elphidium excavatum forma williamsoni Haynes, 1973, ab Williamson, 1858.

pl. 6:17-18; pl. 9:1-16; pl. 12:19; pl. 17:1-12;
?pl. 18:17; pl. 19:16-17; pl. 22:1-24

?Polystomella articulata. d'Orbigny, 1839b, p. 30, pl. 3:9, 10 (fide Murray, 1971).

Polystomella umbilicatula. WILLIAMSON, 1858, p. 42-44, pl. 3:81-82. (non Nautilus umbilicatula Walker and Jacob). TERQUEM, 1875, p. 25, pl. 2 : 3a-b. (fide Lévy et al., 1969; Haynes, 1973). TERQUEM, 1876, p. 429 (fide Lévy et al., 1969; Haynes, 1973).

Polystomella striatopunctata (Fichtel and Moll) variety. HERON-ALLEN and EARLAND, 1909, (part), p. 695, pl. 21:2a-c.

Nonionina depressula Walker and Jacob sp. HERON-ALLEN and EARLAND, 1909, (part), p. 692.

Polystomella striatopunctata (Fichtel and Moll) var. selseyensis. HERON-ALLEN and EARLAND, 1911, (part), p. 448.

Elphidium excavatum (Terquem). CUSHMAN, 1930, (part), p. 21, pl. 8:4-7. HERON-ALLEN and EARLAND, 1932, p. 439, pl.16:21-23. CUSHMAN, 1939, p. 58, pl. 16:10 (figure after Williamson), pl.16:11-12. CUSHMAN, 1949, p. 28, pl. 6:2a-b (fide Haynes, 1973). VAN VOORTHUYSEN, 1957, p. 31, pl. 23:8a-b. VAN VOORTHUYSEN, 1960, p. 255. JARKE, 1961, p. 21-36, pl. 2:2. RICHTER, 1961, p. 163-170, pl. 1. TODD and LOW, 1961, p. 19, pl. 2:5. HAAKE, 1962, (part), p. 47-48, pl. 5:5. WOSZIDLO, 1962, p. 74-75, pl. 3:8. FEYLING-HANSSEN, 1964,

p. 344, pl. 20:7-8. RICHTER, 1964a, p. 343-353, text-fig. 3-4. ADAMS and FRAMPTON, 1965, p. 58, pl. 5:7. BRODNIEWICZ, 1965, p. 214, pl. 7:5, pl. 11:4. MURRAY, 1965a, p. 513, pl. 1:6, 6 (fide Haynes, 1973). MICHELSEN, 1967, p. 238, pl. 5:2. RICHTER, 1967, p. 291-335. MURRAY, 1968, p. 83-96, pl. 1:12a-b. HAMAN, 1969, p. 139-142 (Hamen, 1981, pers. comm.). MURRAY, 1970, p. 484. BOLTOVSKOY and VIDARTE, 1977, (part), p. 38, pl. 2:12.

Elphidium articulatum (d'Orbigny). CUSHMAN, 1930, p. 22, pl. 10:6-8. BANDY, 1953, p. 176, pl. 22:5a-b. MURRAY, 1971, pl. 153, pl. 63:1-7. KNUDSEN, 1973a, p. 188, pl. 3:13. KNUDSEN, 1973b, p. 278, pl. 2:2. KNUDSEN, 1976, p. 431-449. ROSSET-MOULINIER, 1976, p. 89, pl. 1:1-4. APTHORPE, 1980, (part), p. 225, p. 2:6. BOLTOVSKOY ET AL., 1980, p. 29, pl. 13:1-4.

Elphidium alvarezianum (d' Orbigny). HERON-ALLEN and EARLAND, 1932, p. 440, pl. XVI:24-25.

Cribroelphidium cf. *koeboense* (LeRoy). LEHMANN, 1957, p. 348, pl. 2:21-24.

Elphidium clavatum Cushman. JARKE, 1961, p. 21-36, pl. 2:2. BRODNIEWICZ, 1965, (part), p. 210-213, pl. 10:2, 4, 7.

Ephidium sp. 1. HAAKE, 1962, pl. 5:9.

Cribrononion cf. *alvarezianum* (d'Orbigny). LUTZE, 1965, p. 101-102, pl. 15:4-6.

Elphidium oceanicum (Cushman). LÉVY, 1966, p. 5, pl. 1:2a-b.

Elphidium kusiroense Asano. MATOBA, 1967, p. 254, pl. 27:9a-b.

Elphidium aff. *semistriatum* (d'Orbigny). CITA and PREMOLI-SILVA, 1967, (part), p. 35, pl. 2:10.

Elphidium sp. CITA and PREMOLI-SILVA, 1967, (part), pl. 2:14-15.

Cribrononion excavatum (Terquem). HAAKE, 1967, (part), p. 13-27, pl. 1:7-8.

Cribrononion articulatum (d'Orbigny). LUTZE, 1968, p. 27, pl. 1:1-2.

Elphidium umbilicatulum (Williamson). LÉVY ET AL., 1969, p. 96, pl. 1:6, pl. 2:1-2. KNUDSEN, 1971b, p. 281-282, pl. 13:8-11, pl. 23:1-4.

Cribroelphidium articulatum (d'Orbigny). ROSSET-MOULINIER, 1972, p. 176, pl. 14:1-5.

Elphidium incertum (Williamson). SHEENAN and BANNER, 1972, p. 31-40, pl. 1 1-5.

Elphidium williamsoni. HAYNES, 1973, p. 207, pl. 24:7, pl. 25:6, 9, pl. 27:1-3. HANSEN and LYKKE-ANDERSEN, 1976, p. 9, pl. 5:1 - 6. CULVER and BANNER, 1978, p. 53-72. KNUDSEN, 1979, p. 210, pl. 1:19, pl. 5:6-7. MURRAY, 1979, p. 52, fig. 16:C-D. SCOTT and MEDIOLI, 1980, p. 40, pl. 5:4. SCOTT ET AL., 1980, p. 228. KNUDSEN, 1982, p. 170, fig. 14:12:19, fig. 14:14:10-11.

Elphidium hughesi Cushman and Grant. BERGEN and O'NEILL, 1976, p. 1290, pl. 1:1-2.

Cribroelphidium excavatum (Terquem). SCOTT, 1977, p. 169, pl. 6:1. SCOTT ET AL., 1977, p. 1578, pl. 5:4.

Elphidium sp. group A. CANN and DE DEKKER, 1981, p. 663, pl. 1:7-16, 18-23.

Elphidium ex gr. excavatum (Terquem). *Elphidium williamsoni* Haynes. HAYNES, 1981, p. 61-62, pl. 8:11.

Types:

Holotype: _Polystomella umbilicatula_, (non _Nautilus umbilicatulus_, Walker and Jacob); Williamson, 1858, p. 42-44, pl. 3.:81-82.

Hypotypes: _Elphidium williamsoni_ Haynes, 1973, p. 207-209, pl. 24:7, pl. 25:6, 9.

Deposited in: British Museum - Natural History, Stub 1970:II:26:597; slide 197 0:II:26:431:432; sections 1970:II:26:507, 1970:II:26:508.

Types of junior synoynms:

?_Polystomella articulata_.

Holotype: lost-d'Orbigny, 1839b, p. 30, pl. 3:9, 10.

Deposited in: ? Laboratoire de Paleontologie du Museum de l'Histoire Naturelle, Paris.

Representative plesiotype: pl.21:1-2.

Diagnostic characteristics: An inflated, rotund form, with smooth peripheral outline and rounded periphery. A flat umbilicus on each side, chambers extending completely to the umbilicus; a boss/papillae may be present. Ponticuli very regular and well developed, covering up to half the chamber width. Wall very finely and densely perforate.

Description: As described by: Williamson (_Polystomella umbilcatula_) in 1858, Haynes (_E. williamsoni_) in 1973, and Hansen and Lykke-Andersen (_E. williamsoni_) in 1976.

Maximum diameters: Diameter 0.48 mm, width approx. 0.20 mm (Haynes, 1973, p. 208).

Remarks: The specific name williamsoni was suggested by Haynes, (1973) for the inflated, many chambered marsh and estuarine species first referred to by Williamson (1858, p. 42-44, Pl.3:81-82) as Polystomella umbilicatula (Walker and Jacob) and widely referred to by many European workers as Elphidium excavatum (Terquem) (i.e.: van Voorthuysen 1957, 1960, Jarke 1961, Richter 1961, 1964a, 1964b, 1967, Woszidlo 1962, Haake 1962, 1967, Feyling-Hanssen 1964, Brodriewicz 1965, and Murray 1965a, 1968, and 1970). Lévy et al. (1969) refer to this marsh species as E. umbilicatula (Williamson) but, as pointed out by Haynes (1973) this latter designation contravenes Article 49 of the ICZN (Stoll et al. 1961) because Williamson placed his species in synonymy with Nautilus umbilicatulus Walker and Jacob, a species clearly distinct from his. Consequently, Haynes suggested the designation E. williamsoni, a nomen novum (ICZN, Appendix E, Paragraph 21; Stoll et al. 1961) for this form because it was clearly Williamson's species. The epithet williamsoni has been followed here. However, Haynes designated his own material as holotype of the new nominal species; thus contravening Article 72D of the ICZN (Stoll et al. 1961) which specifically states that in this case Williamson's specimen should have been designated as holotype. Consequently, Williamson's specimen is designated here as the only valid holotype; and Haynes' specimens (holotype and paratypes) should be demoted to hypotypes. Haynes (1981) included this form in the E. excavatum "polytypic species" group.

Rodrigues and Hooper (1982) are of the opinion that Terquem's original concept of E. excavatum included E. williamsoni.

This species has also been referred to as Elphidium articulatum (d'Orbigny). The relationship between E. articulatum and E. williamsoni is very confusing in the literature and there are many contradictory opinions.

E. articulatum was described by d'Orbigny (1839b) from the coast of Patagonia and the Falkland Islands. Williamson (1858, p. 43) remarked on the similarity between his species and d'Orbigny's figure of P. articulata, stating that the only difference between the two was that d'Orbigny described his specimens as having numerous septal apertures dispersed irregularly over the entire plane, instead of being confined to a single row as in his specimens.

Cushman (1930) distinguished between E. articulatum and E. excavatum (=E. williamsoni?) and maintained the distinction later.

Heron-Allen and Earland (1932) also reported finding E. articulatum from the Falkland Islands - and distinguished it from E. excavatum. Heron-Allen and Earland reported some confusion about the type when they examined d'Orbigny's collection in Paris. The specimen identified there as P. articulata was sharp edged with 12 chambers and in their opinion (p. 439-440) was possibly P. flexosa.

Parker (1952a) considers E. articulatum closely related to E. bartletti Cushman, and that young specimens of the two are identical. Parker says (1952a, p. 411): "A comparison with specimens from the

Falkland Islands shows the Portsmouth species to be almost identical although slightly less compressed." She further states: "It is possible that E. bartletti represents the Arctic development of E. articulatum which is not reported from that area." Loeblich and Tappan (1953, p. 98) report that d'Orbigny's type figure shows a sharp, acutely angled periphery, rather than the broadly rounded periphery of all other specimens referred to his species, and present in E. bartletti.

Haynes (1973), regards the type specimen of E. articulatum as lost but says that the type figure of E. articulatum shows a lobate species with inflated chambers, small septal pits, and areal apertures, which is different from the flat sided E. excavatum with sutural bridges. These observations of the type figure are in agreement with the concept of E. bartletti.

Rosset-Moulinier (1976, p. 89) has examined topotypic material (i.e. from the Falklands and Patagonia) of E. articulatum supplied by Boltovskoy and states E. articulatum is conspecific with E. williamsoni.

Murray (1982 pers. comm.) examined the d'Orbigny collection in Paris in the early 1960's and said that the state of preservation of the specimen was so poor as to render it useless.

Haynes (1982 pers. comm.) has suggested that the name E. articulatum be regarded as a nomen dubium; and due to the conflicting opinions in the literature on the concept of E. articulatum, Haynes suggestion has been taken here. The only unambiguous epithet for this form is williamsoni Haynes ab Williamson.

Distribution: A widely distributed form, extensively documented in the literature. Reported from shallow subtidal and intertidal zones in outer estuaries, lagoons, tidal flats and in particular marshes, where the salinity is near normal and there is no wave action, only tidal flux. It is the dominant Elphidium in intertidal areas of marshes along the European and North American (particularly north of New York) Atlantic seaboards. It is also found in glacio-fluvial and post-glacial late Pleistocene-Holocene sediments (i.e. Knudsen 1979), and has been reported as far back as the Eemian in Europe (van Voorthuysen 1957).

Elphidium excavatum (Terquem) forma *selseyensis*
Heron-Allen and Earland, 1911 (emended Brand, 1941)

pl.1:2:2; pl.7:1; pl. 8: 10-13; pl.10: 9-13; pl.11:15;
pl.12:14-15; pl.13: 12-15; pl.14: 8-9, 18; pl. 22: 1-9

Polystomella striatopunctata (Fichtel and Moll) variety. HERON-ALLEN and EARLAND, 1909, (part), p. 695, pl. 21:2a-c.

Nonionina depressula Walker and Jacob *sp*. HERON-ALLEN and EARLAND, 1909 (part) p. 92.

Polystomella striatopunctata (Fichtel and Moll) var. *selseyensis*. HERON-ALLEN and EARLAND, 1911 (part), p. 448.

Elphidium incertum (Williamson). CUSHMAN and COLE, 1930, p. 96, pl. 13:6,7. CUSHMAN, 1930, (part), p. 18, pl. 7:5, 8, 9. CUSHMAN, 1944, p. 25, pl. 3:28-31. PHLEGER and WALTON, 1950, (part), p. 277, pl. 2:17, 18. SCHNITKER, 1971, p. 198, pl.7:4a-b.

Elphidium incertum (Williamson) var. *clavatum* Cushman. CUSHMAN and COLE, 1930, p. 96, pl. 13:8-9. CUSHMAN, 1944, p. 25, pl.3:32-33. PARKER, 1952a, (part), p. 412, pl. 5:10-11. TODD and BRÖNNIMANN, 1957, (part), p. 39, pl. 6:10.

Elphidium brooklynense. SHUPACK, 1934, p. 10, opp. p. 9, figs. 7a-b.

Elphidium discoidale (d'Orbigny). SHUPACK, 1934, p. 11, opp. p. 9, figs. 9a-b.

Elphidium gunteri Cole. SHUPACK, 1934, (part), p. 11, opp. p. 9, figs. 6-b. CUSHMAN, 1944, p. 27, pl. 3:42. TODD and LOW, 1961, p. 19, pl. 2:10.

Elphidium clavatum Cushman. SHUPACK, 1934, p. 11, opp. p. 9, figs. 8a-b. WEISS, 1954, p. 159, pl. 32:14. BUZAS, 1965b, (part), p. 58-59, pl. 2:6-7, pl. 3:1-2. SCHNITKER, 1971, p. 198, pl.7:5a-b.

Elphidium selseyense (Heron-Allen and Earland). CUSHMAN, 1939, p. 59-60, pl. 16:26-27 (figures after Heron-Allen and Earland). RICHTER, 1961, p. 163-170, pl. 1. HAAKE, 1962, (part), p. 49, pl. 5:12-15; pl. 6:2-4. RICHTER, 1964a, p. 343-353, text-fig. 5. ATKINSON, 1969, p. 538. MURRAY, 1970, p. 484. HAMAN, 1973, p. 134. HAYNES, 1973, (part), p. 204-205, pl. 22:3-4, pl. 26:4, 7, 9, pl. 29:1-3. CULVER and BANNER, 1978, p. 53-78.

Elphidium incertum selseyensis (Heron-Allen and Earland). BRAND, 1941, p. 65-66. FEYLING-HANSEN, 1954, p. 142, pl. 2:12a-b.

Elphidium tumidum Natland. CUSHMAN and TODD, 1947, (part), p. 14, pl. 2:21.

Cribroelphidium limnosum. CUSHMAN and BRÖNNIMANN, 1948, p. 19, pl. 4:7. TODD and BRÖNNIMANN, 1957, p. 39, pl. 16:13.

Elphidium incertum (Williamson) variants. PARKER, 1952b, (part), p. 448, pl. 3:14, 17, pl. 4:1-2.

Elphidium gunteri Cole var. galvestonense Kornfeld. BANDY, 1954, (part), p. 136, pl. 30:2.

Elphidium florentinae Shupack. WEISS, 1954, p. 159, pl. 32:8-11.

Elphidium strattoni (Applin) var. joaquinensis. BANDY and ARNAL, 1957, p. 55, pl 7:6.

Elphidium vadescens (Cushman and Bronnimann). TODD and BRÖNNIMANN, 1957, p. 39, pl. 7:10-11.

Elphidium galvestonense Kornfeld. TODD and LOW, 1961, p. 19, pl. 2:9.

Elphidium longipontis Stschedrina. BRODNIEWICZ, 1965, (part), p. 213, text-fig. 33, pl. 7:5, 7, 8.

Cribrononion excavatum (Terquem). HAAKE, 1967, (part), p. 13-27, pl. 1:6, 10-11.

Elphidium excavatum (Terquem). BOLTOVSKOY and BOLTOVSKOY, 1968, (part), p. 148, pl. 1:16a-b. BANNER and CULVER, 1978, p. 177-207, pl. 9:12-14.

Cribroelphidium selseyense (Heron-Allen and Earland). BACHHUBER and MCCLELLAND, 1977, p. 259, text-fig. 3:B.

Elphidium selseyense (Heron-Allen and Earland). HOFKER, 1977, p. 257, pl. 8:8-9, pl. 9:1.

Elphidium clavatum selseyense (Heron-Allen and Earland). WILKINSON, 1979, p. 638, pl. 1:5.

Elphidium excavatum forma album (Feyling-Hanssen). POAG ET AL., 1980, pl. 1:9.

Elphidium articulatum (d'Orbigny). APTHORPE, 1980, (part), p. 225, pl.28:7.

Elphidium ex gr. excavatum (Terquem). Elphidium selseyense (Heron-Allen and Earland). HAYNES, 1981, p. 61-62, pl. 8:13.

Elphidium excavatum forma selseyensis (Heron-Allen and Earland). MILLER ET AL., 1982, p. 132-133, pl. 1:13-16, pl. 5:10-13, pl. 6:9-13. KNUDSEN, 1982, (part), p. 170, fig.:14:12:11-12, fig.:14:14:7.

Types:

(?)Syntypic series: Polystomella striatopunctata (Fichtel and Moll) var. Heron-Allen and Earland, 1909, p. 695, pl.21:2a-c.

Deposited in: Heron-Allen and Earland collection, (from Selsey Bill, Sussex), British Museum (Natural History), slide nos: 51, 54, 56, 57, 61, 65, 66, 67.

Lectotype: designated by Brand, 1941, p. 66, as: Polystomella striatopunctata variety selseyensis Heron-Allen and Earland, 1909, p. 695, pl. 21:2a, 2c; not 2b.

Metatype, (possible syntype): designated by Banner and Culver, 1978, as: Elphidium excavatum pl. 9:12-14.

Deposited in: Heron-Allen and Earland collection, British Museum (Natural History), BM(NH) No. ZF3833.

Types of junior synonyms:

Elphidium brooklynense.

Holotype: Shupack, 1934, p. 10, opp. p.9:7a-b

Deposited in: American Museum of Natural History (New York) No. 695

Cribroelphidium limnosum.

Holotype: Cushman and Brönnimann, 1948, p. 19, pl. 4:7

Deposited in: Cushman Collection, Smithsonian Institution, USNM No. 56645.

Paratype: USNM No. 56747 (as above).

Elphidium strattoni (Applin) var. *joaquinensis*.

Holotype: Bandy and Arnal, 1957, p. 55-56; pl. 7:6.

Deposited in: Smithsonian Institution, USNM No. 237448.

Representative plesiotype: pl. 8:13, USNM No. 312512.

Diagnostic characteristics: Test generally larger than *E. excavatum* forma *clavata* and forma *excavata*; the peripheral outline is smooth to lobate, with a subacute periphery. The test thicker is through the umbilicus, consequently the umbilicus appears raised. Sutures slightly backwards curved or straight; with irregular indistinct to strongly developed ponticuli and often papillae filling the sutures. The umbilicus contains papillae, or bosses (irregular lateral extensions of the chambers), or both.

Description: As described by: Heron-Allen and Earland (*P. striatopunctata* variety) in 1932 and Haynes in 1973 (*E. selseyense*).

Maximum Diameters: 0.43 mm (Haynes, 1973, p. 205); 0.25 mm - 0.64 mm (Lutze, 1965, text-fig. 8).

Remarks: The name *E. excavatum* forma *selseyensis* is retained for the specimens described by Heron-Allen and Earland (1909, 1911), collected from the shores of Selsey Bill. There are two species of particular interest in their collection: *Polystomella striatopunctata* (Fichtel and Moll) variety *selseyensis*, and *Nonionina depressula* Walker and Jacob variety *selseyensis*. Specimens of the former, in the opinion of the author, actually belonged to two formae, most specimens are *Elphidium excavatum* forma *williamsoni*, the remainder are forma *selseyensis* (Heron-Allen and Earland) (this work). Most specimens of the latter species appeared to the author to be formae of *Elphidium excavatum*, mainly forma *selseyensis*. The remaining specimens appeared not to belong to the genus *Elphidium*. It should be noted that Heron-Allen and Earland did not designate any "type" specimens of their new variety of *Polystomella striatopunctata*; and although there are specimens in the collection labelled *Nonionina depressula* var. *selseyensis*, in the 1909 publication Heron-Allen and Earland refer only to "*Nonionina depressula* Walker and Jacob sp." (p. 692).

Brand (1941) published an emended description of this species and he designated Heron-Allen and Earland's 1909 figure (Pl. 21:2a, 2c; not 2b) as lectotype.

The *E. excavatum* forma *selseyensis* described here does not include the form described by Feyling-Hanssen (1972) as *E*. *excavatum* forma *selseyensis*.

Haynes (1973) presents SEM photographs of specimens which "closely resemble" (Haynes, 1973, p. 205) those collected by Heron-Allen and Earland and housed in the British Museum (*E*. *selseyense* of Haynes, 1973).

Banner and Culver (1978, Pl. 9:12-14) illustrate a specimen of *E*. *excavatum* which is a metatype (possible syntype) identified by

Heron-Allen and Earland as Polystomella striatopunctata variety selseyensis. This specimen (# ZF3833) illustrated by Banner and Culver (1978) is considered here to belong to Elphidium excavatum forma selseyensis.

Haynes, (1981) included this form in his E. excavatum "polytypic species" group.

Junior synonyms of this form are: Elphidium brooklynense Shupack (1934), Elphidium strattoni var. joaquinensis Bandy and Arnal, (1957), and Cribroelphidium limnosum Cushman and Bronnimann (1948).

Distribution: Preliminary observations indicate that E. excavatum forma selseyensis occurs nearshore, especially in shallow, temperate waters (reaching 10-15oC) under estuarine influence along European and North American coastlines.

Elphidium excavatum (Terquem) forma clavata
Cushman, 1930 (emended, Loeblich and Tappan, 1953).

pl.1:1:3; pl.2:1-8, 9-17; pl. 3:1-6, 9-12; pl. 4:1, 6-9, 13-14; pl. 5:1-7; pl. 6:3-6; pl. 7:4-9; pl. 8: 4-8, 14; pl. 9:18; pl. 10:1-5; pl. 11:5-8; pl. 12: 11; pl. 13:3-5, 8-9, 16; pl. 14:4-5, 13-14; pl. 23: 1-21.

Elphidium incertum (Williamson) var. clavatum. CUSHMAN 1930, p. 20, pl. 7:10a-b. CUSHMAN, 1939, p. 57, pl. 16:1a-b. CUSHMAN, 1948, p. 57, pl. 6:8. VAN VOORTHUYSEN, 1949, p. 65, pl. 1:4b-c. PHLEGER, 1952a, p. 83, pl. 14:10.

Elphidium incertum (Williamson). CUSHMAN, 1939, p. 57, pl. 15:23-24. TEN DAM and REINHOLD, 1941, p. 52, pl. 3:8a-b. PARKER, 1948, p. 248, pl. 5:7. PHLEGER, 1952a, p. 83, pl. 14:7. WEISS, 1954, p. 159, pl. 32:7. ADAMS and FRAMPTON, 1965, p. 58, pl. 5:6. SLOAN, 1981, p. 281, pl. 2:1a-b.

Elphidium incertum (Williamson) and variants. PARKER, 1952b, (part), p. 448, pl. 3:16.

Elphidium clavatum Cushman. LOEBLICH and TAPPAN, 1953, (part), p. 98, 101- 102, pl. 19:8. WEISS, 1954, (part), p. 159, pl. 32:13. TODD and LOW, 1961, (part), p. 18, pl. 2:1. ANDERSON, 1963, p. 315. COOPER, 1964, p. 95-96, pl. 6:5-7. BRODNIEWICZ, 1965, (part), p. 210-213, pl. 10:1, 6, 7, 8. BUZAS, 1965a, p. 23, pl. 3:3a-b. NAGY, 1965, p. 124, pl. 2:21 (fide Feyling-Hanssen, 1972). BUZAS, 1966, (part), p. 591, pl. 7:1-2, 5-8. MATOBA, 1967, p. 254, pl. 27:8a-b. MICHELSEN, 1967, p. 236-237, pl. 4:6a-b. TODD and LOW, 1967, p. A33. MURRAY, 1969, (part), p. 416. MATOBA, 1970, p. 51, pl. 6:11a-b. KNUDSEN, 1971b, p. 273, pl. 11:10-13, pl. 20:7-8. SCHNITKER, 1971, (part), p. 198. SEN GUPTA, 1971, p.89, pl. 2:28-29. BARTLETT and MOLINSKY, 1972, p. 1204-1215, pl. 1:1a-b. CULVER and BANNER, 1978, p. 56. BERGEN and O'NEIL, 1979, p. 1290, pl. 1:5-6. LAGOE, 1979a, p. 260, pl. 1:3, 5, 6. RODRIGUES and HOOPER, 1982, (part), p. 411-416, text-fig. 2:G-P, text-fig. 3:A-P.

Elphidium incertum clavatum Cushman. FEYLING-HANSSEN, 1954, p. 141, pl. 2:11. BOLTOVSKOY, 1954, p. 275, pl. 24:7. PHLEGER, 1960b, pl. 5:11. FEYLING-HANSSEN, 1964, p. 345, pl. 20:11-15. COLE and FERGUSON, 1975, p. 21, pl. 7:9-10.

Elphidium incertum incertum (Williamson). FEYLING-HANSSEN, 1954, p. 141, pl. 2:10. FEYLING-HANSSEN. 1964, p. 344, pl. 19:16-17.

Elphidium selseyense (Heron-Allen and Earland). HAAKE, 1962, (part), p. 49-50, pl. 6:1. WOSZIDLO, 1962, p. 74-75, pl. 3:10.

Elphidium excavatum (Terquem). TODD and BRÖNNIMANN, 1957, (part), p. 39, pl. 6:12. MURRAY, 1971, p. 159, pl. 66:3, 5. HANSEN and LYKKE-ANDERSON, 1976, p. 10, pl. 6:1-6. BUZAS ET AL., 1977, p. 95. BOLTOVSKOY and VIDARTE, 1977, p. 38, pl. 2:11-12. SCHAFER and COLE, 1978, p. 27, pl. 9:7. KNUDSEN, 1979, (part), p. 208-209, pl. 1:13-14, pl. 4:6-7, pl. 5:3-6. COLE, 1981, p. 100, pl. 15:1-12.

Elphidium incertum (Williamson) "COMPLEX". BARTLETT, 1965b, p. 14, pl. 1:4-12.

Cribrononion excavatum excavatum (Terquem, 1875). LUTZE, 1965, p. 96, pl. 15:39.

Cribrononion excavatum clavatum (Cushman, 1930). LUTZE, 1965, p. 96, pl. 15:40-41.

Elphidium clavatum Cushman "Complex". GREGORY, 1970, p. 226, pl. 14:1.

Elphidium incertum (Williamson) forma clavatum Cushman. WAGNER, 1970, p. 24, pl. 2:3-5.

Elphidium excavatum (Terquem) forma clavata Cushman. FEYLING-HANSSEN, 1972, p. 339, pl. 1:1-9, pl. 2:1-9. KNUDSEN, 1973a, p. 188, pl. 5:4. FEYLING-HANSSEN, 1976a, p. 92, fig. 8:13-14. FEYLING-HANSSEN, 1976b, p. 177. FEYLING-HANSSEN, 1976c, p. 355. KNUDSEN, 1976, p. 431-449, pl. 2:14-17. KNUDSEN, 1977, text-fig. 7:15-18, text-fig. 8:5-6. KNUDSEN, 1978, (part), p. 34, pl. 3:3-5, pl. 5:1-3. MILLER, 1979, p. 27, pl. 1:3 -8, pl. 2:3-8, pl. 3:2-8, pl. 4:1-3, 6-16, pl. 5:1-3, 6-8, pl. 6:9-16. MILLER ET AL., 1982, p. 124-127, pl. 1:5-8, pl. 2:3-8, pl. 3: 3-8, pl. 4:1-6, pl. 5:4-8, 14, pl. 6:1-5. VILKS ET AL., 1982, pl. 1:18. KNUDSEN, 1982, p. 170, fig. 14:12:6-8, fig. 14:12:1-4.

Elphidium excavatum (Terquem) forma alba. FEYLING-HANSSEN, 1972, p. 340, pl. 3:1-9. FEYLING-HANSSEN, 1976c, pl. 4:4. VILKS ET AL., 1982, pl. 1:16-17.

Cribroelphidium sp. cf. C. clavatum (Cushman). LANKFORD and PHELEGER, 1973, p. 117, pl. 3:24.

Cribroelphidium excavatum clavatum Cushman. SCOTT, 1977, p. 169, pl. 6:2.

Elphidium clavatum clavatum Cushman. WILKINSON, 1979, p. 634, pl. 1:1.

Elphidium clavatum subclavatum Gudina. WILKINSON, 1979, p. 639, pl. 1:2.

Elphidium clavatum terminatum. WILKINSON, 1979, p. 639, pl. 1:7, pl. 2:2-4.

Elphidium clavatum lobatalum. WILKINSON, 1979, p. 637, pl. 1:3, pl. 2:7.

Elphidium excavatum (Terquem) forma clavatum Cushman. POAG ET AL., 1980, pl. 1:12.

Cribrononion excavatum (Terquem) forma clavatum Cushman. SCOTT and MEDIOLI, 1980, p. 35, pl. 5:5. SCOTT ET AL., 1980, p. 228.

Elphidium excavatum forma lidoensis Cushman. SLOAN, 1981, p. 277, pl. 1:6.

Elphidium ex gr. excavatum (Terquem). E. clavatum Cushman. HAYNES, 1981, p. 61-62, pl. 8:8.

Types:

Holotype: Elphidium incertum (Williamson) variety clavatum. Cushman, 1930, p. 20, pl. 7:10a-b.

Deposited in: Cushman Collection, Smithsonian Institution, USNM No. 10403.

Hypotypes: Elphidium clavatum Cushman. Loeblich and Tappan, 1953, p. 98, 101-102, pl. 19:8-10.

Deposited in: Smithsonian Institution, USNM Nos. P2024a-b, P2025.

Representative plesiotype: Miller, 1979, pl. 1:4, pl. 2:4; Miller et al., 1982, pl. 1:5, pl. 2:4, pl. 3:4; USNM No. 36-312510

Diagnostic characteristics: Generally: small, disc-shaped, orange-brown translucent form; often with an umbilical boss, and always with an imperforate (complete or incomplete) collar surrounding the umbilicus. The sutures are generally backwards curved, with few narrow often incomplete, ponticuli. It is interesting to note that Cushman named this form clavatum (clavical, from collar? from imperforate collar?).

Description: As described by: Loeblich and Tappan (E. clavatum) in 1953 and Feyling-Hanssen (E. excavatum forma clavata) in 1972.

Maximum diameters: 0.23 -0.77 mm (Loeblich and Tappan, 1953, p. 98); 0.17 - 0.48 mm (Feyling-Hanssen, 1964, p. 187; 1972, p. 345); 0.34 - 0.84 mm (Bartlett, 1965b, p. 16)

Remarks: The name *Elphidium excavatum* forma *clavata* is retained for the small disc-shaped, orange-brown translucent form figured by Cushman (1930, p.20, Pl. 7:10). However, Cushman's description may cover not only forma *clavata*, but forma *selseyensis* and forma *magna* as well.

Haake (1962) was the first to consider *E. clavatum* a junior synonym of *E. selseyense*.

Brodniewicz (1965) pointed out first that Cushman may have been describing two forms. Cushman's collection at the Smithsonian includes specimens belonging to four formae (*clavata*, *excavata*, *magna* and *selseyensis*) under the name *E. incertum* var. *clavatum*. Forma *clavata* was elevated to specific rank by Loeblich and Tappan (1953), and first designated an ecophenotype of *Elphidium excavatum* by Feyling-Hanssen (1972). Four of Wilkinson's (1979) subspecies are considered junior synonyms. Haynes (1981) included it in his *E. excavatum* "polytypic species" group.

Distribution: *Elphidium excavatum* forma *clavata* is the central member of this *E. excavatum* group; it is reported in recent and Holocene sediments from estuaries, nearshore zones, bays, and continental margins from the high arctic to tropical environments. It is perhaps best known for its occurrence (where it is often dominant) in Weichselian (Wurm-Wisconsin) pro-glacial, interstadial and late glacial deposits (Feyling-Hanssen 1972). However, it did not first appear in the Weichselian; it has been recorded as far back as the earliest marine Pleistocene on both sides of the Atlantic (e.g. Snyder and Katrosh 1979, van Voorthuysen 1949, 1951)

Elphidium excavatum (Terquem) forma gunteri Cole, 1931

pl. 11:17-18; pl. 12:16-18; pl. 13:1-2; pl. 14:1-3;
pl.15:8-15; pl. 17:13-15; pl. 18:1-3; pl. 24:1-24.

?Polystomella oceanensis. FORNASINI, 1904, p. 13, pl. 3:10 (ab d'Orbigny, 1826, p. 285; described but not illustrated or figured). Elphidium gunteri. COLE, 1931, p. 34, pl. 4:9, 10 (fide Parker et al., 1953). CUSHMAN, 1939, p. 49-50, pl. 13:10 (figure after Cole). PARKER ET AL., 1953, p. 8, pl. 3:18-19. PARKER, 1954, (part), p. 508, pl. 6:16. PHLEGER, 1954, p. 639, pl. 2:3-4. BANDY, 1956, (part), p. 194, pl. 30:19a-b. LEHMANN, 1957, p. 348, pl. 3:1-3. VAN VOORTHUYSEN, 1957, p. 32, pl. 23:11a-b. LANKFORD, 1959, p. 2083, pl. II:7 a-b. PARKER and ATHEARN, 1959, p. 342, pl. 50 :36. PHLEGER, 1960a, p. 277, pl. 3:6,22, pl. 4:12. PHLEGER, 1960b, pl. 7:18; pl. 9:1,17. VAN VOORTHUYSEN, 1960, p. 255. HAAKE, 1962, p. 48, pl. 5:3-4. RICHTER, 1964a, p. 343-353, text-fig. 7. LÉVY, 1966, p. 4, pl. 1:1a-b. CITA and PREMOLI-SILVA, 1967, p. 35-46, pl. 2:4-5. BOLTOVSKOY and BOLTOVSKOY, 1968, (part), p. 148, pl. 1:15a-b. LÉVY ET AL., 1969, p. 94. KNUDSEN, 1971b, p. 277, pl. 12:9, 10; pl. 21:4-7. 1973b, p. 279, pl. 2: 5. ROSSET-MOULINIER, 1976, p. 92, pl. 1:10, 11; pl. 2:1-4. BUZAS ET AL., 1977, p. 95. KNUDSEN, 1979, p. 209, pl. 6:4-7. SNYDER and KATROSH, 1979, pl. 2:1-2. BOLTOVSKOY ET AL., 1980, p. 30, pl. 13:1 5-18. SLOAN, 1981, p. 285, pl. 2:4a-b.

BUZAS and SEVERIN, 1982, p. 37, pl. 8:4.

Elphidium gunteri var. galvestonense. KORNFELD, 1931, (part), p. 87, pl. 15:2a-3b. CUSHMAN, 1939, p. 60, pl. 16:25 (figure after Kornfeld). PHLEGER, 1951, p. 46. PHLEGER and PARKER, 1951, p. 10, pl. 5:13-14. BANDY, 1954, (part), p. 136, pl. 30:2a-b.

Elphidium oceanense (d'Orbigny). CUSHMAN, 1939, p. 56, pl. 15:8a-b (figures after Fornasini ab d'Orbigny).

Cribroelphidium trinitatense. CUSHMAN and BRÖNNIMANN, 1948, (part), p. 20, pl. 4:8.

Elphidium littorole. LE CALVEZ and LE CALVEZ, 1951, p. 251, fig. 5:a-b.

Elphidium guntheri (sic) var. waddensis. VAN VOORTHUYSEN, 1951, p. 25, pl. 2:16a-b.

Elphidium rugulosum Cushman and Wickenden. BANDY, 1956, p. 194, p. 30:21a, b.

Elphidium trinitatense (Cushman and Brönnimann). TODD and BRÖNNIMANN, 1957, p. 39, pl. 7:12.

Elphidium tumidum Natland. PHLEGER and EWING, 1962, p. 178, pl. 4:18.

Elphidium oceanensis (d'Orbigny). MURRAY, 1968, p. 83-96, pl. 1:10a-b. MURRAY, 1971, (part), p. 165, pl. 69:3-7. BOLTOVSKOY and VIDARTE, 1977, p. 38, pl. 3:1. MURRAY, 1979, p. 52, fig. 16:A-B. APTHORPE, 1980, pl. 28:1-2.

Elphidium cf. reticulosum Cushman. MATOBA, 1970, p. 52, pl. 6:12a-b.

Elphidium sagra (d'Orbigny). TODD and LOW, 1971, p. C16, pl. 3:7a-b. SYNDER and KATROSH, 1979, pl. 2:3.

Cribroelphidium gunteri (Cole). ROSSET-MOULINIER, 1972, p. 178, pl.

18:1-5.

Elphidium waddense van Voorthuysen. HAYNES, 1973, p. 206-207, pl. 24:4,10, pl. 26:1, pl. 28:10-11. CULVER and BANNER, 1978, p. 53-72.

Elphidium guntheri (sic) Cole. HANSEN and LYKKE-ANDERSEN, 1976, p. 12, pl. 8:10-12, pl. 9:1-3.

Elphidium vadescens (Cushman and Brönnimann). HANSEN and LYKKE-ANDERSEN, 1976, p. 12, pl. 7:12, pl. 8:1-9.

Elphidium gunteri Cole forma salsum. POAG, 1978, (part), p. 402, pl. 2:11-12.

Elphidium gunteri Cole forma typicum. POAG, 1978, p. 402, pl. 2:13-16. POAG, 1981, p. 61, pl. 37:1, pl. 38:1a-1b.

Cribrononion gunteri (Cole). PRIME, 1980, p. 30, pl. 1:13.

Cribrononion granulosum (d'Orbigny). ALBANI and SERANDREI BARBERO, 1982, p. 238, pl. 1:3.

Types:

Holotype: Elphidium gunteri. Cole, 1931, p. 34, pl. 4:9-10.

Deposited in: Florida State Geological Museum, S-2103.

Hypotypes: designated by Parker et al., 1953, p. 8, as: Elphidium gunteri variety galvestonense Kornfeld, 1931, (part), p. 87, pl. 15:2a-3b.

Deposited in: Stanford University Paleontological Type Collection, types no. 689 and 692 (microspheric form).

Types of junior synonyms:

?Polystomella oceanensis:

Original designation: Fornasini, 1904, p. 13, pl. 3:10 (ab d'Orbigny, 1826, p. 285; described but not illustrated or figured).

Deposited in: ? Laboratoire de Paleontologie du Museum de l'Histoire Naturelle, Paris. (no designated type specimen, Y. Le Calvez, pers. comm. to Hansen and Lykke-Andersen, 1976).

Cribroelphidium trinitatense:

Holotype: Cushman and Brönnimann, 1948, p. 20, pl. 4:8, USNM No. 56646.

Paratype: USNM No. 56748.

Deposited in: Cushman Collection, Smithsonian Institution.

Elphidium guntheri (sic) var. *waddensis*:

Holotype: van Voorthuysen, 1951, p. 25, pl. 2:16a-b.

Deposited in: Netherlands Geological Survey, Haarlem, no. F. 1810.

Elphidium littorole.

Holotype: Le Calvez and Le Calvez, 1951, p. 251, fig. 5a-b.

Deposited in: not given.

Representative plesiotype: pl. 15:9, pl. 24:1-3.

Diagnostic characteristics: A small to medium sized *Elphidium*, rather rotund, with a coarsely perforate wall. The sutures are straight, not depressed, and marked by many regular, raised, rectangular shaped ponticuli, often longer than the chambers are wide. The umbilicus contains papillae/irregular bosses (irregular lateral extensions of the ponticuli and chambers).

Description: As described by Cole in 1931 (E. gunteri).

Maximum diameters: diameter 0.44 mm, thickness 0.26 mm (Cole, 1931, p. 34); 0.35 - 0.43 mm (Kornfeld, 1931, p. 87, microspheric form); diameter 0.39 mm, thickness 0.18 mm (van Voorthuysen, 1951, p. 25).

Remarks: E. excavatum forma gunteri is the name retained for the round, thick, coarsely perforate form described from the Pliocene of Florida by Cole (1931). The type locality was later determined to be Pleistocene in age (Poag 1978). Included in this morphotype is the microspheric form of E. gunteri var. galvestonense described by Kornfeld (1931). The holotype of E. gunteri cannot be found at the moment and Buzas and Culver (1981 pers. comm.) suggest that one of Kornfeld's specimens (#692, designated as a hypotype of E. gunteri by Parker et al. 1953) become the neotype of E. gunteri.

Feyling-Hanssen (1972, p. 344) remarked on the similarity between E. gunteri and E. excavatum forma lidoensis; but he pointed out that they could be separated on the basis of the distinct rectangular and numerous sutural bridges (gunteri) and the broading of the sutures towards the umbilicus (lidoensis).

Poag (1978) splits E. gunteri into two ecophenotypes, forma salsum and forma typicum. Those he assigns to forma typicum are specimens with ponticuli having length equal to or greater than the chamber width (perforate wall width between sutures). There is some confusion here because, of Poag's photos (1978, Pl. 2): he places figures 1 - 12 in forma *salsum* (= forma *lidoensis* of this author) and figures 13 - 16 in forma *typicum*, (=forma *gunteri* of this author) and yet only figures 15 and 16 show ponticuli greater in length than the adjacent chamber wall. Instead, here, the two morphotypes are split on the basis of the sutures broadening towards the umbilicus (= forma *lidoensis*) and ponticuli spanning the suture completely (= forma *gunteri*). Consequently, Poag's *E. gunteri* forma *salsum* (Pl. 2:1-10) is placed in forma *lidoensis*; his forma *salsum* (Pl. 2:11-12) and his forma *typicum* are placed in forma *gunteri*.

It is probable that *P. oceanensis*, described by d'Orbigny (1826) is the same morphotype as *E. excavatum* forma *gunteri*. However, the validity of both the name *P. oceanensis* and the species itself is in doubt. (When transferred to the masculine genus *Elphidium* the epithet should have become *oceanense*, but many workers retained the feminine epithet *oceanensis*).

D'Orbigny (1826) described, he never figured or illustrated, the species. Hansen and Lykke-Andersen (1976) on a personal communication from Y. Le Calvez, state that there is no (and probably never was a) holotype of the species. Both Hansen and Lykke-Andersen (1976, p. 12), and Poag (1978, p. 402) consider *E. oceanensis* to be a *nomen nudum*. However, *E. oceanensis* (from d'Orbigny's collection) was figured by Fornasini (1904, Pl. 3:10), so that the authorship of the species is "Fornasini 1904 ab d'Orbigny 1826". Fornasini's figure does not show the rounded periphery or coarse perforations of the *gunteri* morphotype and could be a figure of either forma *selseyensis* or forma *tumidum*.

Murray (1971, 1979) has illustrated specimens he has identified as *E. oceanensis* (some that would be included here in forma *lidoensis*); Murray (1982 pers. comm.) does not think that *E. oceanensis* is conspecific with *E. excavatum* because besides morphological differences, it has a different environmental preferences.

Haynes (1982 pers. comm.) has also remarked that the type of *E. oceanensis* is unrecognizable based on Fornasini's figure - and that a new figure is required. Haynes suggests (1982 pers. comm.) that the name *gunteri* could be retained on the basis of usage.

Junior synonyms of this morphotype also include *E. trinitatense* (Cushman and Brönnimann), and a variety of *E. gunteri*, *E. gunteri* var. *waddensis* described by van Voorthuysen (1951) and later put in synonymy with *E. gunteri* by the same author (van Voorthuysen 1957). Haynes (1973) has elevated van Voorthuysen's variety to specific rank and illustrates specimens of his *E. waddense* (1973, p. 206-207, Pl. 24:4, 10, Pl. 26:1, Pl. 28:10-11) that resemble Murray's specimens of *E. oceanensis* (1971, Pl. 69:1-7); Murray's specimens are considered here to be intermediate between forma *lidoensis* and forma *gunteri* but based on the broadening sutures and indistinct ponticuli they are placed in forma *lidoensis*.

Also considered a junior synonym is *Elphidium littorale* Le Calvez and Le Calvez (1951).

Distribution: A widely distributed form, extensively documented in the literature. A warm to tropical water nearshore form tolerating hypo- to hyper-salinities. Found on both the Atlantic and Mediterranean coasts of Europe along beaches and in lagoons, as well as open bays. Also found throughout the Gulf of Mexico, and along the California coast. Reported from late Pleistocene shallow, brackish, glacio-fluvial deposits on both sides of the Atlantic (Knudsen 1973a, 1973b, 1979, Snyder and Katrosh 1979).

Elphidium excavatum (Terquem) forma *galvestonensis* Kornfeld, 1931

?pl. 11:19-21; pl. 13:17-20; pl. 14:19-20; pl. 16:1-8;
?pl. 18:18; pl. 25:1-16

Elphidium discoidale (d'Orbigny). CUSHMAN, 1930, p. 22, pl. 8:9a-b. CUSHMAN and COLE, (1930), p. 97, pl. 13:10a-b. PHLEGER, 1951, p. 46. PHLEGER and PARKER, 1951, (part), p. 10, pl. 5:11. TODD and BRÖNNIMANN, 1957, (part), p. 39, pl. 6:8.

Elphidium gunteri Cole var. *galvestonense*. KORNFELD, 1931, (part), p. 87, pl. 15:1a-b (not 2a-3b).

Elphidium galvestonense Kornfeld. PARKER ET AL., 1953, p. 8, pl. 3:15-16. PHLEGER, 1954, p. 639, pl. 2:1-2. LEHMANN, 1957, p. 348, pl. 2:37-40. PARKER and ATHEARN, 1959, p. 342, pl. 50:33-35. PHLEGER, 1960a, p. 277, pl. 3:19

Elphidium gunteri Cole. PARKER, 1954, (part), p. 508, pl. 6:16. BANDY, 1956, (part), p. 194, pl. 30:19a-b.

Elphidium excavatum (Terquem). TODD and BRÖNNIMANN, 1957, (part), p.

39, pl. 6:11.

Elphidium morenoi Bermudez. TODD and LOW, 1971, p. 16, pl. 3:6.

Cellanthus galvestonense (Kornfeld). SCOTT, 1976, p. 170

Elphidium galvestonense Kornfeld forma typicum. POAG, 1978, p. 404, pl. 3: 12-16, 19-21. POAG, 1981, p. 60, pl. 35:3, pl. 36:3a-3b.

Elphidium ex gr. excavatum (Terquem). Elphidium cf. advenum sensu Todd and Low. HAYNES, 1981, p. 61-62, pl. 8:12.

Types :

Holotype: Elphidium gunteri var. galvestonense. Kornfeld, 1931, (part), p. 87, pl. 15:1a-b (not 2a-3b).

Lectotype: designated by Parker et al., 1953, p. 8, as: Elphidium gunteri var. galvestonense, Kornfeld, 1931, p. 87, pl. 15:1a-b.

Deposited in: Stanford University Paleontological Type Collection, Type No. 691 (megalospheric form).

Representative plesiotype: pl. 16:3, pl.25:1-3.

Diagnostic characteristics: A large, many chambered (13-18) form with a large very raised boss (or bosses) at the umbilicus and many regular, distinct ponticuli. There may be a ring of papillae surrounding the boss or in the sutures. The wall is heavily calcified and very finely perforate, giving the test a porcelaneous appearance. The periphery is subacute.

Description: As described by: Kornfeld in 1931 (E. gunteri var.

galvestonense megalospheric form); Parker et al. in 1953 (E. galvestonense) and Poag in 1978 (E. galvestonense forma typicum).

Maximum diameters: diameter 0.48 to 0.57 mm, thickness 0.28 mm (Kornfeld, 1931, p. 87, megalospheric form).

Remarks: E. excavatum forma galvestonensis is the morphotype originally described by Kornfeld (1931) as the megalospheric form of E. gunteri var. galestonense. One of Kornfeld's specimens (1931, p. 87, Pl. 15:1a-b, No. 691) has been designated as lectotype by Parker et al. (1953). Poag (1978) has split E. galvestonense into two formae, forma typicum and forma mexicanum. Here, only forma typicum is included in this morphotype. Poag's other forma, forma mexicanum appears to be Kornfeld's E. incertum var. mexicanum a species whose relationship to E. excavatum is uncertain.

Distribution: E. excavatum forma galvestonensis occurs in low frequencies and is most abundant in the Northumberland Strait core sample and the Gulf of Mexico samples. It was not positively identified in any of the European samples, and no occurrences from Europe are documented in the literature. It has not been reported as older than Holocene. It is a nearshore (bay, beach and marsh) form and prefers waters that are warm and saline and that exhibit little fluctuation in these parameters.

Elphidium excavatum (Terquem) forma lidoensis
Cushman, 1936

pl.1:2:1; pl.4:12; pl. 5:8-12; pl. 6:7; pl. 7:10-12; pl. 8:9; pl. 9:17; pl. 10:15-16; pl. 11:9-13; pl. 12:4-5, 7-10; 13; pl. 13:11; pl. 14:10; pl. 15:1-7, 9-14; pl. 18:4-7; pl. 19:1-7; pl. 26:1-32

?Polystomella arctica (Parker and Jones). TERQUEM, 1876, p. 428, pl. 2:1 (fide Feyling-Hanssen 1972).

Elphidium florentinae. SHUPACK, p. 1934, p. 9, opp. p.9:5a-b.

Elphidium lidoensis. CUSHMAN, 1936, p. 86, pl. 15:6. CUSHMAN, 1939, p. 62-63, pl. 17:17. ACCORDI and SOCIN, 1950, p. 12, 15, pl. 1: 8. CITA and PREMOLI-SILVA, 1967, p. 35-36, pl. 2:1-2. LÉVY, 1966, p. 5, pl. 1:5a-c.

Cribroelphidium salsum. Cushman and Brönnimann, 1948, p. 19, pl. 4:6. TODD and BRÖNNIMANN, 1957, p. 39.

Cribroelphidium vadescens. Cushman and Brönnimann, 1948, p. 18, pl. 4:5. LEHMANN, 1957, p. 348, pl. 2:28-29.

Elphidium clavatum Cushman. WEISS, 1954, (part), p. 159, pl. 32:12. MURRAY, 1969, (part), p. 416, pl. 17:1-4. SCHNITKER, 1971, (part), p. 198, pl. 7:5a-b .

Elphidium gunteri Cole var. galvestonense Kornfeld. BANDY, 1954, (part), p. 136, pl. 30:2.

Eliphidium tumidum Natland. TODD and BRÖNNIMANN, 1957, (part), p. 39, pl. 7:9.

Elphidium oceanicum Cushman. LEHMANN, 1957, p. 348, pl. 3:9-12.

Elphidium sp. A. VAN VOORTHUYSEN, 1957, p. 31, pl. 23:10.

Elphidium cf.E. minimum (Segwenza). PARKER, 1958, p. 271, pl. 4:8-9.

Elphidium granulosum (d'Orbigny). PARKER, 1958, p. 270, pl. 4:10-11.

Elphidium incertum (Williamson) var. PHLEGER, 1964, p. 383, pl. 2:2.

Elphidium kozlowskii. BRODNIEWICZ, 1965, p. 205, text-fig. 29, pl. 7:4, pl. 9:1-6.

Nonion depressulus (Walker and Jacob). MURRAY, 1965b, p. 148-149, pl. 25:6-7; pl. 26:7-8.

Elphidium excavatum (Terquem). CITA and PREMOLI-SILVA, 1967, p. 35-36, pl. 2:3. ROSSET-MOULINIER, 1976, (part), p. 89-92, pl. 1:5-9, 12. MURRAY, 1979, p. 50, figs. 15:C-D. BUZAS and SEVERIN, 1982, p. 37, pl. 8:2.

Cribrononion excavatum (Terquem). HAAKE, 1967, (part), p. 13-27, pl. 1:1-3, 9, 12-14. VON DANIELS, 1970, p. 87, pl. 7:11.

Cribrononion lidoense (Cushman). LÉVY ET AL., 1969, p. 94, pl. 1:9a-b.

Elphidium oceanensis (d'Orbigny). MURRAY, 1971, (part), p. 165, pl. 69:1-2.

Cribroelphidium excavatum (Terquem). ROSSET-MOULINIER, 1972, p. 177, pl. 16:1-4, pl. 17:1-4.

Elphidium excavatum (Terquem) forma *lidoensis* Cushman. FEYLING-HANSSEN, 1972, p. 344, pl. 6:1-7. SNYDER and KATROSH, 1979, p. 254, pl. 2:4. MILLER ET AL., 1982, p. 134-136, pl. 1:17-20, pl. 4:7-12, pl. 5:9, pl. 6:15-16.

Elphidium selseyense (Heron-Allen and Earland). HAYNES, 1973, (part), p. 204-205, pl. 22:1-2, pl. 24:11, pl. 26:5, 10.

Cribroelphidium excavatum clavatum (Cushman). SCOTT ET AL., 1977, p. 1579, pl. 5:2.

Elphidium gunteri Cole forma *salsum*. POAG, 1978, (part), p. 402, pl.

2:1-10. POAG, 1981, p. 61, pl. 37:2, pl. 38:2a-2b.

Elphidium clavatum lidoense Cushman. WILKINSON, 1979, p. 637, pl. 1:4.

Elphidium excavatum var. A. SLOAN, 1981, p. 278, pl. 2:2a-b.

Elphidium incertum var. A. SLOAN, 1981, p. 282, pl. 2:3a-b.

Types:

Holotype: *Elphidium lidoense* Cushman, 1936, p. 86, pl. 15:6a-b, USNM No. 23201.

Paratypes: USNM Nos. 19176, 23020, 39935.

Deposited in: Cushman Collection, Smithsonian Institution.

Types of junior synonyms:

Elphidium florentinae:

Holotype: Shupack, 1934, p. 9, opp. p. 9: 5a-b.

Deposited in: American Museum of Natural History (New York) No. 696

Cribroelphidium salsum:

Holotype: Cushman and Brönnimann, 1948, p. 19, pl. 4:6, USNM No. 56644.

Paratype: USNM No. 56750.

Deposited in: Cushman Collection, Smithsonian Institution.

Cribroelphidium vadescens:

Holotype: Cushman and Brönnimann, 1948, p. 18, pl. 4:5, USNM No. 56643.

Paratype: USNM No. 56649.

Deposited in: Cushman Collection, Smithsonian Institution.

Elphidium kozlowskii:

Holotype: Brodniewicz, 1965, p. 205, text-fig. 29, pl. 7:4, pl. 9:1-6. (pl.9:5).

Deposited in: Paleozoological Institute of the Polish Academy of Sciences (Warsaw) No. F. VIII / 89-94.

Representative plesiotypes: "boreal" water form, pl. 7:11, USNM No. 312513; "Lusitanian" water form, pl. 25:14-16.

Diagnostic characteristics: Test compressed, sutures backwards curved, distinctly broadening towards the umbilicus, filled with papillae; ponticuli often absent (or not visible); umbilicus open and large, filled with papillae, or irregular bosses, or both.

Description: As described by: Cushman in 1936 (*E. lidoense*) and by Feyling-Hanssen in 1972 (*E. excavatum* forma *lidoensis*).

Maximum Diameters: 0.50 - 0.60 mm (Cushman, 1936, p. 86); 0.20 - 0.40 mm (Brodniewicz, 1965, p. 205).

Remarks: The name *E. excavatum* forma *lidoensis* is the name retained for the form described by Cushman (*E. lidoense*, 1936) and Feyling-Hanssen, (*E. excavatum* forma *lidoensis*, 1972). Within this forma, two "subforma" are observed: a "boreal" environment form from areas of extremes in climatic variation, i.e. Miramichi Estuary, Annapolis Basin, and Long Island Sound; and a "Lusitanian" environment form, from areas with a narrower climatic range, i.e. San Diego Bay, San Antonio Bay, Venice, and Bay of Izmir. Both forms exhibit the key characteristics of the forma. However, the "boreal" form can be linked to *E. excavatum* forma *excavata*; the wall perforations are fine and the papillae small. The "Lusitanian" form resembles, and can be linked to, *E. excavatum* forma *gunteri*; the periphery is rounded, wall perforations coarse, papillae more variable in size,and a larger number of bosses present in the umbilicus.

Feyling-Hanssen (1972, p. 344) remarked on the similarity of *E. gunteri* and *E. lidoense*; but he pointed out that they could be separated on the basis of the distinct rectangular and numerous sutural bridges (*gunteri*) and the broadening of the sutures towards the umbilicus (*lidoensis*).

As mentioned earlier, part of Poag's (1978) *E. gunteri* forma *salsum* is included in this form.

The placement of *E. oceanense* (d'Orbigny) is in doubt, but specimens assigned to this form by some workers (i.e. Murray 1971, [part]) either belong to this form or are intermediate between the two formae *gunteri* and *lidoensis*.

Junior synonyms include *Elphidium florentinae* Shupack (1934), *Cribroelphidium salsum* and *C. vadescens* (both) Cushman and Brönnimann (1948), and *E. kozlowskii* Brodniewicz, (1965).

Distribution: E. excavatum forma lidoensis was first collected by Cushman, (E. lidoense, Cushman 1936, 1939) from Venice, Italy; where it was later (again) recorded by Cita and Premoli-Silva (1967) as E. lidoense.

The occurrence of E. excavatum forma lidoensis in European and North American waters is difficult to document; it appears that this form has been identified by other species names.

The occurrences of E. excavatum forma lidoensis recorded in the literature suggest a shallow, subtidal estuarine environment with waters attaining a summer temperature of at least 20°C. It appears to be a marginal marine form; almost all the occurrences are areas under estuarine influence (among them Miramichi Estuary, Chezzetcook Inlet, Annapolis Basin, Long Island Sound, San Antonio Bay, Venice, and Dovey Estuary, [U. K.]) or lagoons and mangrove swamps (southern California and Trinidad).

Elphidium excavatum (Terquem) forma tumidum Natland, 1938.

pl. 11:1-4, 14-15; pl. 12:6; pl. 27:12-19.

Elphidium tumidium. NATLAND, 1938, p. 144, pl. 5:5-6. CUSHMAN, 1939, p. 65, pl. 20:8a-b. TODD and BRÖNNIMANN, 1957, (part), p. 39, pl. 6:7a-9b. LEHMANN, 1957, p. 348, pl. 3:15-16.

Elphidium sp. cf. E. tumidum Natland. PARKER ET AL., 1953, p. 9, pl. 3:28-29.

Elphidium incertum var. clavatum Cushman. TODD and BRÖNNIMANN, 1957, (part), p. 39, pl. 6:10a-b.

Elphidium cf. E. tumidum Natland. PHLEGER, 1960a, p. 277, pl. 3:24.

Cellanthus tumidum (Natland). SCOTT, 1976, p. 170. SCOTT ET AL., 1976, p. 74.

Types:

Holotype: Elphidium tumidum, Natland, 1938, p. 144, pl. 5:5-6.

Deposited in: Smithsonian Institution, USNM No. 22550.

Representative plesiotype: pl.11:16, pl. 27:15.

Diagnostic characteristics: A large, ornamented form resembling forma selseyensis. However, the ornamentation and ponticuli are much more regular on forma tumidum. The umbilicus is large, circular, depressed and filled with papillae/bosses. The chamber extensions into the umbilicus are truncated sharply. The periphery is broadly rounded, and the chambers inflated.

Description: As described by Natland (E. tumidum, 1938).

Maximum diameters: diameter 0.50 mm, thickness 0.22 mm (Natland, 1938, p. 144).

Remarks: The name E. excavatum forma tumidum is given to the morphotype described by Natland (E. tumidum, 1938). Natland (1938) reported it to be distinct from, but related to E. articulatum. Scott (1982 pers. comm.) has observed intergradation between this form and other morphotypes of E. excavatum in California lagoons and marshes, though intergradation is not fully documented here, and this form was not found at any other locations.

Distribution: Natland (1938) reported this form to be common off southern California; but there have been relatively few occurrences documented in the literature under this name. No evidence was found that this form has been widely documented under another name. From the literature, it can be concluded that this form is restricted to the west coast of the United States and the Gulf of Mexico.

Elphidium excavatum (Terquem) forma cuvillieri Levy, 1966.

pl. 6:20; pl. 13:6-7; pl. 14:6-7; pl. 16:9-14;
pl. 18:8-15; pl. 19:8-15; pl. 28:1-23.

?Polystomella poeyana. D'ORBIGNY, 1839a, p. 55, pl. 6:25-26.

Elphidium poeyanum (d'Orbigny). CUSHMAN, 1930, p. 25, pl. 10:4-5. PARKER ET AL., 1953, p. 9, pl. 3:26. PARKER, 1954, p. 509, pl. 6:17. BANDY, 1954, (part), p. 136, pl. 30:6a-b. PHLEGER, 1954, p. 639, pl. 2:8-9. TODD and BRÖNNIMANN, 1957, p. 39, pl. 7:2-4. PHLEGER, 1960a, p. 277, pl. 3:17, pl. 5:10. TODD and LOW, 1961, p. 20, pl. 2:7. TODD and LOW, 1971, p.C16, pl.3:8. HANSEN and LYKKE-ANDERSEN, 1976, p. 13, pl. 9:9-12; pl. 10:1-5. POAG, 1981, p. 63, pl. 39:3, pl.40:3a-3b.

Elphidium cf. articulatum (d'Orbigny). CUSHMAN, 1944, (part), p. 26, pl. 3:41.

Cribroelphidium kugleri. CUSHMAN and BRÖNNIMANN, 1948, p. 18-19, pl. 4:4a-b. TODD and BRÖNNIMANN, 1957, p. 39. LEHMANN, 1957, p. 348, pl.

2:25-27.

Elphidiononion poeyanum (d'Orbigny). HOFKER, 1951, p. 356 (fide Loeblich and Tappan, 1964, p. C635).

Cribroelphidium poeyana (d'Orbigny). LOEBLICH and TAPPAN, 1964, p. C635, fig. 508:3a-4b.

Elphidium cuvillieri. LEVY, 1966, p. 5-6, pl. 1:6a-c, pl. 2. ROSSET-MOULINIER, 1972, p. 177, pl.15:1-4. HAYNES, 1973, p. 197, pl. 24:17-18, pl. 26:12. ROSSET-MOULINIER, 1976, p. 93, pl. 3:4-8. MURRAY, 1979, p. 50, fig. 14:E-F.

Cribrononion cuvillieri (Levy). LÉVY ET AL., 1969, p. 93, pl. 1:10a-11.

Cribrononion transluscens (Natland). VON DANIELS, 1970, p. 88, pl. 7:13. ALBANI and SERANDREI BARBERO, 1982, (part), p. 240, pl.1:7-9 (not 10).

Elphidium transluscens (Natland). HANSEN and LYKKE-ANDERSEN, 1976, p. 11, pl. 7:1-11.

Elphidium kugleri (Cushman and Brönnimann). BUZAS ET AL., 1977, p. 95. BUZAS and SEVERIN, 1982, p. 37, pl. 8:5.

Elphidium discoidale (d'Orbigny) forma *transluscens*. POAG, 1981, p. 59, pl. 35:2, pl. 36:2a-2b.

Elphidium discoidale (d'Orbigny) forma *typicum*. POAG, 1981, p. 59, pl. 35:1, pl. 36:1a-1b.

Types:

Holotype: *Elphidium cuvillieri*, Lévy, 1966, p. 5-6, pl. 1:6a-c, pl. 2.

Deposited in: not given

Typesof junior synonyms:

?*Polystomella poeyana*:

?Holotype: d'Orbigny, 1839a, p. 55, pl. 6:25-26.

Lectotype: designated by Loeblich and Tappan, 1964, p. C635, Fig. 508:3a-b

Deposited in: Laboratoire de Paleontologie du Museum de l'Histoire Naturelle; Paris.

Cribroelphidium kugleri:

Holotype: Cushman and Brönnimann, 1948, p. 18-19, p. 4:4a-b.

Deposited in: Cushman Collection, Smithsonian Institution, USNM No. 56642.

Paratype: USNM No. 56746 (as above).

Representative plesiotype: pl. 26:8.

Diagnostic characteristics: A smooth, round, disc shaped *Elphidium* about the same size as forma *clavata*. The peripheral outline can range from smooth to very lobate. The sutures are straight or gently backwards curved, and characterized by very regular rows of sutural pores. Papillae are completely absent in this form; the umbilicus is slightly depressed (perforate or imperforate) and closed by a glassy plate of fused chamber ends.

Description: As described by: Lévy in 1966 (*E. cuvillieri*), Lévy et al. in 1969 (*Cribrononion cuvillieri*) and Haynes in 1973 (*E. cuvillieri*).

Maximum diameters: 0.5 mm (Lévy, 1966, p. 6); 0.36 - 0.47 mm (Rosset-Moulinier, 1976, p. 93).

Remarks: The name *E. excavatum* forma *cuvillieri* is the name retained for the species described by Lévy (1966) as *E. cuvillieri*. He reported this form to be a common shallow water form in the Mediterranean. This leads to the question as to why it had not been previously recognized or described. One possible explanation is that has been included by other authors with *E. poeyana* (d'Orbigny). *E poeyana* was described by d'Orbigny from Cuba (1839a).

Williamson (1858) remarked on the similarity between his *P. umbilicatula* (=*E. excavatum* forma *williamsoni*) and d'Orbigny's *P. poeyana*, stating the only difference was in the alleged arrangement of septal apertures.

Loeblich and Tappan 1964, designated one of d'Orbigny's specimens as lectotype (Loeblich and Tappan, 1964, p. C365, Figure 508:3a-4b). The material at the Smithsonian Institution identified by Loeblich and Tappan is considered very similar and possibly conspecific with the morphotype *cuvillieri*.

This form was probably described by Cushman and his co-workers as *Cribroelphidium kugleri* (Cushman and Brönnimann 1948, Todd and Brönnimann 1957, and Lehmann 1957).

Levy (1966, p. 6) remarks on the similiarity between his species (*E. cuvillieri*) and d'Orbigny's. Lévy (1966) did not compare his specimens directly with d'Orbigny's, but with specimens from the

"Stampien" supplied by Poignant which are considered equivalent with topotypes from Cuba (Cuvillieri and Szakall 1949). Lévy (1966) also remarked on the similarity of his species to *E. lidoense* Cushman.

The name *cuvillieri* is retained until d'Orbigny's material can be examined. The name *cuvillieri* is an unambiguous designation for the form described by Lévy; the uncertainty lies in its relationship to d'Orbigny's species (*E. poeyana*).

Distribution: The distribution of this form is difficult to document because of the relatively few (and those quite recent) references to *E. cuvillieri*. It is a warm shallow water form preferring near normal salinities. It has probably been reported from both sides of the Atlantic as *E. poeyana* and from North America as *E.* (or *C.*) *kugleri*; from warm, shallow, near normal marine environments.

Elphidium excavatum (Terquem) forma magna
Miller, Scott and Medioli, 1982.

pl. 1:1:2; pl. 4:2-5; 15-20; pl. 6:1-2; pl. 7:2-3;
pl. 14:15-17; pl. 27:1-11.

Elphidium discoidale (d'Orbigny). CUSHMAN, 1939, p. 54, pl. 15:7. PHLEGER and PARKER, 1951, (part), p. 10, pl. 5:10. PARKER ET AL., 1953, p. 7, pl. 13:13-14. LEHMANN, 1957, p. 348, pl. 2:18-20.

Elphidium incertum (Williamson) var. clavatum Cushman. CUSHMAN, 1948 (part), p. 57, pl. 6:8. PARKER, 1952a, (part), p. 412, pl. 5:11.

Elphidium clavatum Cushman. LOEBLICH and TAPPAN, 1953, (part), p. 98. TODD and LOW, 1961, (part), p. 18-19, pl. 2:1. TODD and LOW, 1967, (part), p. A33, pl. 4:16-17. "Complex". GREGORY, 1970, (part), p. 226, pl. 14. RODRIGUES and HOOPER, 1982, (part), p. 411-416, text-fig. 2:A-F.

Cribroelphidium incertum (Cushman, [not Williamson]). SCOTT, 1977, p. 170, pl. 6:4-5.

Elphidium excavatum (Terquem) forma clavata Cushman. KNUDSEN, 1979, (part), p. 208-209, pl. 4:4-5.

Cribrononion excavatum incertum (Cushman, [not Williamson]). SCOTT ET AL., 1980, p. 228, pl. 4:4-5.

Elphidium galvestonense (Kornfeld). BOLTOVSKOY ET AL., 1980, p. 29, pl. 13:12.

Elphidium excavatum (Terquem) forma magna. Miller, Scott and Medioli, 1982, p. 138-139, pl. 1:4-5, pl. 5:1-3.

Primary representative plesiotype: pl. 8:1; USNM No. 312508

Secondary representative plesiotypes: pl. 7:2, pl. 8:2, pl. 8:3; USNM No. 312509.

Stratigraphic Age: recent

Type Locality: Chezzetcook Inlet, N. S., Canada; Station 53a (Scott 1977, Scott and Medioli 1980, Scott et al. 1980).

Derivation of Specific Name: magnus; Latin, meaning large.

Diagnostic characteristics: Test often large, peripheral outline smooth to slightly lobate, periphery subacute, and walls greatly convex giving the umbilicus a raised appearance. Umbilicus large, usually filled with one large knobby boss; sutures smooth, backwards curved, with ponticuli and some papillae in the sutures. Some (or all) of the sutures constricted before reaching the umbilicus, forming the imperforate collar around the umbilicus. Differs from forma clavata only in size, shape and environment where found.

Description: Test free, planispiral, involute, biumbonate cental boss of clear shell material, usually large, sometimes absent, in a few cases subdivided; walls convex, periphery subacute, peripheral outline smooth to slightly lobate in the latest part of the test, chambers 10-13 (usually 11 or 12) in the final whorl, gradually increasing in size as added. The sutures are depressed, backwards curved, usually closed (but from one to all may remain open) before reaching the umbilicus, as a result of fusing of the chamber ends; forming a complete (or imcomplete) imperforate collar or ring around the umbilical area. Sutures with a single row of apertural pores; and from few to many short, narrow, distinct ponticuli, often not extending entirely across the sutures. Wall usually thick, calcareous, orange-brown to colourless to white; transparent to opaque with progressive chamber overlap; with radiate structure. Wall distinctly perforate; pores round, septa and apetural face with few pores; tendency towards developing fewer or no pores in the central extensions of the chamber walls; aperture a single row of pores at the base of the apertural face.

The subacute periphery is illustrated on Plate 27:4.

<u>Maximum Diameters</u>: 0.30 mm - 0.60 mm (perhaps larger).

<u>Remarks</u>: This name is given to the forma found in turbulent nearshore zones.

It may be the form identified by Cushman as the large opaque nearshore form he called <u>Elphidium</u> <u>incertum</u> (Williamson). There are specimens of this forma in the Cushman collection, identified by Cushman as <u>E</u> <u>incertum</u>, <u>E</u>. <u>incertum</u> var. <u>clavatum</u>, and <u>E</u>. <u>discoidale</u>. Feyling-Hanssen (1972) has found opaque specimens of early Holocene age which he has named <u>E</u>. <u>excavatum</u> forma <u>alba</u>; and he placed Cushman's white forms in synonomy with his. However, after examining material supplied by Prof. Feyling-Hanssen; the conclusion was reached that specimens identified as <u>E</u>. <u>excavatum</u> forma <u>alba</u> were etched specimens of *E excavatum* forma *clavata* and forma *excavata*. This same conclusion had previously been reached by Scott et al. (1977). The processes and possible cause of etching have been discussed by Murray (1967) and other possible cause have been covered by Walker (1971) and Mageau and Walker (1976).

Distribution: *E*. *excavatum* forma *magna* has been found in recent sediments from nearshore turbulent zones, mainly in the Maritime Provinces of Canada. Gregory (1970, *E*. *clavatum* "complex") found it in Bedford Basin, Scott (*Cribroelphidium incertum*, 1977) and Scott et al. (*Cribroelphidium excavatum incertum*, 1980) found it the dominant form in the turbulent zone of Chezzetcook Inlet, Nova Scotia.

It has also been identified in samples from the Annapolis Basin, Nova Scotia, and the Beaufort Sea.

E. *excavatum* forma *magna* has been reported as *E*. *clavatum* (Loeblich and Tappan 1953, Todd and Low 1961, 1967) or *E*. *incertum* (Parker 1952a) by these and probably other authors as well. Bartlett (*E*. *incertum* "COMPLEX", 1965b) reported large opaque forms commonly associated with turbulent, nearshore environments or the outer shelf.

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PLATES 1 - 29

PLATE 1

Photographs of five formae of Elphidium excavatum (Terquem). Photos taken through a low power dissecting microscope (magnifications unknown, approximently 30-50 x).

1:1. E. excavatum forma excavata (Terquem). Note the depressed umbilicus; straight, depressed sutures and slight to markedly lobate peripheral outline. Specimens from (left to right): Bay of Chaleur SRA-52 (2), and Chezzetcook Inlet station $54a_1$.

1:2. E. excavatum forma magna Miller, Scott and Medioli. This form is larger with a subacute periphery and raised umbo. Note the large boss on the specimen on the right. Specimens from: Chezzetcook Inlet station $54a_1$.

1:3. E. excavatum forma clavata Cushman; the small, flat, disc-shaped form. Specimens from: Labrador core 12, 825-830 cm.

2:1. E. excavatum forma lidoensis Cushman. Note the star shaped pattern of papillae in the umbilicus. Specimens from (left to right): Long Island Sound No. 722, Miramichi Estuary 6a, Bay of Chaleur SRQ-52, and Beaufort Sea F2257.

2:2. E. excavatum forma selseyensis (Heron-Allen and Earland). Pink colour denotes living material stained with Rose Bengal. Note the ornamentation in the large umbilicus. All three specimens from Long Island Sound, No. 722.

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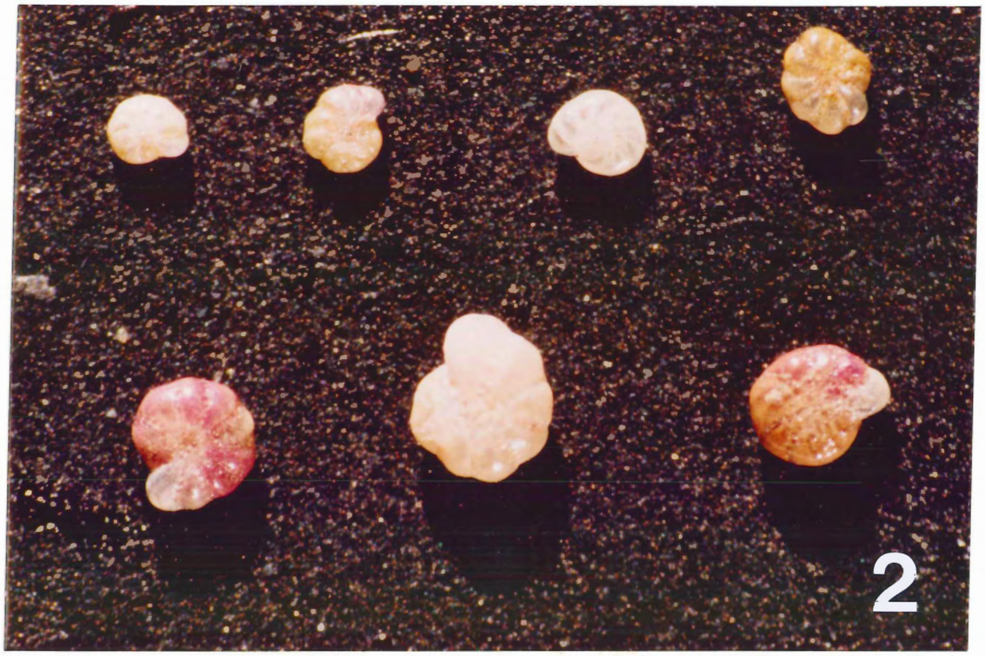

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PLATES 2-19

These plates illustrate the ten morphotypes of *Elphidium excavatum* (and the intergradational series) present in the samples studied from the locations listed on Table 1. Magnifications are given in diameters, not in terms of area. Side views of whole specimens. Each specimen is identified by its specimen number (SN).

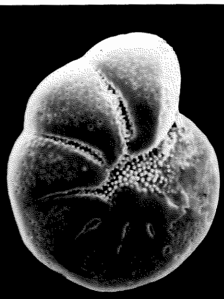
PLATE 2

1-8. Specimens of *E. excavatum* forma *clavata* Cushman, from a Holocene assemblage from the Beaufort Sea. All specimens have an incomplete or complete imperforate collar or umbilical area; though the boss is incomplete or absent in some cases. 1. SN67 x 125. 2. SN68 x 145. 3. SN69 x 149. 4. SN70 x 118. 5. SN71 x 104. 6. SN72 x 183. 7. SN73 x 131. 8. SN74 x 104.

9-20. An intergradational series of the two formae *clavata* and *excavata* from a late Pleistocene assemblage from Hirtshals Denmark.

9-17. *E. excavatum* forma *clavata* Cushman; the umbilical boss may be complete, incomplete, or absent but the imperforate collar or imperforate umbilical area is always present. 9. SN77 x 82. 10. SN78 x 99 . 11. SN79 x 76. 12. SN80 x 127. 13. SN81 x 100. 14. SN82 x 97. 15. SN83 x 132. 16. SN84 x 97. 17. SN85 x 129.

18-20. *E. excavatum* forma *excavata* (Terquem). 18. An intermediate form, approaching forma *excavata* SN86 x 89. 19. SN87 x 123. 20. SN88 x 84.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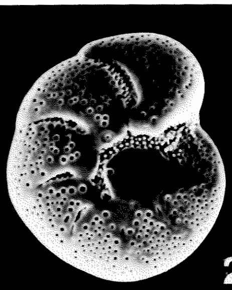
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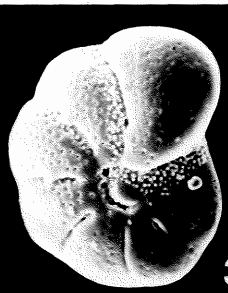
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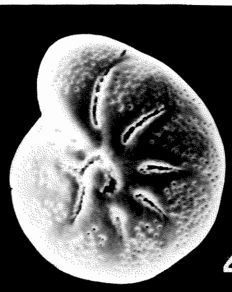
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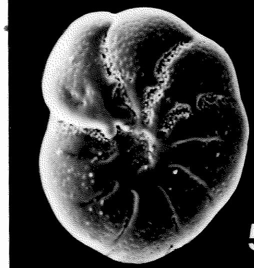
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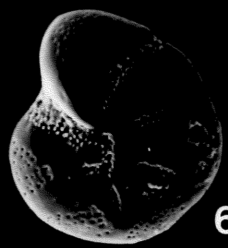
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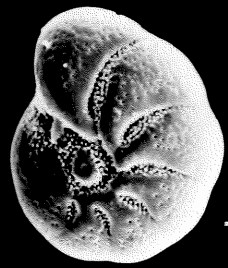
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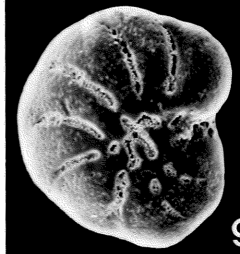
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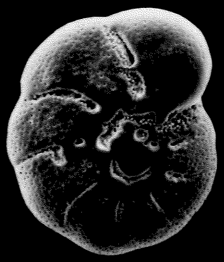
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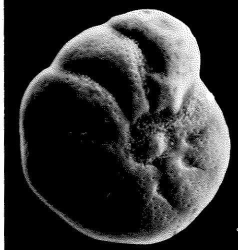
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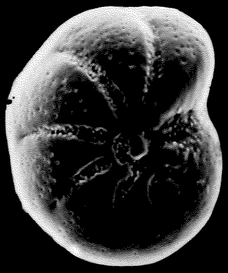
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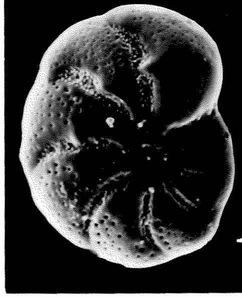
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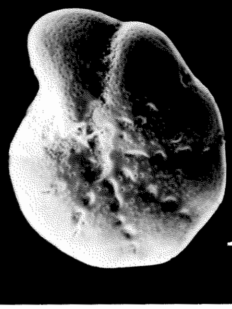
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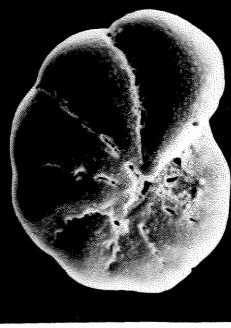
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PLATE 3

Elphidium excavatum (Terquem), an intergradational series of two formae *clavata* and *excavata* from a Holocene assemblage from the Beaufort Sea.

1-6. Typical specimens of *E. excavatum* forma *clavata* Cushman. 1. SN186 x 174. 2. SN187 x 133. 3. SN188 x 166. 4. SN189 x 143. 5. SN190 x 184. 6. SN191 x 230.

7-8. *E. excavatum* forma *excavata* (Terquem). 7. SN192 x 104. 8. SN193 x 92.

9-12. *E. excavatum* forma *clavata*, ornamented specimens. 9. SN194 x 102. 10. SN195 x 84. 11. SN196 x 94. 12. SN197 x 103.

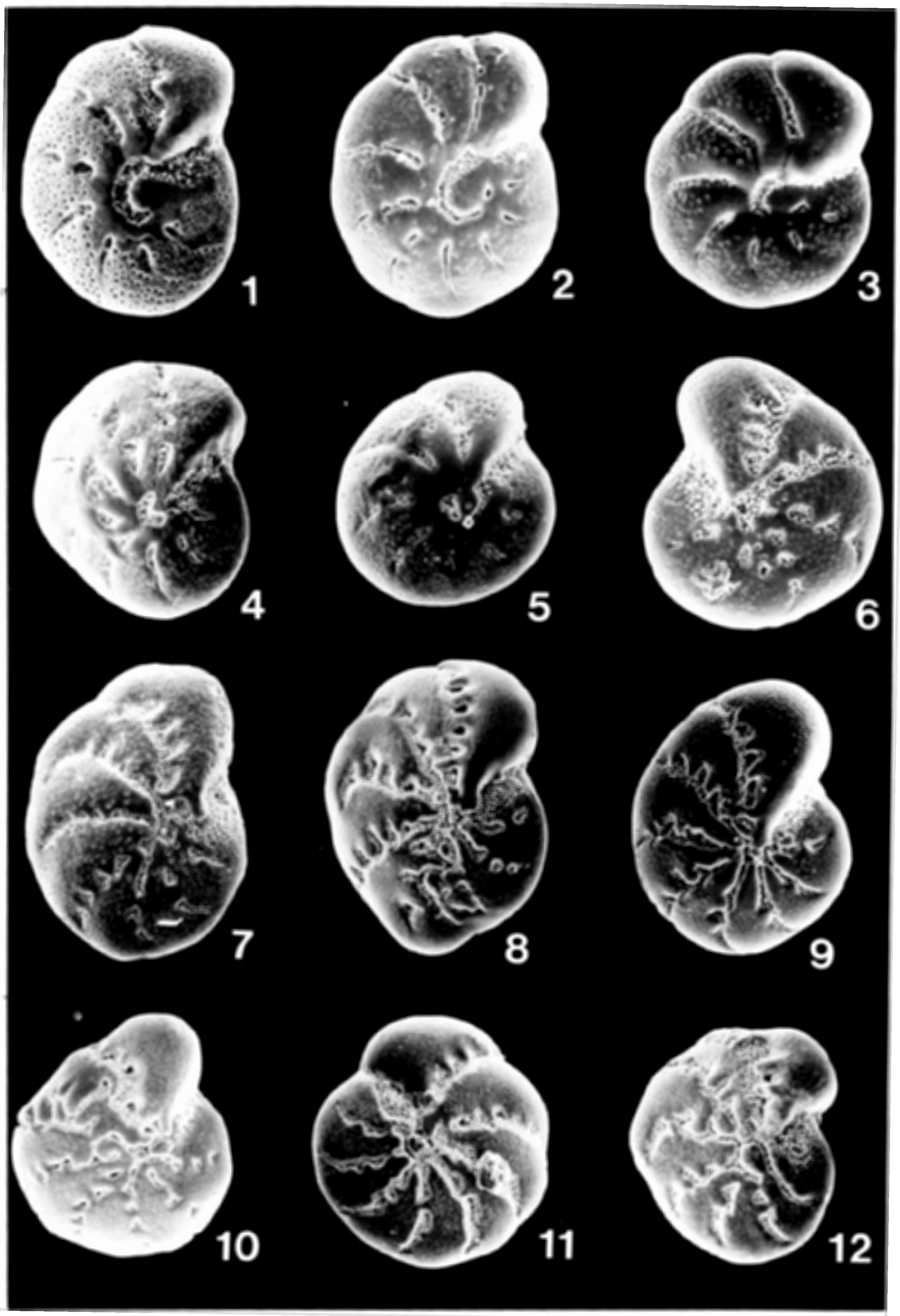
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PLATE 4

1-12. Elphidium excavatum (Terquem), an intergradational series from a Pleistocene assemblage from the Champlain Sea. Four formae are present.

1. Elphidium excavatum forma clavata Cushman SN596 x 115.

2-5. Elphidium excavatum forma magna Miller, Scott and Medioli. Recognized by its subacute periphery and the raised umbilical area. If a boss is present it is usually large. 2. SN490 x 147. 3. SN501 x 170. 4. SN483 x 176. 5. SN491 x 129.

6-9. Elphidium excavatum forma clavata Cushman. 6. SN488 x 123. 7. SN497 x 159. 8. SN502 x 145. 9. SN493 x 125.

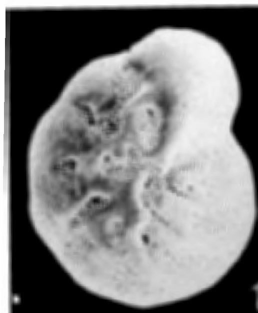
10-11. Elphidium excavatum forma excavata (Terquem). Two specimens intermediate between formae clavata and excavata. The umbilicus is quite depressed and (for the most part) the sutures open in the umbilicus (as in forma excavata), but the sutures are curved and there is an incomplete imperforate collar present (as in forma clavata). 10. SN495 x 136. 11. SN500 x 144.

12. Elphidium excavatum forma lidoensis Cushman. The sutures are curved, opening towards the umbilicus, and the ponticuli absent or poorly developed, SN489 x 164.

13-20. Elphidium excavatum (Terquem) an intergradational series from a population from the Scotian Shelf (off Liverpool, N.S.) Canada.

13-14. Elphidium excavatum forma clavata Cushman. Two typical (though broken) specimens. 13. SN901 x 95. 14. SN771 x 108.

15-20. Elphidium excavatum forma magna Miller, Scott and Medioli. 17-20. These specimens have the large, raised boss typical of this forma. 15. SN908 x 61. 16. SN906 x 72. 17. SN905 x 69. 18. SN903 x 71. 19. SN909 x 66. 20. SN907 x 66.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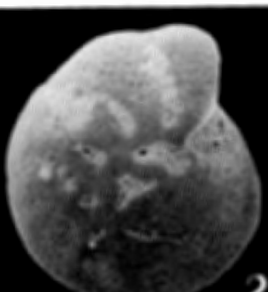
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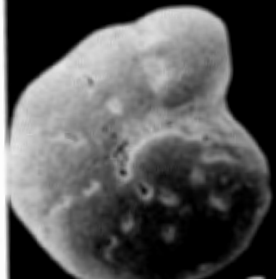
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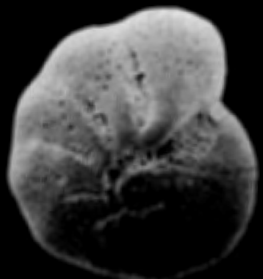
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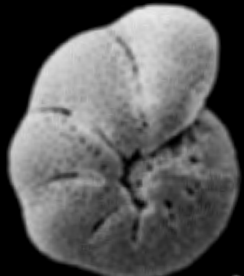
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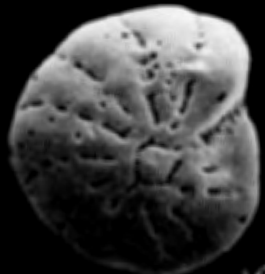
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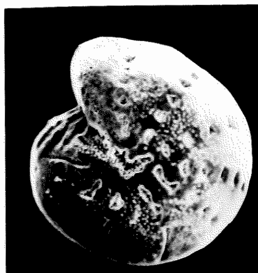
PLATE 5

Elphidium excavatum (Terquem), an intergradational series assembled from a population from Miramichi Estuary, New Brunswick, Canada. Collected from the open bay zone (Scott et al. 1980). Note the wider range of variability of the group (three formae present), and the large degree of ornamentation.

1-7. *E. excavatum* forma *clavata* Cushman. 1. SN108 x 75. 2. SN109 x 143. 3. SN110 x 117. 4. SN111 x 97. 5. SN112 x 126. 6. SN113 x 127. 7. An intermediate form, approaching *E. excavatum* forma *lidoensis* Cushman, SN114 x 91.

8-12. *E. excavatum* forma *lidoensis* Cushman. 8. SN115 x 96. 9. SN116 x 81. 10. SN117 x 98. 11. SN118 x 99. 12. SN119 x 102.

13-16. *E. excavatum* forma *excavata* (Terquem). In warmer, less saline waters, this forma has a larger umbilicus and the umbilicus and sutures contain granular material and papillae. These specimens greatly resemble the neotype illustrated by Lévy et al. (1975). 13. SN120 x 88. 14. SN121 x 93. 15. SN122 x 83. 16. SN123 x 97.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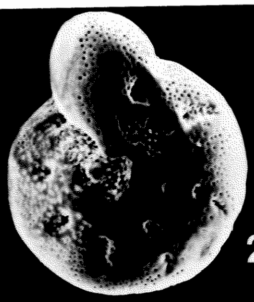
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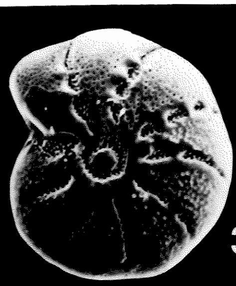
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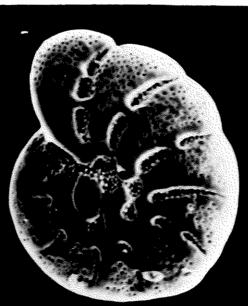
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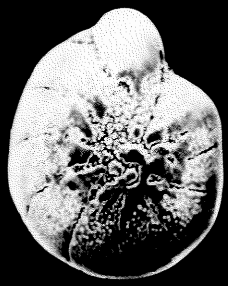
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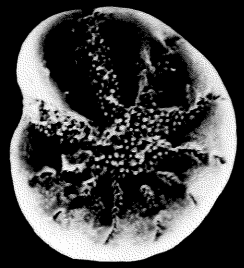
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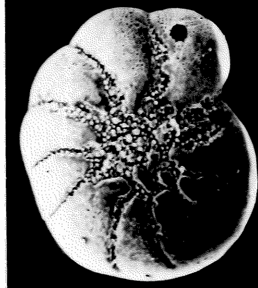
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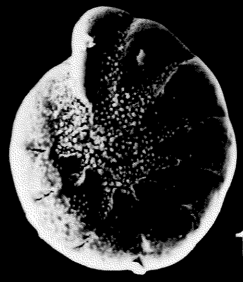
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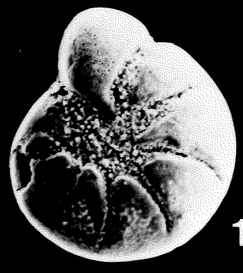
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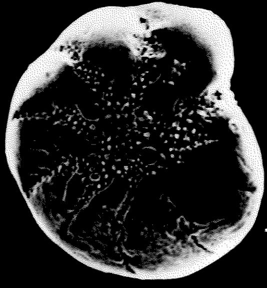
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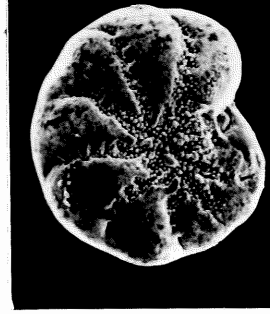
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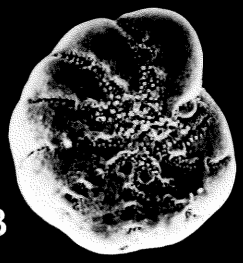
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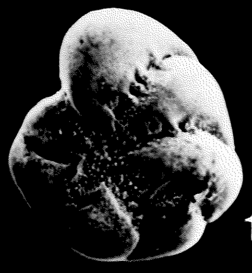
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PLATE 6

Elphidium excavatum (Terquem), an intergradational series assembled from a population from the Bay of Chaleur, Gulf of St. Lawrence. There is wide variability to the group (six formae present) and a large degree of ornamentation and irregularity to many of the specimens.

1-2. *Elphidium excavatum* forma *magna* Miller, Scott and Medioli. 1. SN269 x 70. 2. SN287 x 87.

3-6. *Elphidium excavatum* forma *clavata* Cushman. 3. SN294 x 141. 4. SN291 x 95. 5. SN282 x 88. 6. SN283 x 117.

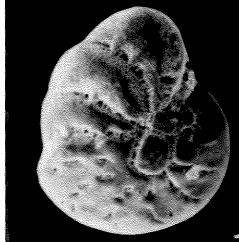
7. *Elphidium excavatum* forma *lidoensis* Cushman. An intermediate specimen between forma *clavata* and forma *lidoensis*, SN293 x 100.

8-16. *Elphidium excavatum* forma *excavata* (Terquem). Notice the regularity, frequency, and development of the ponticuli, the lobate peripheral outline, and the papillae. The wall pores are so fine they are in some cases indistinct. 8. SN286 x 90. 9. SN278 x 69. 10. SN266 x 57. 11. SN280 x 77. 12. SN277 x 72. 13. SN267 x 72. 14. SN262 x 77. 15. An intermediate specimen, approaching forma *williamsoni*, SN274 x 64. 16. SN272 x 73.

17-18. *Elphidium excavatum* forma *williamsoni* Haynes ab Williamson. The ponticuli are not quite as well developed as in a "typical" forma *williamsoni*. 17. SN263 x 69. 18. SN275 x 67.

19. *Elphidium excavatum* forma *excavata* (Terquem). An intermediate specimen, approaching forma *cuvillieri*, SN288 x 80.

20. *Elphidium excavatum* forma *cuvillieri* Lévy. Note the imperforate but continuous umbilicus, SN285 x 105.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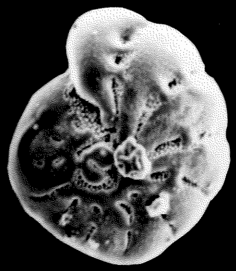
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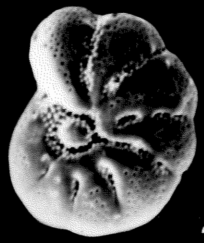
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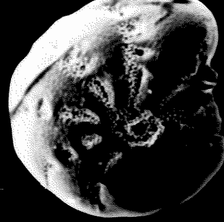
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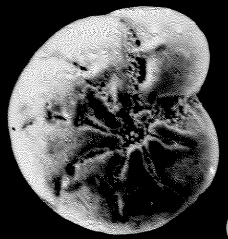
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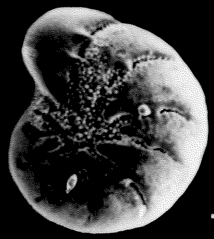
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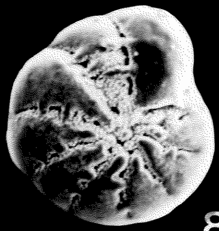
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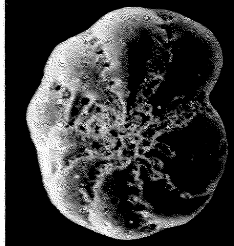
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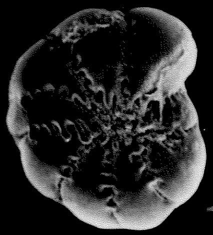
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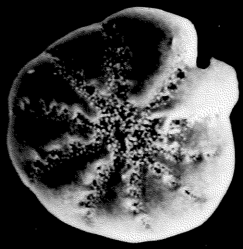
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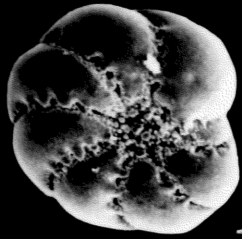
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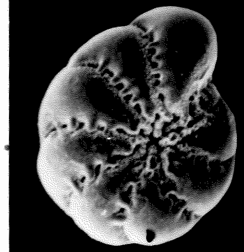
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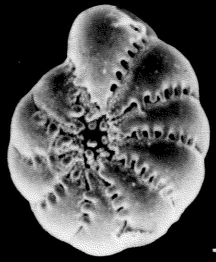
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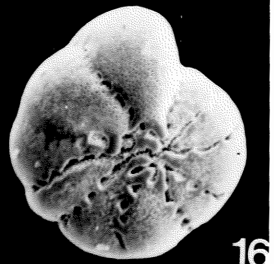
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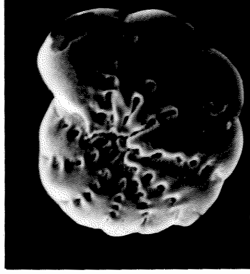
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PLATE 7

Elphidium excavatum (Terquem), an intergradational series assembled from an assemblage from the Annapolis Basin, Nova Scotia, Canada. Note the wide degree of variability (five formae present).

1. *E. excavatum* forma *selseyensis* (Heron-Allen and Earland), from sample 8 SN50 x 90.

2-3. *E. excavatum* forma *magna* Miller, Scott and Medioli, from sample 8. 2. Secondary plesiotype, SN51 x 96. 3. SN52 x 103.

4-9. *E. excavatum* forma *clavata* Cushman. 4,8. From sample 8. 5-7,9. From sample 16. 4. SN53 x 94. 5. SN54 x 142. 6. SN55 x 92. 7. SN56 x 117. 8. SN57 x 105. 9. SN58 x 141.

10-12. *E. excavatum* forma *lidoensis* Cushman, from sample 16. 10. An intermediate specimen between forma *clavata* and forma *lidoensis*, SN59 x 112. 11. Representative plesiotype, SN60 x 104. 12. SN61 x 119.

13-16. *E. excavatum* forma *excavata* (Terquem). 13-14. These specimens from sample 16 resemble the neotype of Lévy et al. (1975). 13. SN62 x 104. 14. SN63 x 104. 15-16. These specimens resemble the specimens from arctic environments, from sample 8. 15. SN64 x 99. 16. SN65 x 118.


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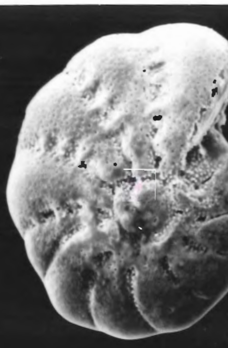
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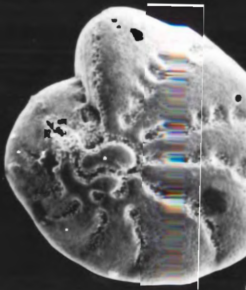
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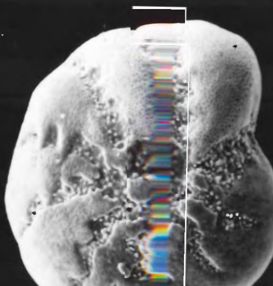
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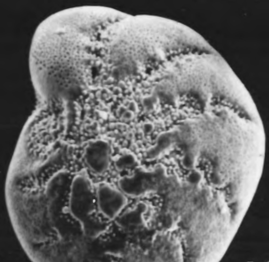
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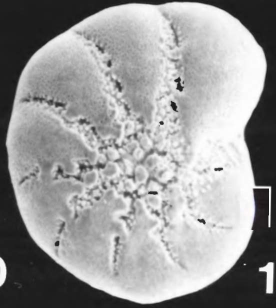
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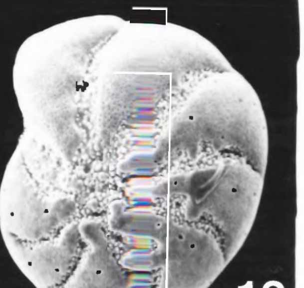
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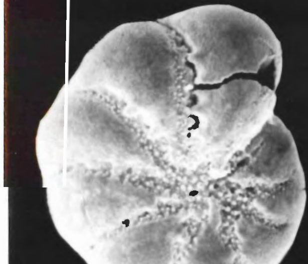
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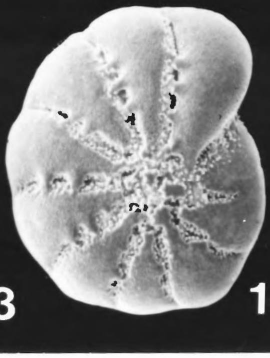
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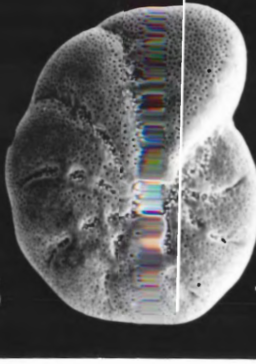
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PLATE 8

Elphidium excavatum (Terquem), an intergradational series assembled from a population from the nearshore zone (Scott et al. 1980) of Chezzetcook Inlet, Nova Scotia. Notice the wide variability of the group (five formae present), and the large degree of ornamentation and irregularity of many of the specimens.

1-3. *E. excavatum* forma *magna* Miller, Scott and Medioli. 1. "Primary" representative plesiotype from station $51a_1$, SN28 x 52. 2. "Secondary" representative plesiotype from $51a_1$, SN29 x 53. 3. "Secondary" representive plesiotype from $53a_1$, SN30 x 53.

4-8. *E. excavatum* forma *clavata* Cushman. 4. From $51a_1$, SN31 x 84. 5. From $54a_2$, SN32 x 90. 6. From $54a_2$, SN33 x 80 . 7. From $51a_1$, SN34 x 68. 8. From $50a_1$, SN35 x 86.

9. *E. excavatum* forma *lidoensis* Cushman. 9. From $50a_2$, SN36 x 66.

10-13. *E. excavatum* forma *selseyensis* (Heron-Allen and Earland). 10. From $49a_1$, SN37 x 74. 11. From $52a_2$, SN38 x 142. 12. From $54a_1$, SN39 x 70. 13. Representative plesiotype, from $55a_2$, SN40 x 51.

14. *E. excavatum* forma *clavata* Cushman, from $50a_2$, SN41 x 86.

15-16. *E. excavatum* forma *excavata* (Terquem), these specimens resemble the neotype of Lévy et al. (1975). 15. From $50a_1$, SN42 x 74. From $55a_1$, SN43 x 78.


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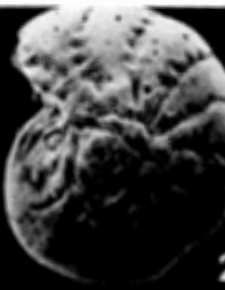
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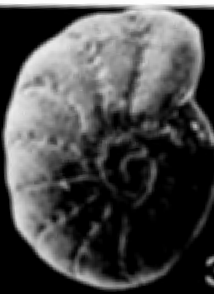
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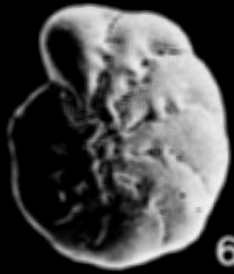
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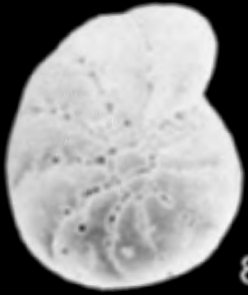
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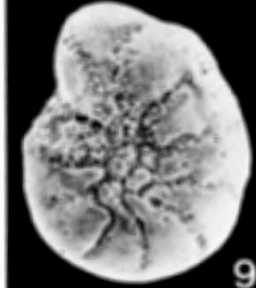
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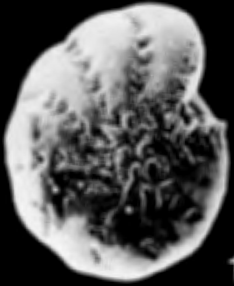
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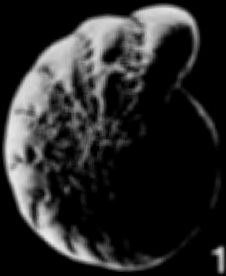
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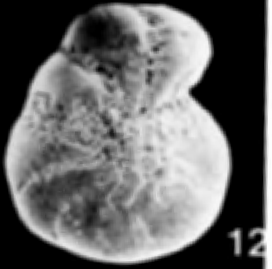
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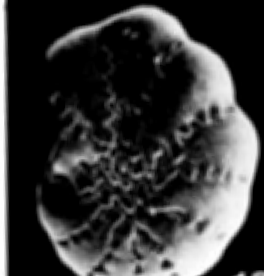
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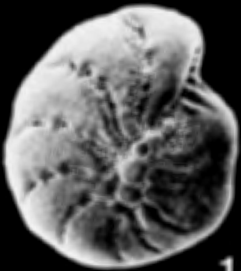
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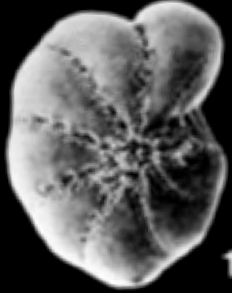
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PLATE 9

1-18. Specimens of _E_. _excavatum_ from a population from a Maine-New Brunswick estuary. Three formae are present, one is very dominant.

1-16. Typical specimens of _E_. _excavatum_ forma _williamsoni_ Haynes ab Williamson. The ponticuli are very regular and extend across the periphery. The walls are densely perforate; and an umbilical boss may or may not be present. 1. SN438 x 130. 2. SN461 x 124. 3. SN439 x 110. 4. SN453 x 114. 5. SN443 x 112. 6. SN456 x 95. 7. SN441 x 100. 8. SN452 x 94. 9. SN451 x 83. 10. SN449 x 85. 11. SN427 x 77. 12. SN428 x 76. 13. SN436 x 80. 14. SN442 x 72. 15. SN458 x 80. 16. SN462 x 75.

17. _E_. _excavatum_ forma _lidoensis_ Cushman, SN477 x 134.

18. _E_. _excavatum_ forma _clavata_ Cusman, SN445 x 81.

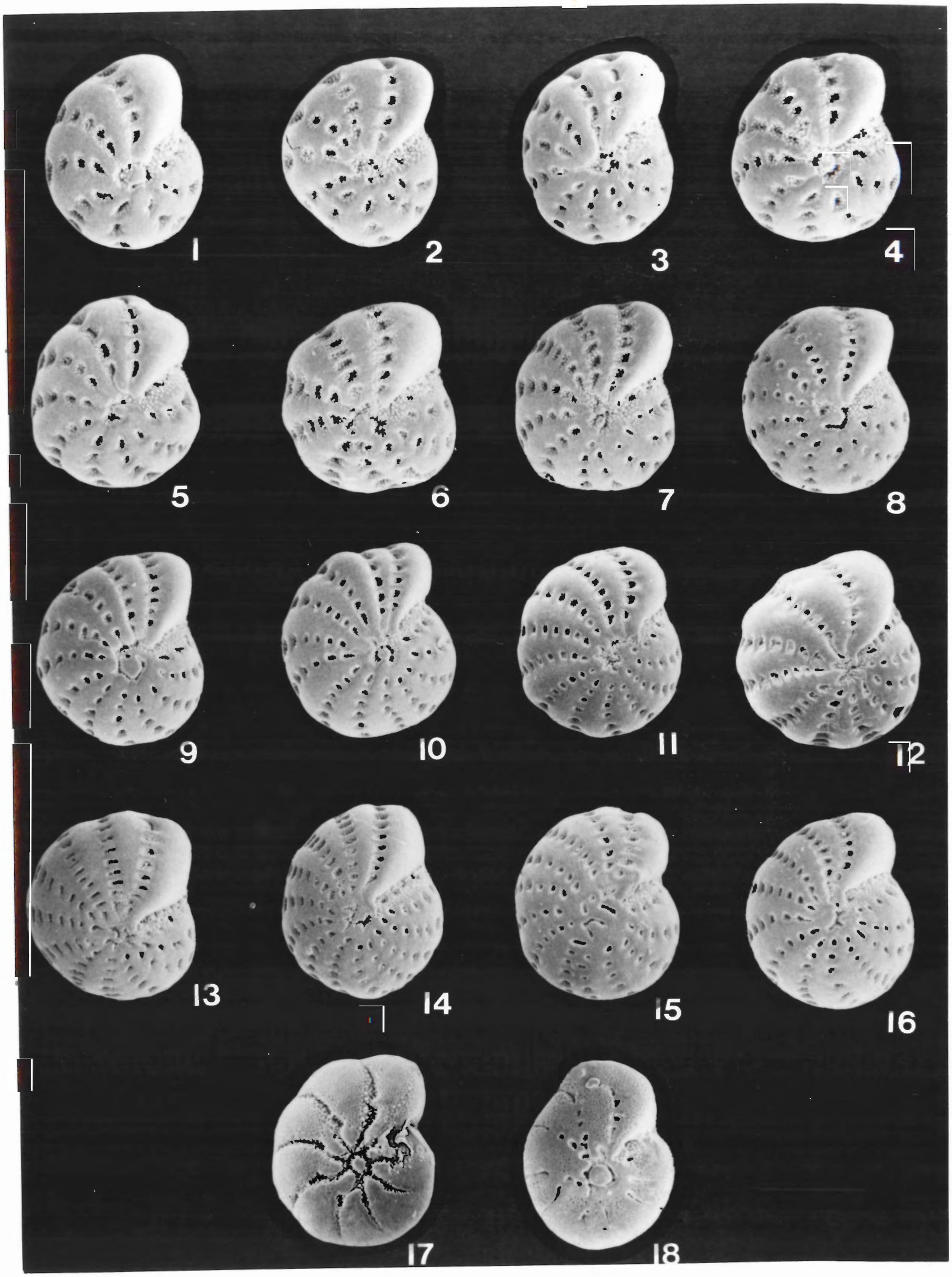
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PLATE 10

1-16. Elphidium excavatum (Terquem) an intergradational series assembled from a population from Long Island Sound. Notice the wide range of variability (four formae present) and the large degree of ornamentation and irregularity of many of the specimens.

1-3. E. excavatum forma clavata Cushman (juveniles?) 1. SN90 x 249. 2. SN91 x 175. 3. An intermediate specimen, SN92 x 148.

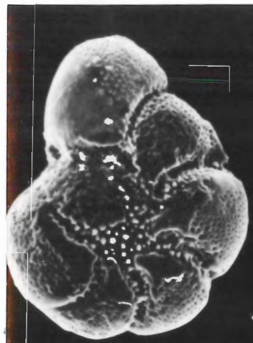
4-5. E. excavatum forma clavata Cushman. 4. SN93 x 134. 5. SN94 x 90.

6-8. E. excavatum forma excavata (Terquem). 6. SN95 x 99. 7. SN96 x 103. 8. SN97 x 96.

9-13. E. excavatum forma selseyensis (Heron-Allen and Earland). 9. SN98 x 62. 10. SN99 x 65. 11. SN100 x 57. 12. SN101 x 83. 13. SN102 x 64.

14. E. excavatum forma excavata (Terquem). An intermediate specimen between forma excavata and forma selseyensis, SN103 x 85.

15-16. E. excavatum forma lidoensis Cushman. 15. SN104 x 93. 16. SN105 x 94.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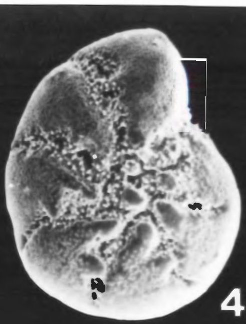
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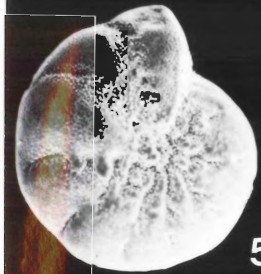
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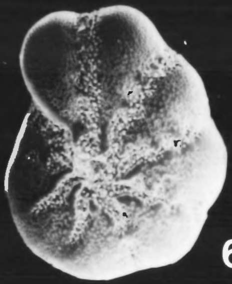
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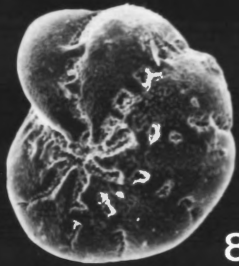
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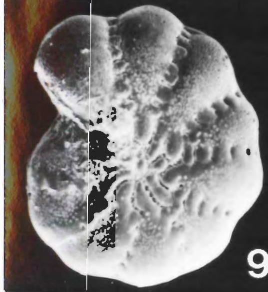
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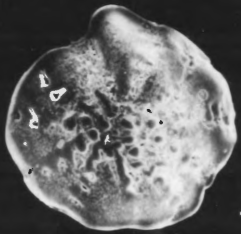
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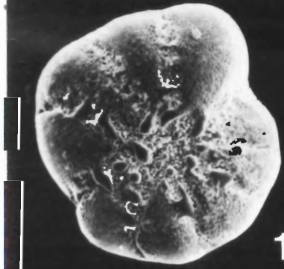
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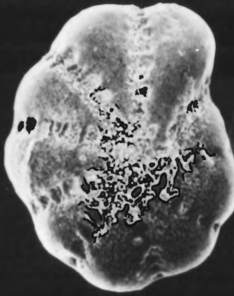
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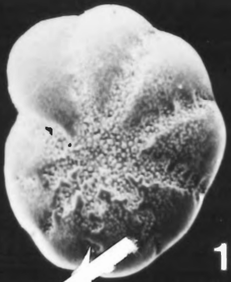
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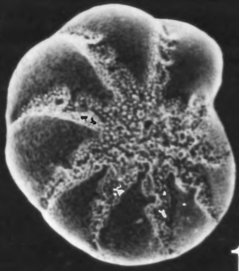
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PLATE 11

Elphidium excavatum (Terquem), an intergradational series of four formae (six present in total) from a population from San Diego Bay, California. This is the only location were the morphotype *tumidum* was observed as a dominant form.

1-4. *E. excavatum* forma *tumidum* Natland. The ponticuli are wide and regularly spaced, the umbilicus is large, circular and filled with papillae/bosses. The chambers end abruptly against the umbilicus. 1. SN786 x 160. 2. SN784 x 141. 3. SN321 x 70. 4. SN316 x 89.

5. *E. excavatum* forma *selseyensis* (Heron-Allen and Earland), SN352 x 102.

6-8. *E. excavatum* forma *clavata* Cushman. These specimens are irregular and ornamented. 6. SN313 x 84. 7. SN356 x 90. 8. SN323 x 63.

9-13. *E. excavatum* forma *lidoensis* Cushman. 9. SN309 x 108. 10. SN310 x 141. 11. SN789 x 167. 12. SN791 x 224. 13. SN306 x 166.

15-16. *E. excavatum* forma *tumidum* Natland. 15. SN305 x 130. 16. Representative plesiotype, SN359 x 140.

17-18. *E. excavatum* forma *gunteri* Cole. No intermediate specimens linking this forma to the other formae were observed. 17. SN304 x 83. 18. SN360 x 81.

19-21. Specimen belived to be *E. excavatum* forma *galvestonensis* Kornfeld. These are not typical specimens; and were tentatively identified with the aid of enlargements (pl. 26:15-16). No intermediate specimens were observed linking this forma to the other formae from this location. These specimens were not included in the statistical analysis. 19. SN325 x 84. 20. SN326 x 147. 21. SN324 x 126.

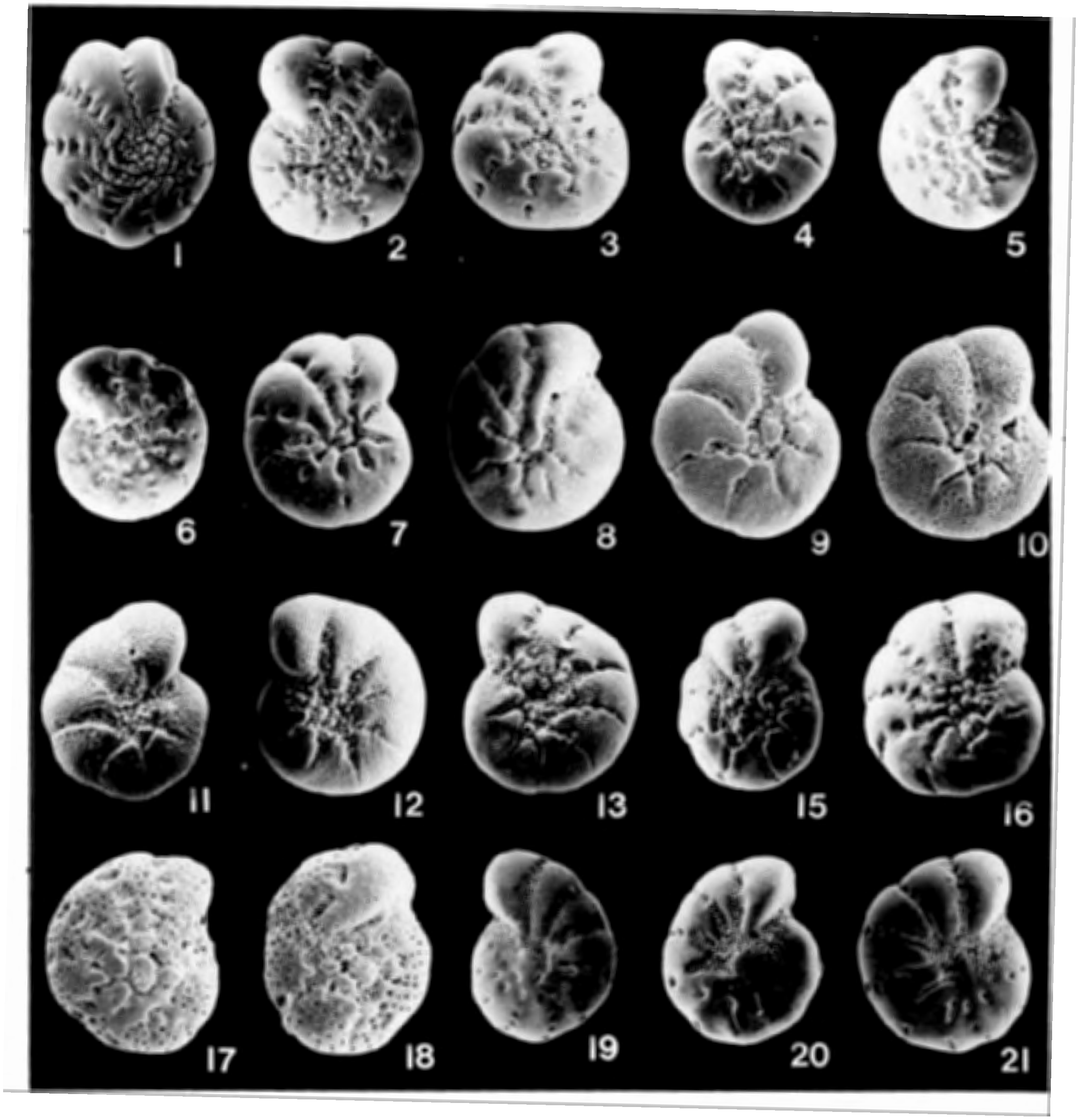
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PLATE 12

Elphidium excavatum (Terquem) an intergradational series of five formae from a Pleistocene assemblage from San Francisco Bay. There is wide variability to the group (seven formae present) and a large degree of ornamentation and irregularity to many of the specimens.

1-3. E. excavatum forma excavata (Terquem). 1. SN751 x 87. 2. SN765 x 85. 3. SN767 x 88.

4-5. E. excavatum forma lidoensis Cushman. 4. SN756 x 98. 5. SN781 x 170.

6. E.. excavatum forma tumidum Natland. An intermediate specimen between forma lidoensis and forma tumidum, with the circular umbilicus and the ponticuli beginning to develop as for the latter form, SN754 x 90.

7-10. E. excavatum forma lidoensis Cushman. 7-8. Two typical specimens. 7. SN760 x 143. 8. SN764 x 189. 9-10. Two irregular ornamented specimens. 9. SN779 x 96. 10. SN753 x 106.

11. E. excavatum forma clavata Cushman, a specimen with an imperforate umbilical collar and sutures not extending externally to the periphery, SN765 x 108.

12. E. excavatum forma excavata (Terquem), SN752 x 89.

13. E. excavatum forma lidoensis Cushman. An irregular specimen, SN778 x 103.

14-15. E. excavatum forma selseyensis (Heron-Allen and Earland). Two irregular specimens. 14. SN761 x 95. 15. SN776 x 95.

16-18. E. excavatum forma gunteri Cole. Irregular specimens. 16. SN773 x 144. 17. SN763 x 130. 18. SN759 x 108.

19. Specimen tentatively identified as *E. excavatum* forma *williamsoni* Haynes ab Williamson, when compared to specimens from a Maine-New Brunswick estuary (pl. 10:1) and from Bay of Izmir, Turkey (pl. 19:16-17). Possibly a juvenile specimen, SN774 x 187.


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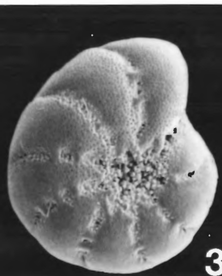
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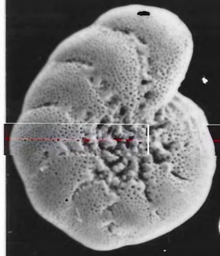
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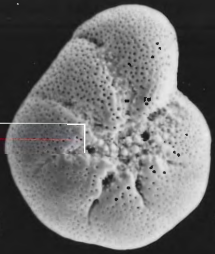
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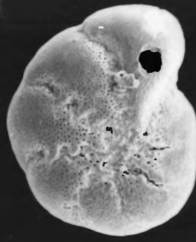
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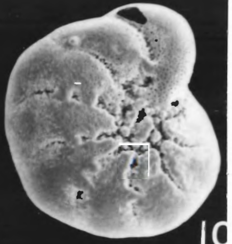
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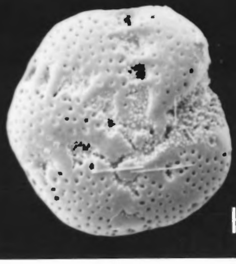
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PLATES 13 - 14

Elphidium excavatum (Terquem) two intergradational series (eight formae present) from a mid-Holocene assemblage from Baie Verte, Northumberland Strait, Canada. At no other location has such variability or ornamentation been observed in the *E. excavatum* group. This location also had the largest percentage of intermediate forms.

PLATE 13

1-2. *E. excavatum* forma *gunteri* Cole. 1. SN154 x 107. 2. SN153 x 105.

3-5. *E. excavatum* forma *clavata* Cushman, ornamented specimens. 3. SN128 x 62. 4. SN129 x 93. 5. SN130 x 93.

6-7. *E. excavatum* forma *cuvillieri* Lévy, specimens lacking the smooth umbilicus typical of the morphotype. 6. SN131 x 68. 7. SN132 x 63.

8-9. *E. excavatum* forma *clavata* Cushman. 8. SN133 x 76. 9. SN134 x72.

10. *E. excavatum* forma *excavata* (Terquem), SN135 x 57.

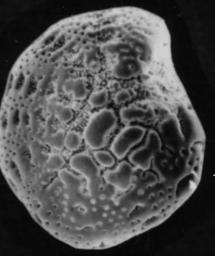
11. *E. excavatum* forma *lidoensis* Cushman, SN136 x 93.

12-15. *E. excavatum* forma *selseyensis* (Heron-Allen and Earland). 12. A specimen approaching forma *tumidum*, SN137 x 81. 13. SN138 x 61. 14. SN139 x 82. 15. An intermediate specimen approaching forma *excavata*, SN140 x 96.

16. *E. excavatum* forma *clavata* Cushman, SN143 x 82.

17-20. *E. excavatum* forma *galvestonensis* Kornfeld. 17. An intermediate specimen between forma *clavata* and forma *galvestonensis*.

The pores are of intermediate density and the ponticuli not strongly developed. The umbo is not fully raised as typical for forma galvestonensis, SN142 x 94. 18-20. Typical specimens. 18. SN160 x 82. 19-20. Etched and broken specimens. 19. SN163 x 59. 20. SN164 x 69.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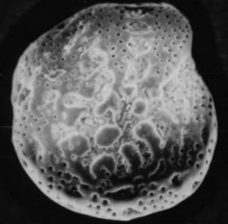
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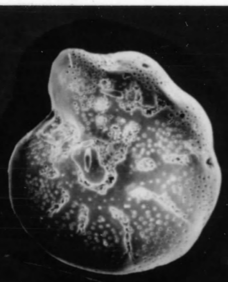
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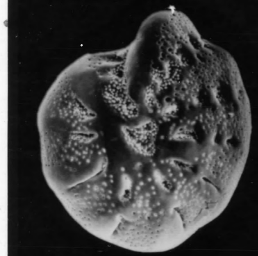
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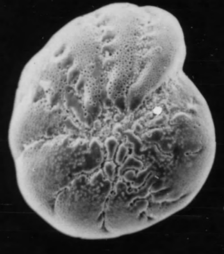
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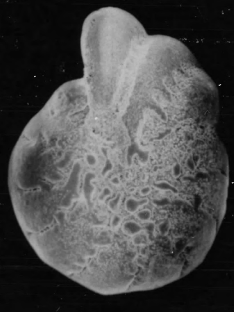
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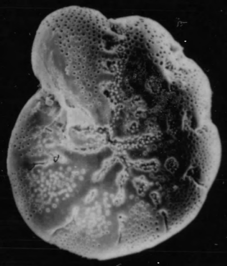
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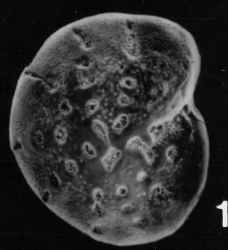
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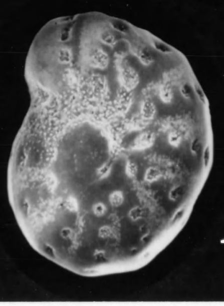
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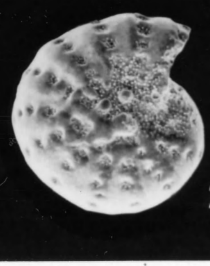
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PLATE 14

1-3. *E. excavatum* forma *gunteri*. 1-2. Typical specimens. 1. SN176 x 94. 2. SN184 x 121. 3. Intermediate specimen, between forma *gunteri* and forma *clavata*, SN231 x 96.

4-5. *E. excavatum* forma *clavata* Cushman. 4. SN252 x 119. 5. SN234 x 88.

6-7. *E. excavatum* forma *cuvillieri* Lévy. 6. An intermediate specimen between forma *clavata* and forma *cuvillieri*, SN167 x 86. 7. SN245 x 80.

8-9. *E. excavatum* forma *selseyensis* (Heron-Allen and Earland). 8. SN170 x 70. 9. SN239 x 77.

10. *E. excavatum* forma *lidoensis* Cushman, an ornamented specimen, SN255 x 94.

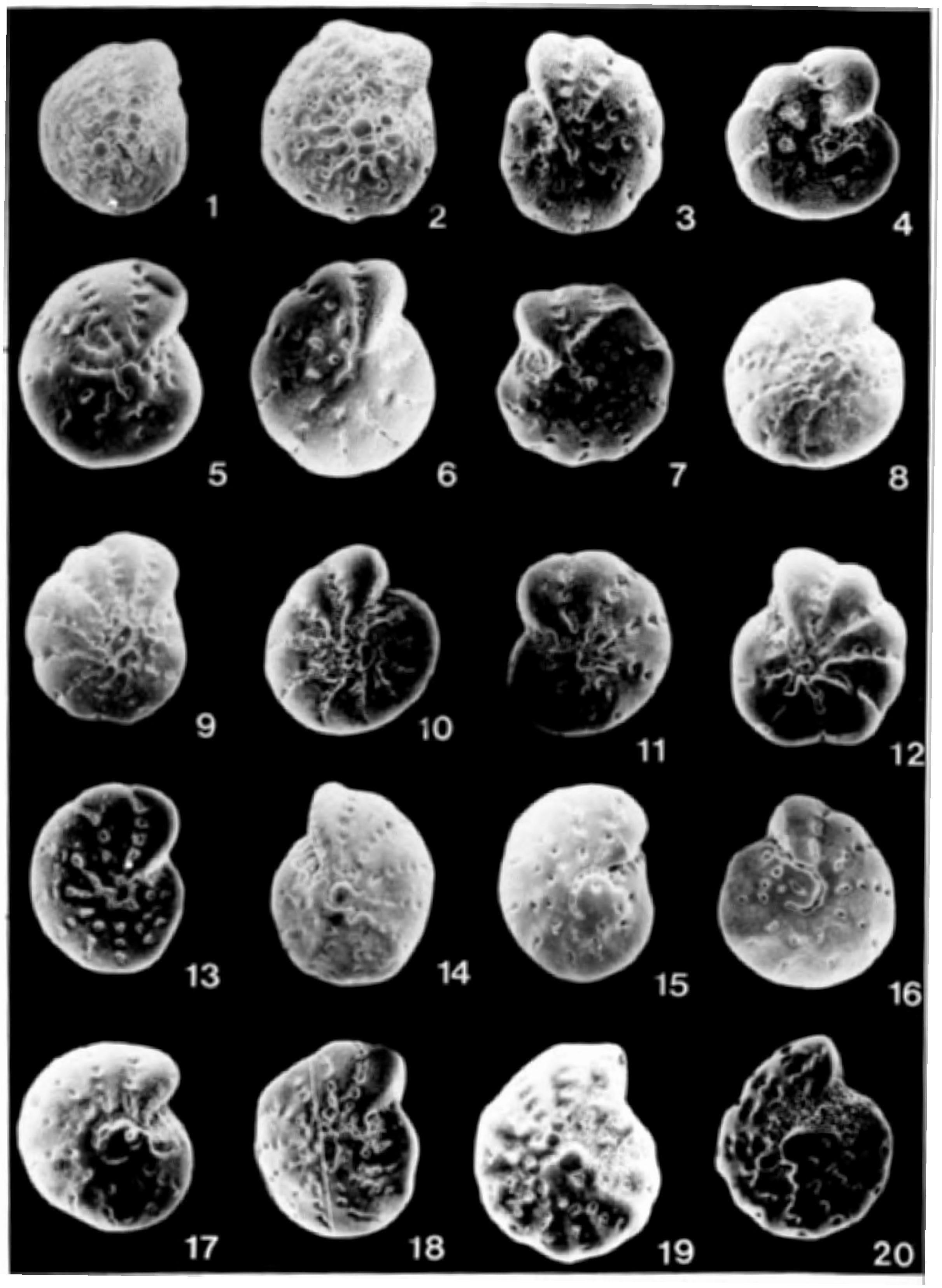
11-12. *E. excavatum* forma *excavata* (Terquem), irregular specimens. 11. SN243 x 87. 12. SN232 x 99.

13-14. *E. excavatum* forma *clavata* Cushman. 13. SN246 x 99. 14. SN240 x 63.

15-17. *E. excavatum* forma *magna* Miller, Scott and Medioli. 15. SN237 x 81. 16. SN242 x 74. 17. SN230 x 89.

18. *E. excavatum* forma *selseyensis* (Heron-Allen and Earland), SN249 x 56.

19-20. *E. excavatum* forma *galvestonensis* Kornfeld. 19. SN179 x 83. 20. SN260 x 132.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PLATES 15 - 16

Elphidium excavatum (Terquem), from a population from San Antonio Bay, Texas.

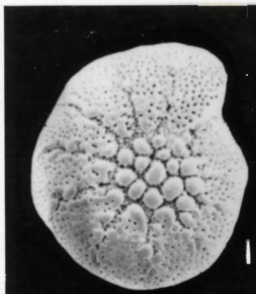
PLATE 15

An intergradational series of the two dominant formae, E. excavatum forma gunteri and forma lidoensis. Note the gradual morphological changes from one forma to the other, through the specimens illustrated. This location has the largest number of intermediate forms linking these two formae.

1-7. E. excavatum forma lidoensis Cushman. These warmer water specimens are more coarsely perforate than those specimens seen in maritime Canada and the northeastern United States. 1. SN705 x 98. 2. SN718 x 126. 3. SN680 x 94. 4. SN728 x 118. 5-7. Intermediate specimens exhibiting characteristics of both formae. If not for the coarse perforations, these three specimens could be identified as forma excavata. 5. SN750 x 149. 6. SN727 x 133. 7. SN724 x 107.

8-15. E. excavatum forma gunteri Cole. Typical specimens of the forma. 8. SN741 x 101. 9. Note the variation in the size and shape of the ponticuli from one suture to another, representative plesiotype SN744 x 101. 10. SN748 x 62 11. SN729 x 66. 12. SN703 x 91. 13. SN723 x 108. 14. SN733 x 126. 15. SN719 x 115.

16-20. E. excavatum forma lidoensis Cushman. 16. SN697 x 189. 17. SN691 x 157. 18. SN676 x 10 . 19. SN735 x 118. 20. SN786 x 117.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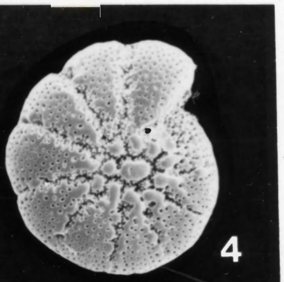
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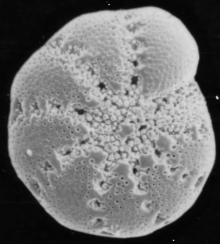
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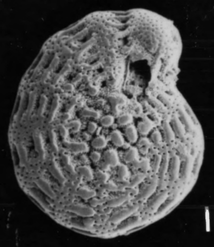
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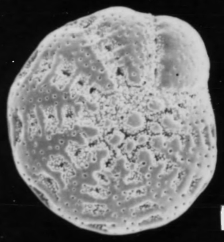
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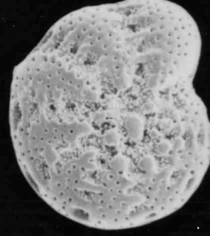
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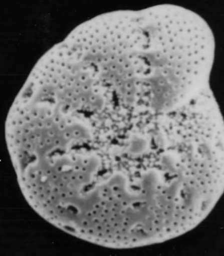
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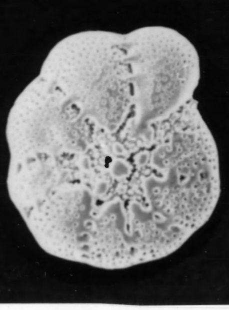
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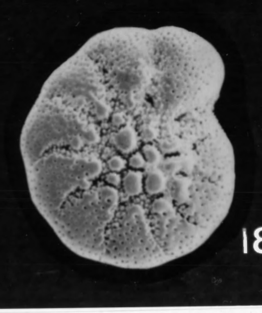
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PLATE 16

The two other formae of E. excavatum identified in San Antonio Bay samples. No intermediate specimens were found linking these two formae to the other forma present or the remainder of the E. excavatum group.

1-8. E. excavatum forma galvestonensis Kornfeld. Typical specimens of this forma. 1. SN701 x 77. 2. SN797 x 83. 3. Representative plesiotype, SN795 x 49. 4. SN796 x 54. 5. SN900 x 62. 6. SN700 x 66. 7. SN720 x 65. 8. SN748 x 63.

9-14. E. excavatum forma cuvillieri Lévy. 9. SN690 x 142. 10. SN737 x 146. 11. SN725 x 123. 12. SN726 x 115. 13. SN696 x 144. 14. SN742 x 127.

15. Elphidium sp., not included in the analysis, SN710 x 134.


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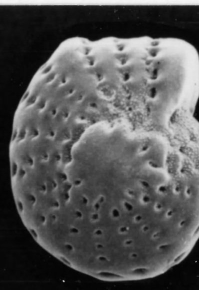
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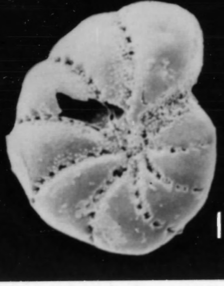
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PLATE 17

Elphidium excavatum (Terquem), two formae observed in a Holocene assemblage from the Wadden Sea, the Netherlands. One forma (*E. excavatum* forma *williamsoni*) comprised over 95% of the population. There were no intermediate specimens observed.

1-12. *E. excavatum* forma *williamsoni* Haynes ab Williamson. 1. SN393 x 125. 2. SN392 x 125. 3. SN395 x 101. 4. SN397 x 130. 5. SN417 x 94. 6. SN408 x 86. 7. SN377 x 79. 8. SN396 x 82. 9. SN336 x 97. 10. SN402 x 80. 11. SN420 x 78. 12. SN375 x 93.

13-15. *E. excavatum* forma *gunteri* Cole. 13. Typical specimen, SN425 x106. 14-15 Etched specimens. 14. SN424 x 110. 15. Intermediate specimen, approaching forma *lidoensis*, SN426 x 123.


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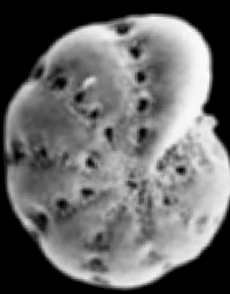
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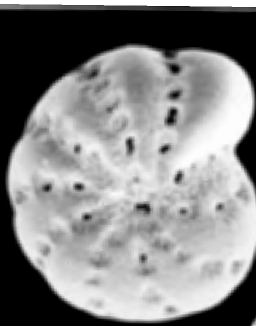
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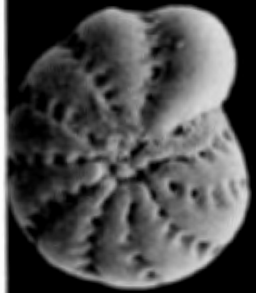
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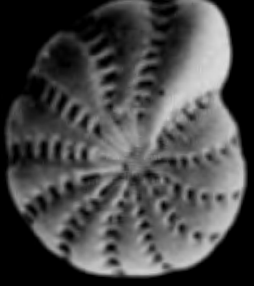
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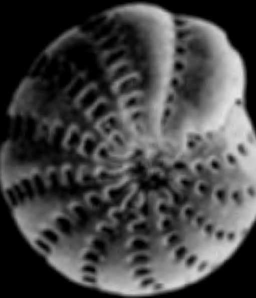
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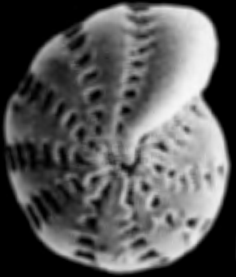
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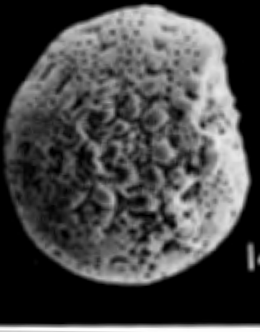
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PLATE 18

Elphidium excavatum (Terquem), from a population from Venice Lagoon, Italy. Four formae are identified and one other is tentatively identified.

1-4. *E. excavatum* forma *gunteri* Cole. 1. Typical specimen, SN629 x 159. 2. SN622 x 131. 3. SN617 x 181. 4. Intermediate specimen approaching forma *lidoensis*, SN619 x 123.

5-7. *E. excavatum* forma *lidoensis* Cushman. 5. SN623 x 137. 6. SN369 x 83. 7. SN633 x 158.

8-15. *E. excavatum* forma *cuvillieri* Lévy. Note the variation in the umbilical regions, sutures, and ponticuli. No intermediate specimens were found linking this forma to other members of the group. 8. SN368 x 87. 9. SN630 x 144. 10. SN384 x 79. 11. SN627 x 116. 12. SN616 x 75. 13. SN635 x 95. 14. SN385 x 71. 15. SN380 x 51.

16,18. *E. excavatum* forma *galvestonensis* Kornfeld. Specimens tentatively identified by comparison with specimens from San Diego Bay and not included in the analysis. No intermediate specimens were found linking this forma to other members of the group. 16. SN387 x 125. 18. SN388 x 120.

17. *E. excavatum* forma *williamsoni* Haynes ab Williamson, SN662 x 106.


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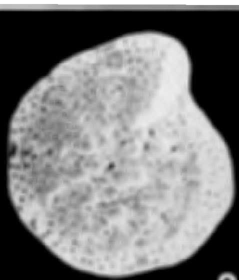
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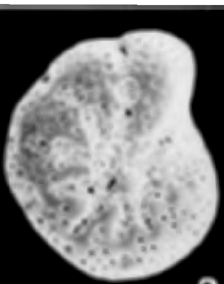
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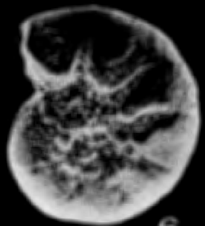
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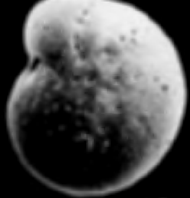
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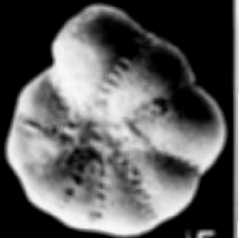
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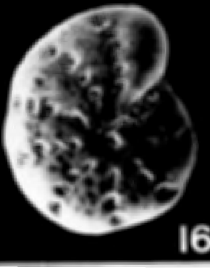
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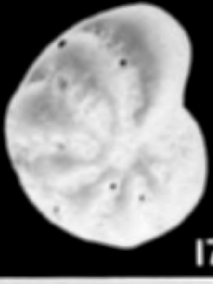
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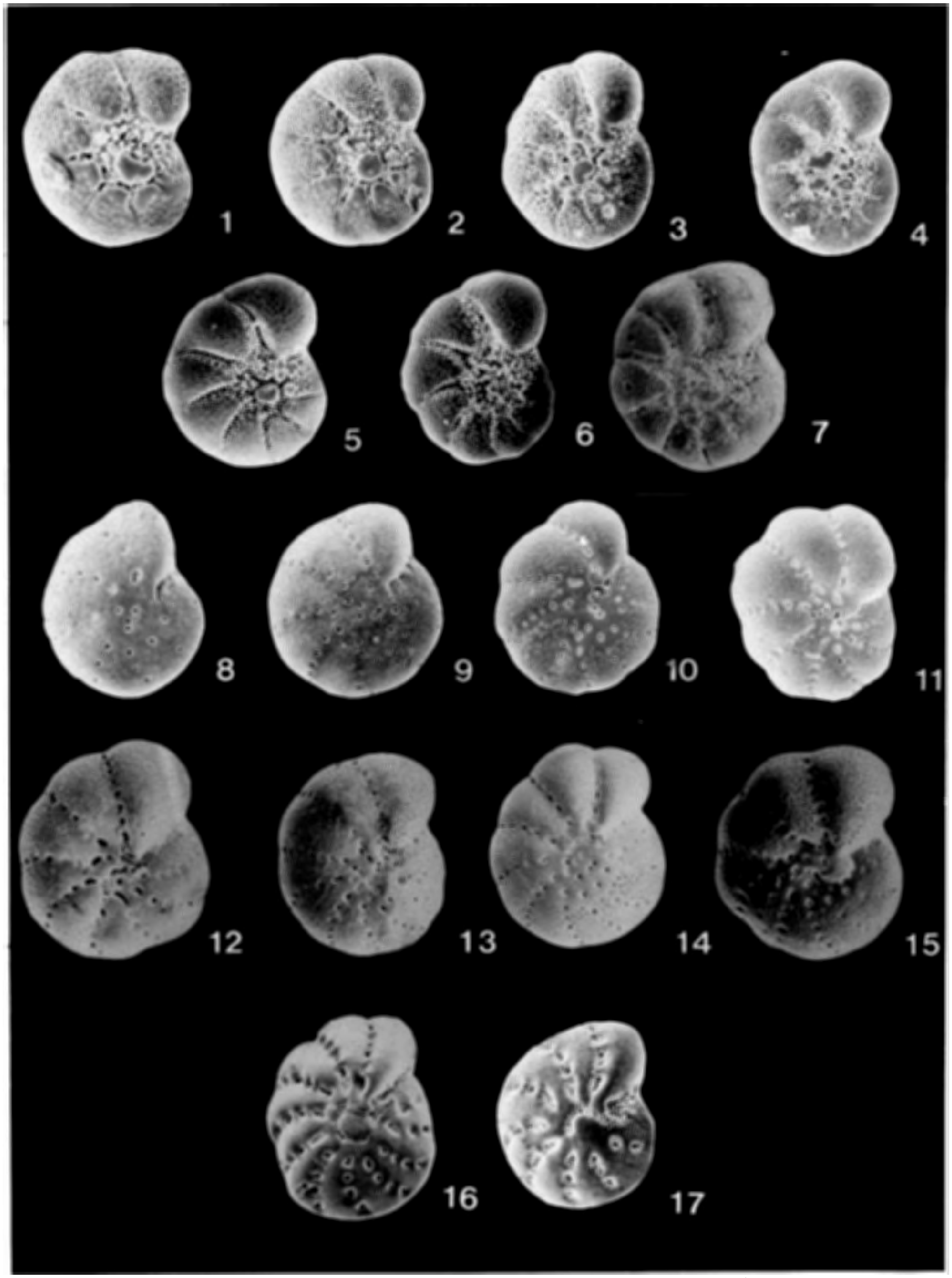
PLATE 19

E. excavatum (Terquem) from a late Pleistocene assemblage, from the Bay of Izmir, Turkey. Three formae were observed, but no intermediate specimens linking these three formae to one another or to other members of the group were observed.

1-7. E. excavatum forma lidoensis Cushman. 1. SN16 x 212. 2. SN75 x124. 3. SN204 x 121 4. SN247 x 87. 5. SN259 x 76. 6. SN265 x 102. 7. SN607 x 66.

8-15. E. excavatum forma cuvillieri Lévy. 8. SN299 x 186. 9. SN329 x 86. 10. SN330 x 84. 11. SN333 x 80. 12. SN581 x 81. 13. SN578 x 70. 14. SN580 x 79. 15. SN590 x 97.

16-17. E. excavatum forma williamsoni Haynes ab Williamson 16. SN661 x 96. 17. SN324 x 137.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PLATES 20-28

The following 9 plates illustrate the morphological features of, and variation within, each morphotype of E. excavatum.

The following code of letters has been used on these plates (plus plate 30), to designate these morphological features.

a	umbilicus
b	suture
c	umbilical boss
d	imperforate umbilical collar
e	papillae
f	ponticulus
g	retral process pit
h	umbilical aperture
i	sutural pore
j	apertural face
k	interiomarginal apertural arches
l	fossette
m	foramen
n	chamber

PLATE 20

Elphidium excavatum forma excavata Terquem. Note the lobate peripheral outline, straight intercameral sutures which extend to the umbilicus and contain papillae, and the absence of an imperforate umbilical collar.

1-2. Recent specimens from Miramichi estuary, equatorial views. 1. SN123 x 77. 2. SN120 x 81.

3. Recent specimen from Annapolis Basin, equatorial view, SN64 x 78.

4-7. Recent specimens from Long Island Sound. 4-6. Equatorial views. 4. SN537 x 96. 5. SN536 x 82. 6-7. SN540, an intermediate specimen approaching forma selseyensis. 6. x 71. 7. Enlargement showing the wall porosity, chambers, umbilicus, imperforate ponticuli, intercameral sutures, and papillae, x 358.

8-10. Pleistocene specimens from San Francisco Bay. 8-9. Equatorial views. 8. SN757 x 88. 9-10. SN768. 9. x 113. 10. Enlargement of the ultimate intercameral suture, showing ponticuli and sutural papillae, x 454.

11. Enlargment of a specimen (equitorial view illustrated by Miller 1979, Pl. 1:1; Pl. 2:1; Miller et al. 1982, Pl. 2:10, Pl. 3:1, Pl. 4:1) from the Labrador Shelf (Late Pleistocene in age). Note the excavated umbilicus, straight intercameral sutures extending to the umbilicus, and lack of imperforate umbilical collar, SN1 x 480.

12. Recent specimen from Chezzetcook Inlet, intermediate specimen approaching forma lidoensis, SN296 x 106.


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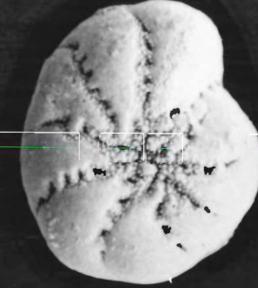
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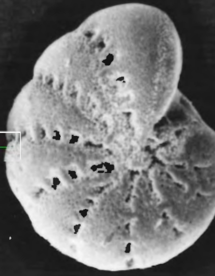
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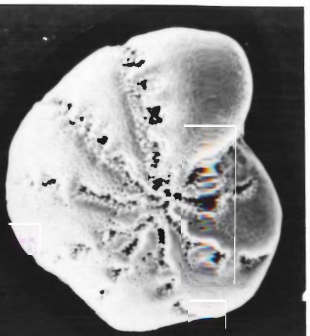


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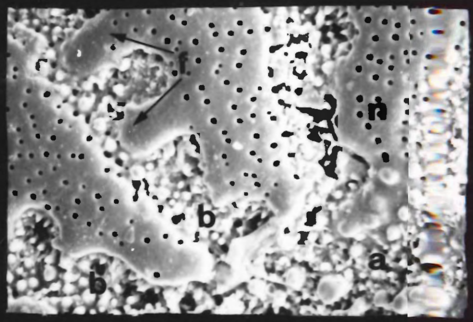

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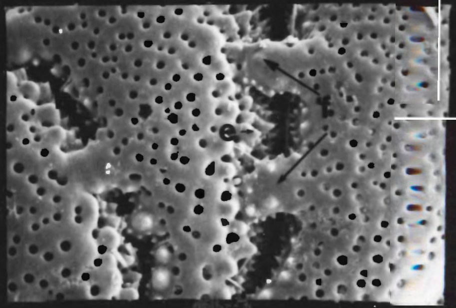

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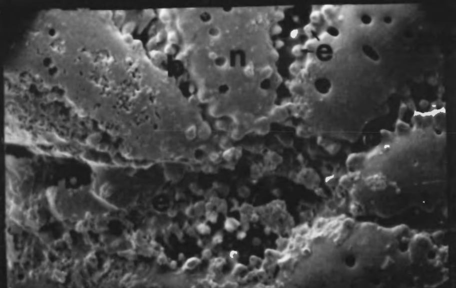

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PLATE 21

Elphidium excavatum forma williamsoni Haynes ab Williamson. This form is characterized by the inflated chambers, smooth peripheral outline, and numerous large, well developed, regular ponticuli. The ponticuli extend across the periphery, the walls are very finely perforate, and an boss may be present.

1-3. Recent specimens from a Maine-New Brunswick estuary. 1-2. Representative plesiotype of the forma. 1. Equatorial view; note partially formed umbilical boss, SN471 x 69. 2. Detail of the ultimate intercameral suture of the same specimen showing finely perforate wall, suture, papillae in the suture and the regularity of the ponticulli, x 347. 3. Juvenile specimen (?) with a umbilical boss, SN438 x 101.

4. Late Pleistocene specimen from San Francisco Bay, juvenile specimen (?) with partially formed umbilical boss, SN774 x 143.

5-6. Recent specimens from Chezzetcook Inlet, Nova Scotia; equatorial views. 5. SN209 x 60. 6. SN297 x 54.

10-11. Recent specimens from Bay of Chaleur. Both have umbilical bosses. 10. SN279 x 83. 11. SN270 x 56.

7-9, 12-24. Holocene specimens from the Wadden Sea, Netherlands. 7, 12-13. SN897. 7. Peripheral view of the apertural face. Note the ponticuli extending across the periphery, x 70. 8-9. SN361. 8. Equatorial view, x 48. 9. Detail of the intercameral suture and regular ponticuli, x 274. 12. Detail of the apertural face showing papillae and the cribrate interiomarginal apertures, x 129. 13. Detail of the interiomarginal apertural arches, x 261.

14-15, 19. SN418. 14. Equatorial view, showing broken ultimate chamber and outer wall of the previous chamber underneath, x 54. 15,19. Interior of the broken ultimate chamber wall, showing the septal wall structure and previous interiomarginal apertual arches, x 467, and x 354, respectively.

16-18. SN375. 16. Equatorial view, x 57. 17-18. Detail of the intercameral suture, showing the finely perforate wall, regular ponticuli, and spinose sutural papillae. 17. x 371. 18. x 530.

20-21. SN378. 20. Equatorial view, x 61. 21. Enlargement of the umbilicus, and intercameral suture extentions into the umbilicus, x 308.

22-24. SN405. 22. Equatorial view, with broken ultimate chamber, x 50. 23. Interior of the ultimate chamber wall, viewed from the inside, illustrating the perforations extending through the wall, x 121. 24. Retral process pits (inside the hollow ponticuli) which house the cytoplasm of the retral processes, x 397.

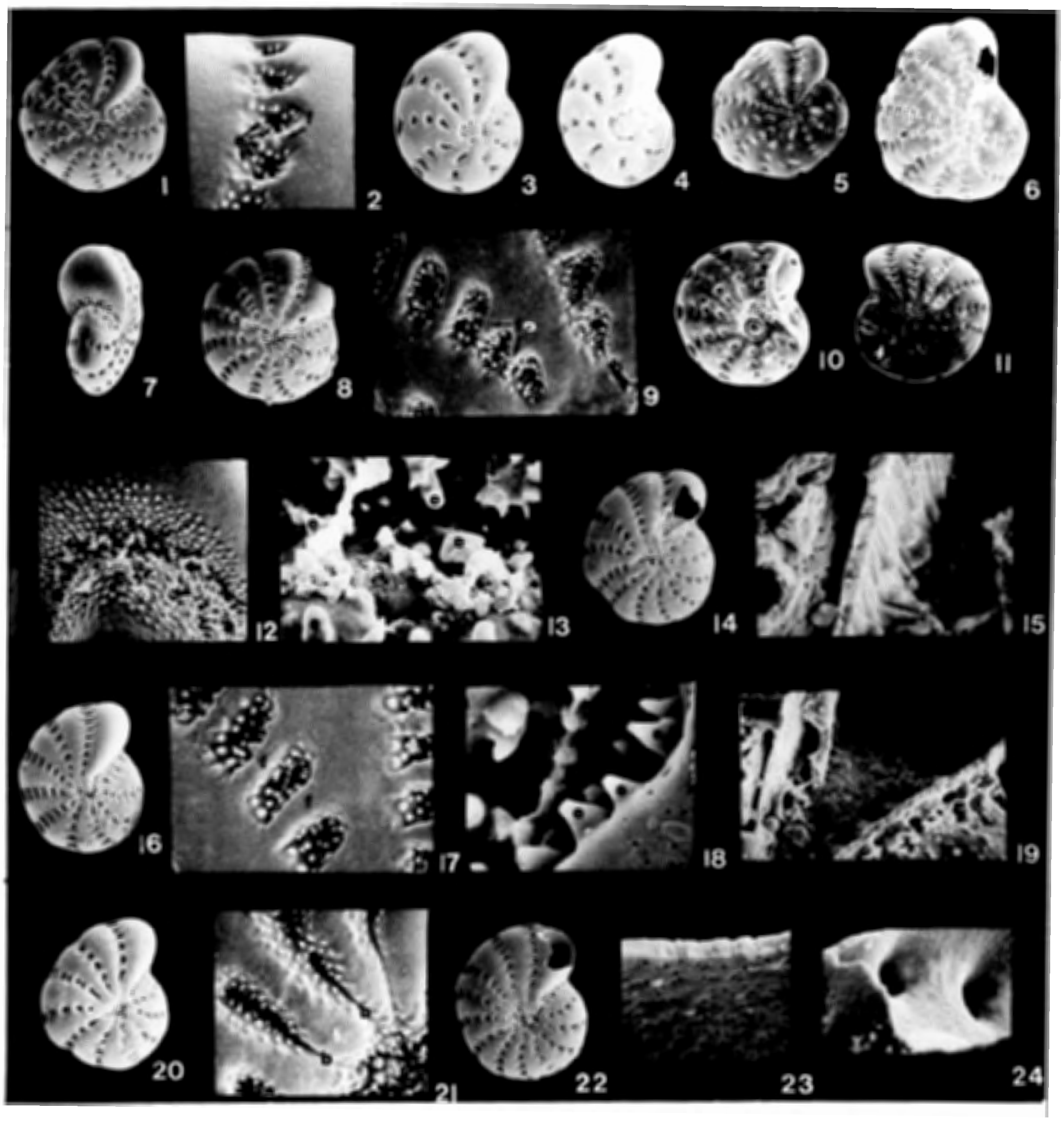
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PLATE 22

Elphidium excavatum forma selseyensis (Heron-Allen and Earland).

1-3. Recent specimens from Long Island Sound. Note the development (particularily the thickness) and regularity of the ponticuli, and the fine papillae in the umbilici and intercameral sutures. 1-3. Equatorial views. 1. SN534 x 48. 2. SN560 x 50. 3-4. SN103. 3. x 73. 4. Detail of the umbilicus, umbilical papillae, chamber extentions into the umbilicus, and intercameral sutures extending into the umbilicus, x 427. 5-6. SN567. 7-8. SN98. 5,7. Equatorial views, x 58, and x 52, respectively. 6,8. Enlargements of intercameral sutures filled with thick imperforate ponticuli and papillae, so the suture is only visible in the horizontal slits (8); x 479, and x 261, respectively.

9-13. Equatorial views. 9. SN553 x 77. 10. SN562 x 73. 11. SN557 x 67. 12. SN558 x 69. 13. SN101 x 72.

14-18. Holocene specimens from Baie Verte, Northumberland Strait. 14-15. SN149. 14. Equatorial view, x 88. 15. Detail of the umbilical region, showing umbilical papillae and bosses, and the perforate chamber wall, x 226. 16. Equatorial view, SN647 x 68.

17-18. SN139, oblique-axial view, penultimate septal face (ultimate chamber removed) showing previous interiomarginal apertures, x 54, and x 128, respectively.

19. Recent specimen, from Chezzetcook Inlet, SN200 equatorial view, x 59.


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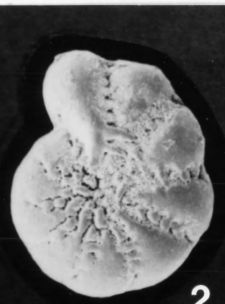
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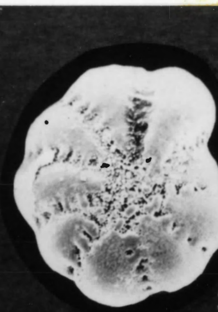
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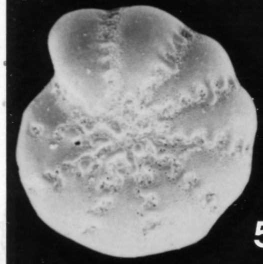
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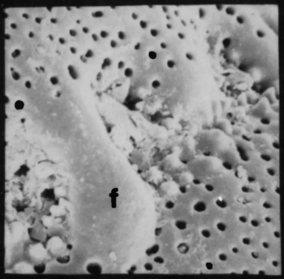
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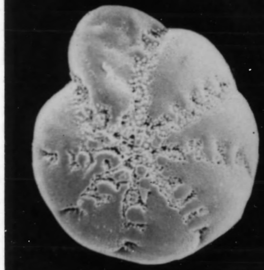
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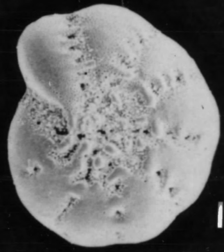
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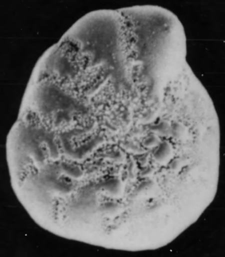
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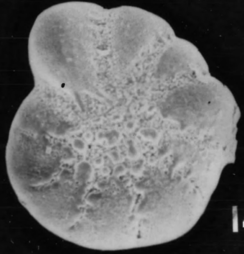
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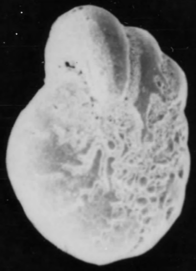
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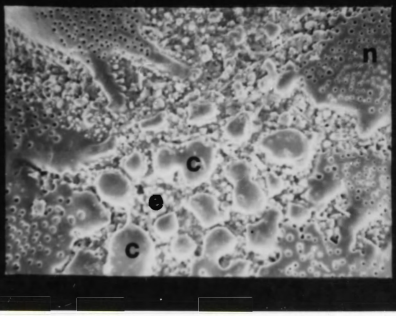
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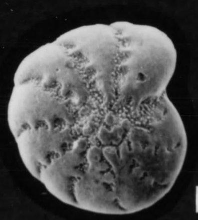
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PLATE 23

Elphidium excavatum forma clavata Cushman. Note the smooth peripheral outline, curved depressed intercameral sutures, complete or incomplete umbilical boss(es) and imperforate umbilical collar. The ponticuli are irregular and often poorly developed.

1. Late Pleistocene specimen from Hirtshals, Denmark, equatorial view, SN89 x 76.

2-3. Late Pleistocene specimens from the Champlain Sea, equatorial views. 2. SN484 x 110. 3. SN492 x 108.

4-7. Recent specimens from Miramichi Estuary, New Brunswick. 4-5. SN515. 6-7. SN521. 4,6 Equatorial views. Note coarser porosity and large umbos, 108, and x 119, respectively. 5,7. Enlargement of the umbilical regions. 5. Note the pores in the umbilical boss, x 432. 7. Enlargement of the imperforate umbilical collar, showing fusion of the chamber ends and abrupt truncation of the intercameral sutures, x 475.

8-11,14-19. Holocene specimens from Baie Verte, Northumberland Stait. 8-10. Specimen beginning to approach forma galvestonensis, SN142. 8. Equatorial view, x 90. 9. Enlargement of the umbilical region, x 276. 10. Detail of the umbilicus, showing the smooth imperforate umbo and intercameral suture ending against the imperforate umbilical collar, x 422. 11. Equatorial view, SN229 x 149. 14. Equatorial view, SN246 x 84. 15-17. SN147. 15. Equatorial view, x 79. 16. Umbilical-apertural equitorial view, x 273. 17. Enlargement of the umbilical region with complete ring of papillae, x 259. 18-19. Equatorial views. 18. SN649 x 82. 19. SN658 x 90.

12. Recent specimen from the Annapolis Basin, equatorial view, SN513 x 104.

13. Recent specimens from the Bay of Chaleur, equatorial view, SN281 x 89.

20-21. Recent specimens from San Diego Bay, equatorial views. 20. SN368 x 108. 21. SN301 x 139.


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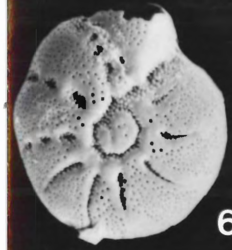
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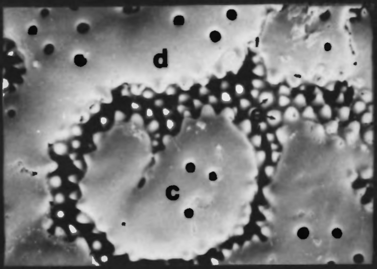

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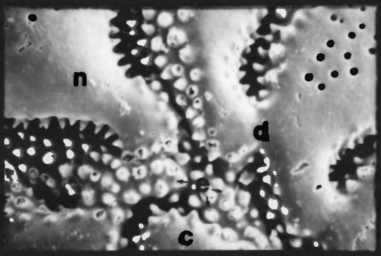

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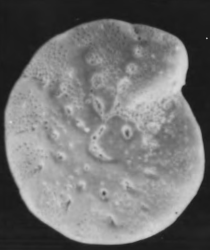
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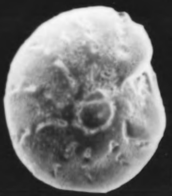
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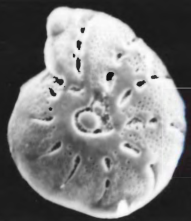
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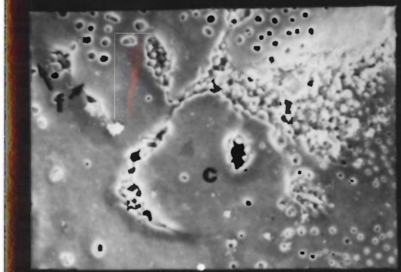

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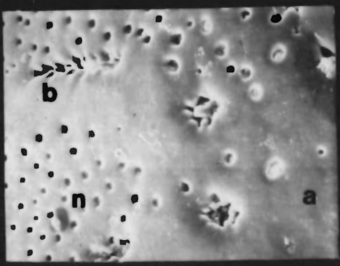

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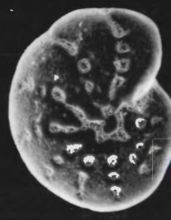
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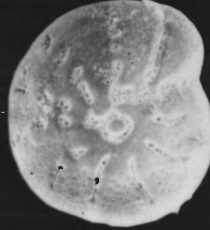
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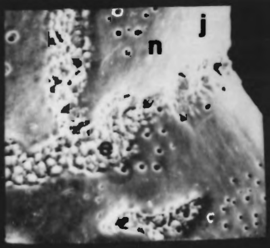

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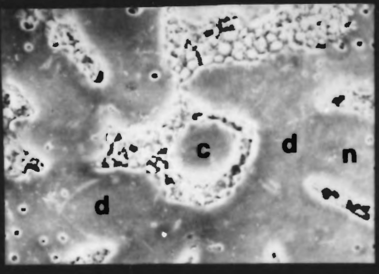

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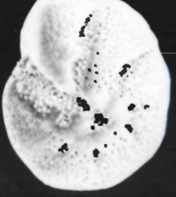
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PLATE 24

Elphidium excavatum forma *gunteri* Cole.

A rotund, inflated form, small to medium sized, with a coarsely perforate wall. The sutures are straight, not depressed, and marked by many regular, raised, rectangular shaped ponticuli. The umbilicus contains papillae/irregular bosses.

1-12. Recent specimens from San Antonio Bay, Texas. 1-3. SN744. 1. Equatorial view, x 96. 2-3. Detail of the chamber walls, illustrating the coarse porosity and umbilical bosses and papillae. 2. "Poorly" developed ponticuli on the ultimate intercameral suture, x 251. 3. "Strongly" developed ponticuli on earlier intercameral sutures of the same specimen. The ponticuli are so closely spaced that the suture appears as a horizontal slits between ponticuli, x 274. 4,8. SN696. 4. Equatorial view, x 62. 8. Unusual ponticuli, appearing as bosses in the intercameral suture, x 419. 5-7. Representative plesiotype, SN745. 5. Equitorial view, specimen with raised umbilicus, x 91 . 6. Oblique-axial view of the apertural face, showing the foramen and the ponticuli extending across the periphery, x 94. 7. Detail of the interiomarginal apertural arches, x 350. 9-10. Equatorial views. Note the width of the ponticuli as a contrast to the width of the chamber wall, 9. SN730 x 57. 10. SN743 x 59. 11-12. SN715. 11. Equatorial view, x 82. 12. Peripheral-umbilical view showing detail of the intercameral sutures and umbilicus, x 250.

13. Recent specimen from San Diego Bay, equatorial view, x 131.

14-20. Holocene specimens from Baie Verte, Northumberland

Strait. 14-16. SN154. 14. Equatorial view, x 106. 15-16. Detail of (15) the chamber wall, x 370; and (16) the umbilicus, x 419. 17-18. SN153. 17. Equatorial view, x 98. 18. Enlargement of umbilical bosses and papillae, x 343. 19-20. Equatorial views. 19. SN670 x 85. 20. An intermediate specimen, providing a morphological link between forma *clavata* and forma *gunteri*, SN231 x 83.

21-24. Equatorial views. The ponticuli are not as well developed on these speciments. 21. Late Pleistocene specimen from San Francisco Bay, SN773 x 133.

22-24. Recent specimens from Venice Lagoon. 22. SN634 x 137. 23. SN366 x 97. 24. SN381 x 157.

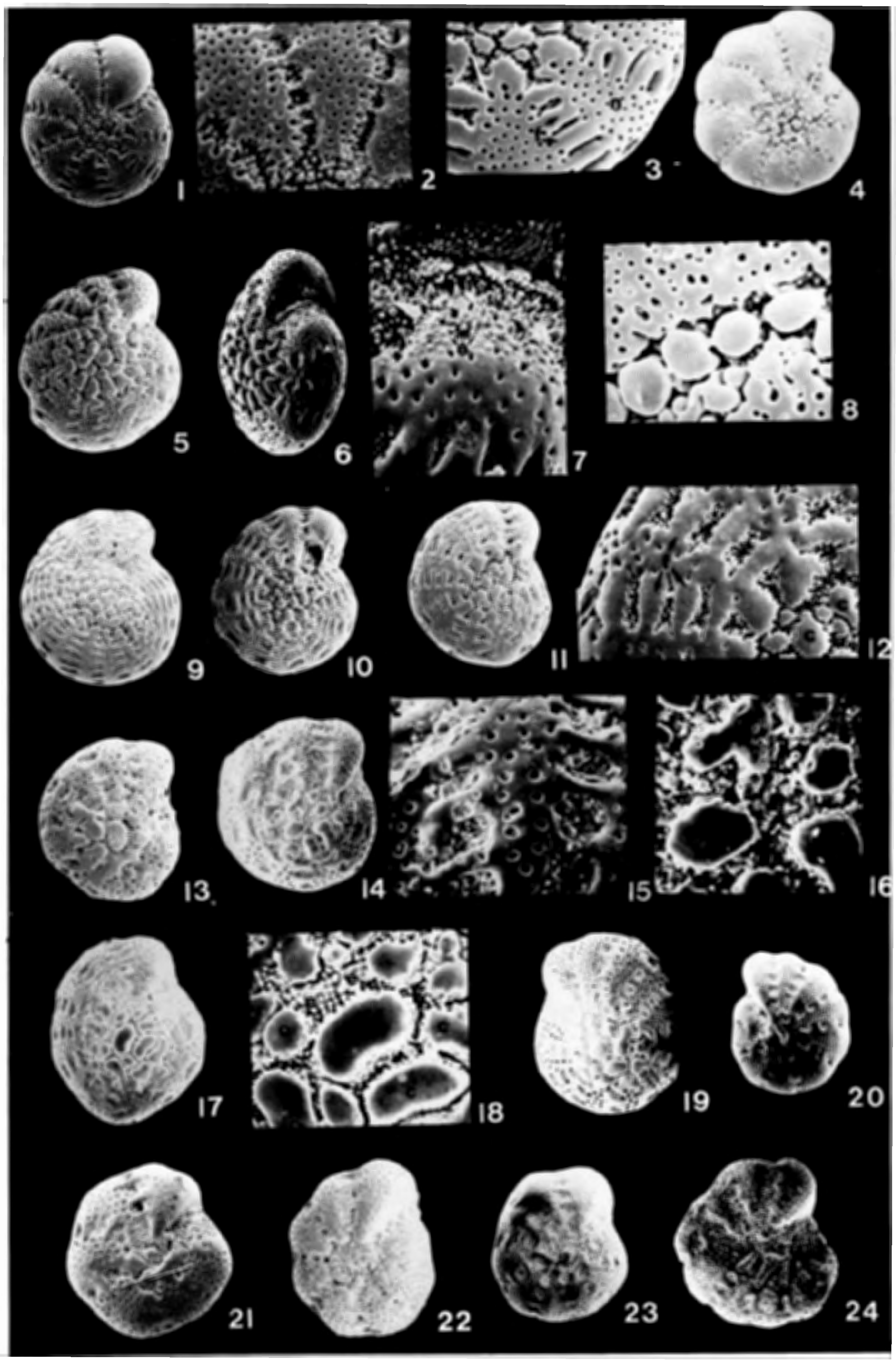
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PLATE 25

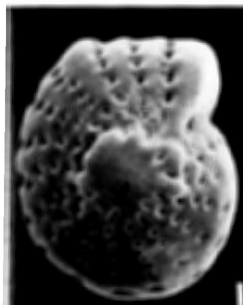
Elphidium excavatum forma *galvestonensis*, Kornfeld.

This is a large, many chambered umbonate form, with many regular, distinct ponticuli. There may be a ring of papillae surrounding the boss or in the sutures. The wall is heavily calcified and very finely perforate.

1-10. Recent specimens from San Antonio Bay. 1-3. Representative plesiotype, SN795. 1. Equatorial view, x 51. 2. Detail of the intercameral suture, chamber wall, and ponticuli, x 325. 3. Enlargement of an etched ponticuli, showing fine porosity extending across the ponticuli, x 1298. 4-7. SN699. 4. Equatorial view, x 61. 5. Enlargement of the umbo, x 306. 6. Detail of papillae in a intercameral suture, x 1088. 7. Detail of papillae on the chamber wall, x 374. 8-9. SN731. 8. Equatorial view, x 151. 9. Intercameral suture, papillae, and umbilical aperture. 10. Equatorial view, SN701 x 86.

11-14. Holocene specimens from Baie Verte, Northumberland Strait. 11. Etched specimen, equatorial view, SN669 x 225. 12,14. Detail of fine wall porosity and imperforate ponticuli. 12. SN161 x 364. 14. SN160 x 282. 13. Equatorial view, SN160 x 94.

15-16. Recent specimens, tentatively identified as this forma; from San Diego Bay, equatorial views. 15. SN324 x 151. 16. SN302 x126.



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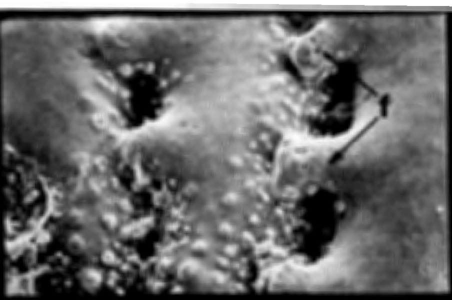

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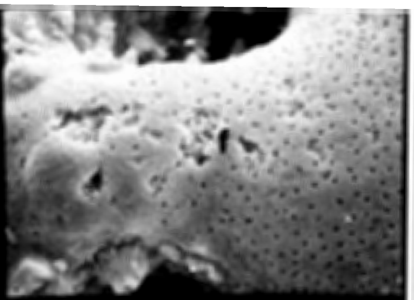

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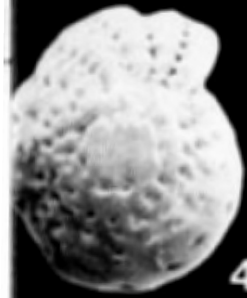

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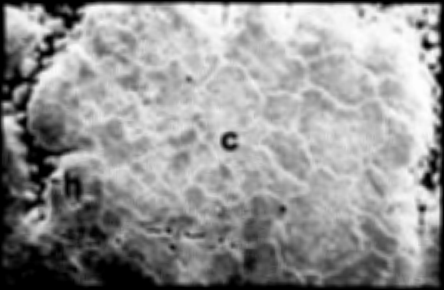

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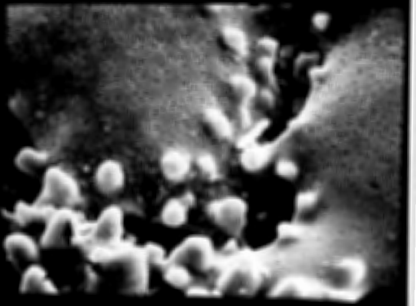

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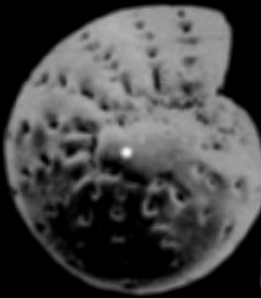

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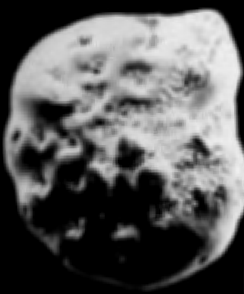

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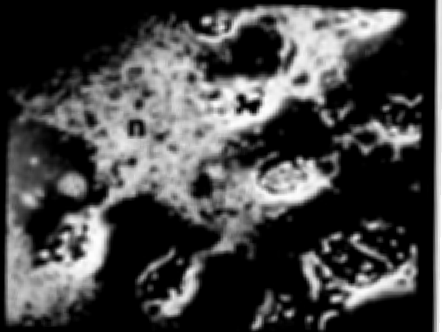

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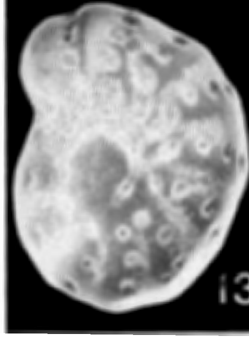

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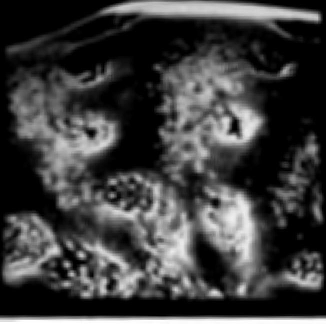

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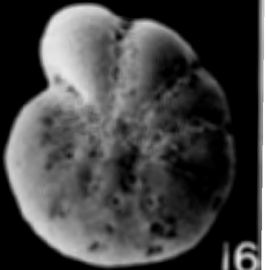

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PLATE 26

Elphidium excavatum forma *lidoensis* Cushman. This is a smaller form, with a large open umbilicus filled with papillae/umbilical bosses. The sutures are backwards curved, distinctly broadening towards the umbilicus and also filled with papillae. The ponticuli are not generally well developed. Within this forma there are two "subforma".

1-2. *E. excavatum* forma *lidoensis*, "boreal" form. This form grades into forma *excavata*, the wall perforations are fine, and the papillae are small. The ponticuli are more strongly developed on this form.

1-3. Recent specimen from Annapolis Basin, SN509. 1. Equatorial view, x 68. 2. Detail of the umbilicus showing umbilical apertures, x 229.

3-5, 10-11. Recent specimens from Long Island Sound. Note the fine porosity, sutures broadening towards the umbilicus, and fine papillae. 3,5. Equatorial views. 3. SN104 x 64. 4. SN545, detail of the umbilical papillae, x 265. 5. SN545, equatorial view, x 71. 10-11. Oblique-axial view of penultimate septal face (ultimate chamber removed), SN546. 10. x 65. 11. Enlargement of the interiomarginal apertural arches and umbilical aperture, x 160.

6. Recent specimen from Chezzetcook Inlet, equatorial view, SN208 x 65.

7-9. Recent specimens from Miramichi Estuary. 7-8. Equatorial views. 7. SN517 x 80. 8. SN117 x 62. 9. Detail of umbilicus, SN117 x 217.

12-13. Holocene specimens from Baie Verte, equatorial views. 12. SN656 x 78. 13. SN639 x 88.

14-32. *E. excavatum* forma *lidoensis*, "Lusitanian" form. This form grades into forma *gunteri*. The periphery is rounded, porosity coarse, and ponticuli not as well developed as in the "boreal" form.

14-19. Recent specimens from San Antonio Bay. 14-16. Representative plesiotype of the "Lusitanian" form, SN717. 14. Equatorial view, x 87. 15. Detail of sutures broadening towards the umbilicus. Compare to figs. 4 and 9; there are less papillae in the sutures of this form, x 271. 16. Enlargement of the umbilicus, note papillae on the edges of the bosses, x 271. 17-18 SN674. 17. Equatorial view, x 155. 18. Umbilical-apertural view, x 421. 19. Equatorial view, x 75.

20-22, 27. Recent specimens from San Diego Bay. 20-21. Equatorial views. 20. Intermediate specimen, approaching forma *tumidum*. Note closed intercameral sutures and lack of papillae, SN359 x 97. 21-22, 27. SN306. 21. Note closed intercameral sutures, x 120. 22. Detail of suture, x 622. 27. Umbilical-apertural view, x 480.

23-25. Recent specimens from Venice Lagoon. 23-24. Equatorial views. 23. SN620 x 90. 24. SN364, note umbilical bosses, x 46. 25. Enlargement of same bosses, x 309.

26. Late Pleistocene specimen from San Francisco Bay, equatorial view, SN762 x 96.

28-32. Late Pleistocene specimens from Bay of Izmir, Turkey. 28-31. SN579. 28. Equatorial view, x 51. 29. Detail of intercameral suture, lacking papillae and broadening towards the umbilicus, x 368.

30. Detail of another suture with papillae, x 275. 31. Umbilical bosses with papillae, x 342. 32. Equatorial view, SN612 x 64.

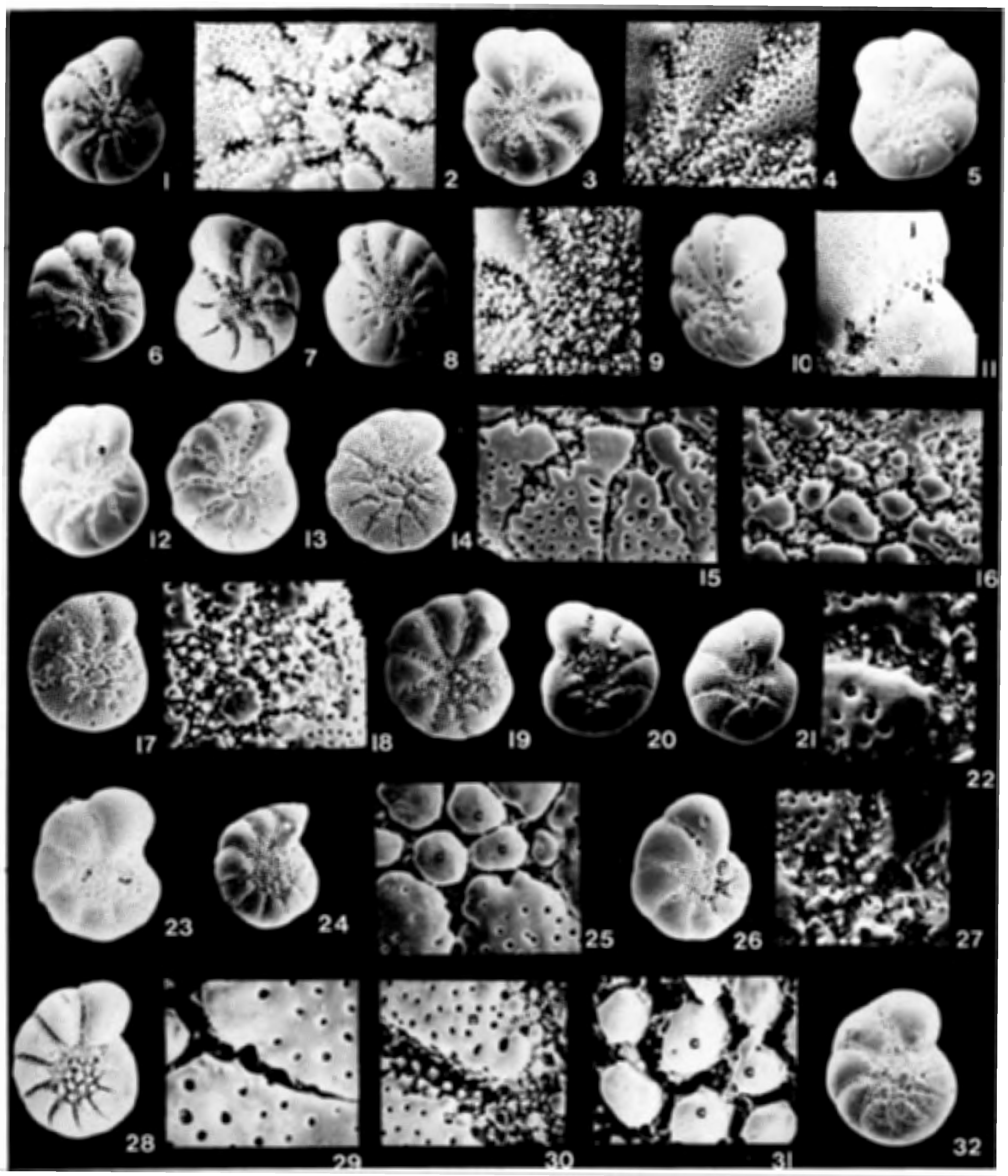
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PLATE 27

1-11. Elphidium excavatum forma magna. This form is recognized by its larger size, smooth peripheral outline, subacute periphery, and strongly convex walls, which give the umbilicus a raised appearance. The umbilicus is usually large and filled with one knobby boss. The sutures are backwards curved, and some (or all) may be constricted before reaching the umbilicus.

1-4. Recent specimens from Chezzetcook Inlet. 1-3. Equatorial views. 1. SN214 x 95. 2. SN198 x 62. 3. SN899 x 78. 4. Axial view, illustrating the subacute periphery, SN898 x 84.

5-8,11. Recent specimens from the Scotian Shelf. 5,7,11. Equatorial views. 5-6. SN911. 5. x 70. 6. Enlargement of the umbilicus showing ring of papillae inside the imperforate collar, x 58. 7-8. SN906. 7. x 299. 8. Detail of the intercameral sutures ending in the umbilicus, x 198. 11. SN910 x 60.

9-10. Late Pleistocene specimens from the Champlain Sea. 9. Oblique-axial view of the penultimate septal face (ultimate chamber removed) showing an interiomarginal apertural arch, SN603 x 151. 10. Equatorial view, SN486 x 107.

12-19. Elphidium excavatum forma tumidum. This is a large, ornamented form resembling forma selseyensis, but the ornamentation and ponticuli are much more regular on forma tumidum. The umbilicus is large, circular, depressed, and filled with papillae/bosses. The chamber extensions into the umbilicus are truncated sharply. The periphery is broadly rounded and the chambers inflated. Recent specimens from San Diego Bay. 12-13. SN355. 12. Equatorial view, x

79. 13. Enlargment of the umbilicus, x 394. 14. Equatorial view, SN317 x 107. 15. Representative plesiotype of the forma, SN360 x 85. 16. Equatorial view, SN304 x 94. 17. Equatorial view, SN315 x 84. 18-19. Etched specimen, SN351. 18. Equatorial view, x 84. 19. Detail of etched umbilicus, x 420.

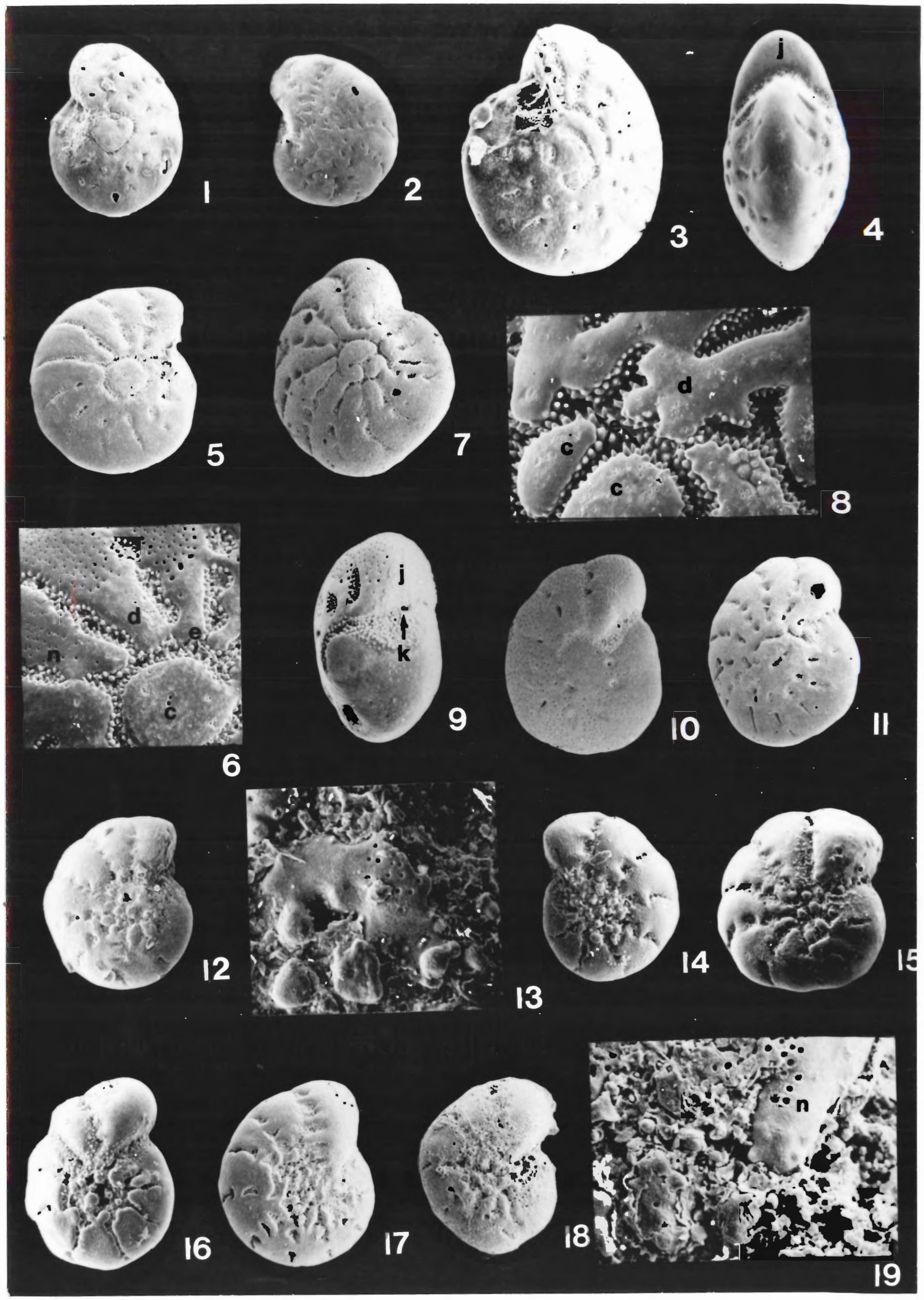
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PLATE 28

Elphidium _excavatum_ forma _cuvillieri_ Lévy. This is a smooth, round disc shaped _Elphidium_ about the same size as form _clavata_. The peripheral outline can range from smooth to very lobate. The sutures are straight or gently backwards curved, and characterized by very regular rows of sutural pores.

1-10,12,15. Late Pleistocene specimens from the Bay of Izmir, Turkey. 1,3,5,6,8,10,15 Equatorial views. 1-2. SN548. 1. x 70. 2. Enlargement of the umbilicus, x 220. 3-4. SN576. 3. x 81. 4. Umbilical-axial view (turned sideways); interiomarginal apertural arches visible, x 306. 5. SN577 x 71. 6-7. SN586. 6. x 75. 7. Enlargement of the intercameral suture, appearing as slits or pores between ponticuli. 8. Representative plesiotype, SN347 x 74. 9. SN584 x 98. 10. SN591 x 89. 12. SN580, (pl. 19:14), enlargement of the umbilicus showing apertural aperture, x 312. 15. SN344 x 62.

11,13-14,16-21. Recent specimens from Venice Lagoon. 11. Enlargement of a perforate umbilicus, SN368 (pl. 18:8), x . 13-14. SN376. 13. Peripheral (axial) view of the penultimate septal face, (ultimate chamber removed), x 64. 14. Detail showing the interiomarginal apertural arches and retral process pits, x 207. 16-18. SN380. 16. Equatorial view, x 411. 17. Enlargement of the umbilicus, x 155. 18. Detail of the intercameral suture, x 218. 19. Equatorial view, SN371 x 62. 20-21. SN379. 20. Equatorial view, x 62. 21. Ponticuli and an intercameral suture appearing as sutural pores, x 339.

22. Recent specimen from San Antonio Bay, equatorial view, SN742

x 89.

23. Recent specimen from Chezzetcook Inlet, equatorial view, SN205 x 80.

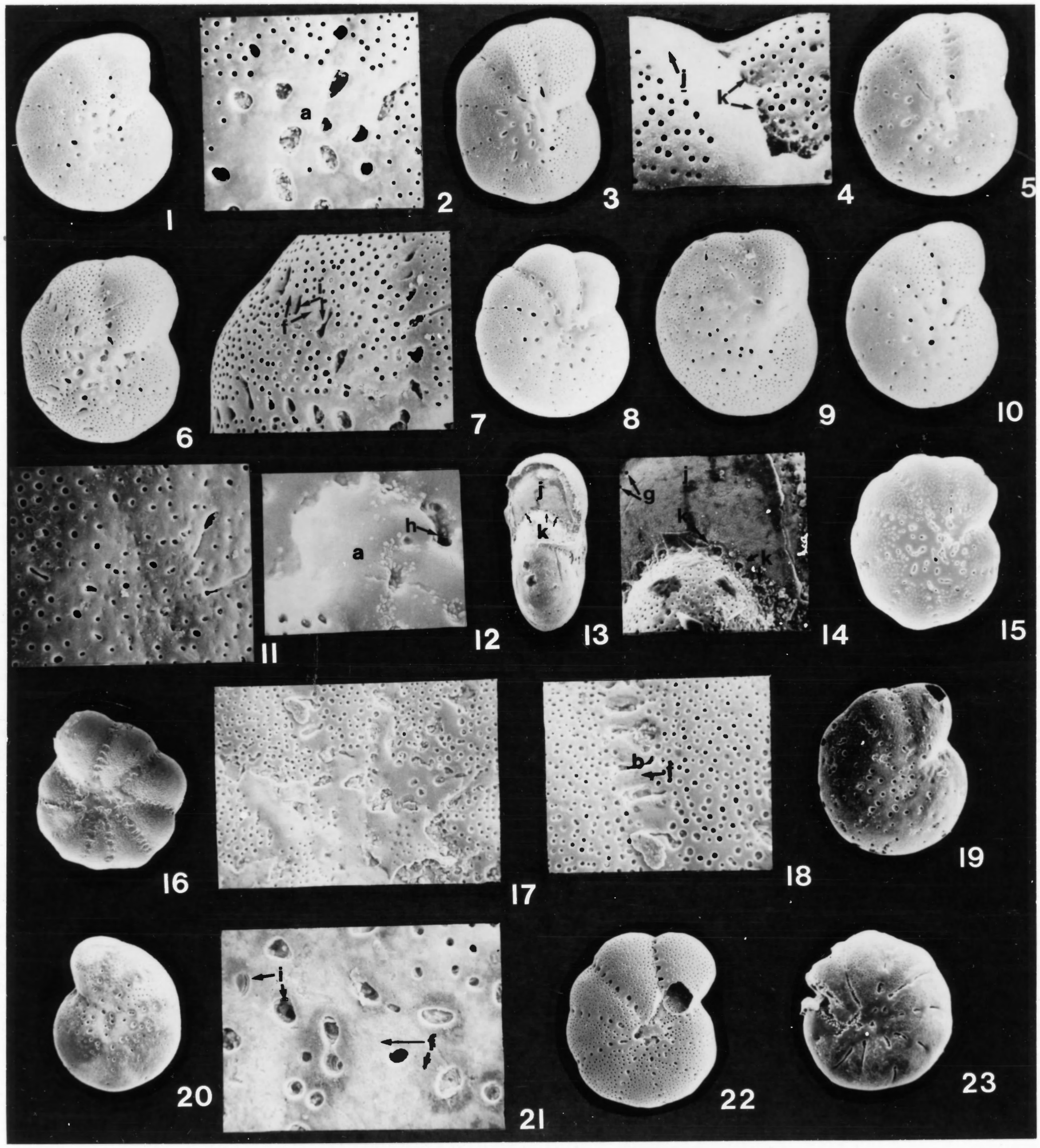
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PLATE 29

Three other species of Elphidiidae tested in the statistical analysis.

1-5. Recent specimens of <u>Elphidium bartletti</u> Cushman from the Scotian Shelf. 1-4. Equatorial views. 1. SN865 x 78. 2. SN878 x 88. 3. SN863 x 58. 4-5. SN888. 4. x 59. 5. Enlargement of the sutural pores, x 294.

6-10. Recent specimens of <u>Elphidium subarcticum</u> Cushman from the Scotian Shelf. 6-7. SN844. 6. Detail of the umbilicus, x 464. 7. Equatorial view, x 69. 8-10. Equatorial views. 8. SN830 x 76. 9. SN857 x 113. 10. SN884 x 78.

11-15. Late Pleistocene specimens of <u>Haynesina orbiculare</u> (Brady) from the Champlain Sea. 11-14. Equatorial views. 11. SN811 x 84. 12. SN801 x 105. 13. SN812 x 94. 14. SN818 x 104. 15. Enlargement of the umbilicus, x 540.


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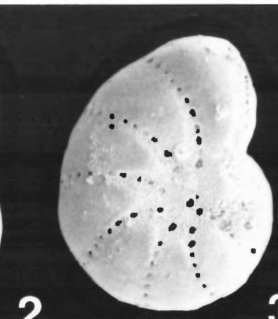
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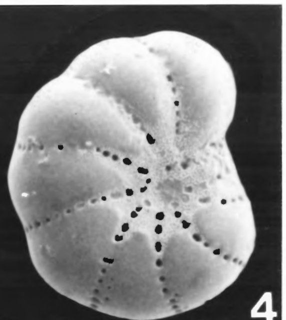
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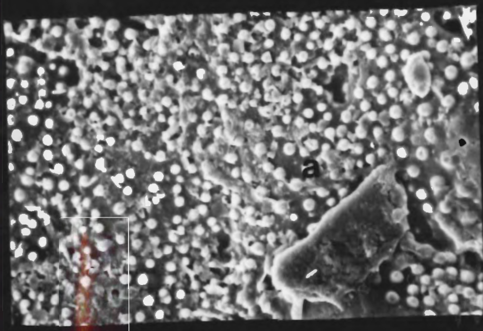

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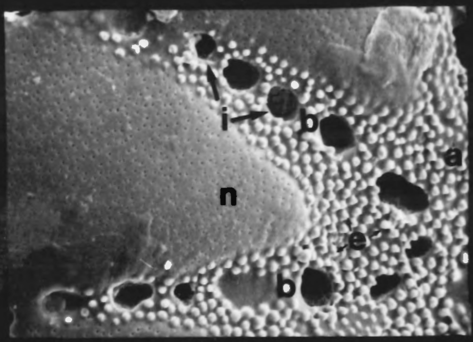

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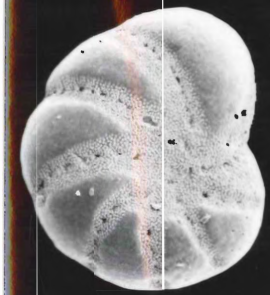
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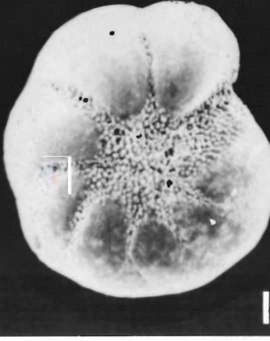
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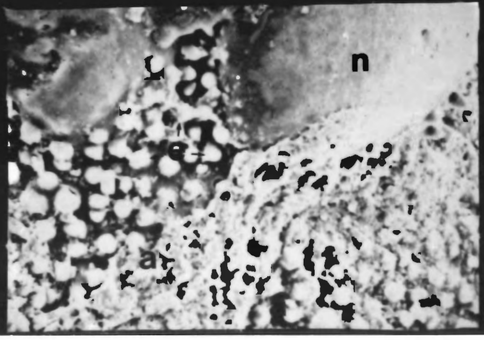

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APPENDIX A: TEST and Foraminiferal (raw) data, as measured from specimen photographs.

Table A1: TEST foraminiferal data.

LOC	SPNO	FORM	NOBO	GSD	POSQ
1	67	1	0	.293	0.000
2	137	1	1	.373	2.449
1	68	1	0	.242	0.000
1	69	1	1	.247	1.000
1	70	1	1	.297	1.000
1	71	1	1	.340	1.732
1	72	1	1	.431	0.000
1	73	1	1	.275	0.000
1	74	1	1	.352	0.000
1	75	1	1	.243	0.000
2	185	1	1	.250	1.732
2	188	1	1	.272	0.000
2	189	1	0	.304	2.646
2	190	1	1	.339	1.414
2	191	1	0	.322	3.317
2	192	1	0	.506	4.359
2	193	3	3	.559	5.196
2	194	1	1	.472	4.243
2	195	1	2	.503	5.385
2	196	1	1	.455	3.873
2	197	1	2	.501	3.873
3	77	1	1	.402	2.000
3	78	1	1	.353	1.000
3	79	1	1	.475	4.243
3	80	1	1	.280	1.414
3	81	1	1	.325	1.000
3	82	1	1	.392	2.000
3	83	1	1	.278	0.000
3	84	1	1	.355	3.162
3	85	1	0	.283	2.000
3	89	1	1	.391	3.162
4	3	1	1	.378	2.236
4	4	1	1	.350	1.414
4	5	1	1	.327	2.000
4	6	1	1	.362	1.414
4	7	1	1	.255	0.000
4	8	1	1	.313	1.414
4	9	1	0	.193	3.317
4	10	1	1	.183	2.449
4	47	1	0	.212	1.414
4	48	1	1	.200	1.732
5	12	1	1	.374	3.873
5	13	1	1	.375	3.000
5	14	1	1	.29[illegible]	[illegible]
5	17	1	1	.295	[illegible]
5	18	1	1	.273	2.449
5	19	1	1	.250	0.000
5	20	1	1	.335	3.000
5	21	1	1	.230	1.000
5	22	1	0	.233	2.646
5	23	1	0	.295	2.449
5	24	1	0	.258	1.732
5	25	1	0	.325	3.000
5	27	1	0	.231	3.464
5	46	1	1	.351	2.449
6	108	1	0	.413	5.099
6	109	1	1	.219	2.646
6	110	1	1	.277	3.162
6	111	1	2	.334	2.646
6	112	1	2	.272	1.000
6	113	1	2	.230	2.000
6	114	4	3	.362	2.236
6	115	4	2	.343	2.828
6	118	4	2	.369	1.414
6	[illegible]	4	[illegible]	.331	2.828
6	1[illegible]3	4	[illegible]	.304	0.000
6	1[illegible]9	4	1	.357	2.449
6	120	4	0	.379	4.000
6	124	4	1	.240	1.000
6	125	4	1	.384	3.873
6	12[illegible]	4	0	.278	2.449
6	127	4	0	.401	1.000
7	128	4	1	.533	6.000
7	129	[illegible]	1	.338	2.646
7	13[illegible]	1	0	.341	3.873
7	133	1	1	.417	4.243
7	134	4	1	.433	4.583
7	135	4	3	.374	2.000
7	137	3	3	.377	3.742
7	138	3	3	.526	4.796
7	139	3	[illegible]	.452	4.899
7	143	[illegible]	[illegible]	.306	4.359
7	145	[illegible]	[illegible]	.409	4.472
7	146	[illegible]	2	.294	3.000
7	147	[illegible]	[illegible]	.381	3.873
7	149	3	4	.378	4.690
7	150	1	[illegible]	.252	2.449
7	151	4	3	.355	2.236
7	153	[illegible]	[illegible]	.476	4.796
7	155	[illegible]	[illegible]	.258	5.000
7	15[illegible]	[illegible]	[illegible]	.323	4.583
7	157	[illegible]	[illegible]	.521	3.606
7	160	[illegible]	[illegible]	.420	4.796
7	[illegible]	3	[illegible]	.444	4.000
7	[illegible]	3	[illegible]	.475	4.583
7	[illegible]	3	[illegible]	.315	2.646
7	[illegible]	[illegible]	[illegible]	.332	2.828

LOC	SPNO	FORM	NOBO	GSD	POSQ
7	177	3	3	.429	4.796
7	182	4	3	.473	4.583
7	185	1	2	.258	1.732
7	227	3	3	.507	4.000
7	229	1	2	.399	3.606
7	233	3	4	.535	5.292
7	234	1	1	.416	4.796
7	235	1	1	.352	2.646
7	239	3	3	.433	4.690
7	245	1	2	.400	4.690
7	246	1	1	.353	4.243
7	249	3	4	.605	5.657
7	252	1	1	.262	2.000
7	255	4	3	.340	2.449
8	50	3	4	.469	4.359
8	53	1	2	.404	3.873
8	54	1	1	.401	2.828
8	55	1	1	.295	5.292
8	56	1	1	.479	3.873
8	57	1	2	.361	3.464
8	58	1	2	.417	3.742
8	59	3	3	.305	3.162
8	60	4	4	.395	2.646
8	61	4	0	.340	2.646
8	62	4	0	.395	3.464
9	31	1	1	.416	3.742
9	32	1	1	.478	4.583
9	33	1	1	.400	4.000
9	34	1	1	.459	4.359
9	35	1	1	.458	4.690
9	37	3	2	.462	4.899
9	38	3	4	.231	6.083
9	39	3	4	.480	4.472
9	40	3	3	.640	6.481
9	41	1	2	.375	4.000
9	44	1	1	.330	3.317
9	199	4	3	.331	3.317
9	200	3	3	.454	4.899
9	203	4	0	.409	2.449
9	206	4	1	.293	2.236
9	207	4	0	.364	2.828
9	208	4	0	.335	3.162
9	296	1	1	.398	4.000
9	340	4	1	.298	4.123
10	92	4	0	.270	3.000
10	93	1	1	.321	2.646
10	98	3	2	.590	6.325
10	99	3	2	.553	7.000
10	100	3	4	.531	5.477
10	101	3	4	.380	5.099
10	102	3	4	.540	3.873
10	104	4	0	.378	3.162
10	[illegible]	4	0	.352	3.162
10	217	1	1	.331	2.646
10	221	4	1	.262	3.162
10	222	3	3	.474	4.583
10	223	3	4	.398	5.292
10	224	4	2	.308	3.317
10	226	3	4	.340	3.873
11	276	1	1	.342	3.317
11	278	3	2	.449	5.385
11	281	1	2	.332	3.464
11	282	1	1	.378	4.000
11	283	1	1	.266	2.646
11	284	4	1	.297	2.828
11	289	1	1	.274	2.236
11	291	1	1	.300	3.464
11	292	1	2	.312	2.646
11	293	4	0	.311	3.000
11	294	1	1	.220	2.828
12	301	1	1	.190	1.000
12	305	4	1	.214	0.000
12	306	4	1	.172	0.000
12	307	1	1	.197	2.236
12	308	1	1	.309	4.359
12	309	1	1	.259	2.828
12	310	4	1	.201	2.236
12	322	4	1	.213	1.732
12	323	4	1	.424	5.000
12	327	4	0	.238	1.000
12	328	4	0	.256	2.236
13	16	4	1	.141	0.000
13	75	4	2	.242	0.000
13	244	4	4	.249	0.000
13	247	4	3	.347	0.000
13	254	4	3	.307	1.000
13	255	4	2	.293	0.000
13	333	4	3	.303	0.000
13	339	4	3	.301	0.000
13	340	4	1	.233	0.000
13	341	4	1	.275	1.414
13	342	4	4	.355	1.000
13	343	4	3	.299	0.000

Tables A2 and A3: Foraminiferal (raw) data used in the statistical analysis. Columns numbered 1-18 represent the following variables:

Column	Variable
1	LOC
2	SPNO (SN)
3	FORM
4	PAP
5	UMCO
6	DEUM
7	POR
8	AOMA
9	NOBO
10	PERO
11	DEPO
12	SUT
13	CHAM
14	PONT
15	POSU
16	GSD
17	GS90
18	REPO

POSU and GSR were computed internally; POSU by taking the square root of PONT and GSR by dividing GS90 by GSD.

Table A2: Elphidium excavatum (Terquem) data used in the analysis.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	67	1	1	1	2	2	1	0	2	0	2	9	0	0	.293	.233	0
1	68	1	1	1	2	2	1	0	1	0	2	8	0	0	.242	.208	0
1	69	1	1	1	2	2	1	1	2	1	2	8	1	1	.247	.200	1
1	70	1	1	1	2	2	1	1	1	0	2	9	1	0	.297	.244	0
1	71	1	1	1	2	2	1	1	2	1	2	10	3	1	.340	.271	2
1	72	1	1	1	2	2	1	1	2	0	2	7	0	0	.181	.159	0
1	73	1	1	1	2	2	1	1	2	0	2	9	0	0	.275	.221	0
1	74	1	1	1	2	2	1	1	2	0	2	9	0	0	.352	.294	0
1	76	1	1	1	2	2	1	1	2	0	2	9	0	0	.243	.214	0
2	186	1	1	1	2	2	1	1	2	1	2	9	3	1	.285	.210	2
2	187	1	0	1	2	2	1	1	2	1	2	10	5	1	.373	.244	2
2	188	1	0	1	2	2	1	1	2	0	2	8	0	0	.272	.230	0
2	189	1	0	1	2	2	1	0	1	2	2	9	7	1	.304	.253	2
2	190	1	0	1	2	2	1	1	1	1	2	8	2	1	.359	.315	2
2	191	1	1	1	1	2	1	0	1	2	2	7	11	1	.322	.274	2
2	192	2	1	0	1	2	1	0	2	2	2	8	19	2	.505	.371	2
2	193	2	1	0	1	2	1	3	2	3	2	10	27	2	.559	.421	2
2	194	1	1	1	1	2	1	1	1	2	2	9	19	2	.472	.359	2
2	195	1	1	1	1	2	1	2	2	3	2	8	29	3	.508	.448	3
2	196	1	1	1	1	2	1	1	2	1	2	9	15	1	.465	.430	2
2	197	1	1	1	2	2	1	2	2	2	2	8	15	2	.401	.327	2
3	77	1	1	1	2	2	1	1	2	1	2	9	4	1	.402	.346	1
3	78	1	1	1	2	2	1	1	2	1	2	9	1	1	.353	.294	2
3	79	1	1	1	2	2	1	1	2	2	2	11	13	1	.475	.390	2
3	80	1	0	1	1	2	1	1	1	1	2	9	2	1	.280	.225	1
3	81	1	1	1	1	2	1	1	2	0	2	9	1	0	.326	.290	0
3	82	1	1	1	1	2	1	1	2	1	2	10	4	1	.392	.315	1
3	83	1	1	1	1	2	1	1	1	0	2	9	0	0	.273	.241	0
3	84	1	1	1	1	2	1	1	2	1	1	9	10	1	.365	.295	1
3	85	1	1	1	1	2	1	0	2	1	2	8	4	1	.283	.228	1
3	86	2	1	0	1	2	1	0	2	3	1	8	21	2	.429	.342	2
3	87	2	1	0	1	2	1	0	3	1	1	8	5	1	.315	.256	1
3	88	2	1	0	1	2	1	0	3	2	1	9	13	1	.469	.373	1
3	89	1	0	1	1	2	1	1	2	2	2	11	10	1	.381	.352	2
4	1	2	1	0	1	2	1	0	3	1	1	8	5	1	.437	.386	1
4	2	2	1	0	1	3	1	0	2	3	2	11	19	1	.239	.187	1
4	3	1	1	1	1	2	1	1	2	2	2	9	5	1	.373	.342	2
4	4	1	1	1	2	2	1	1	1	1	2	9	2	1	.350	.335	2
4	5	1	1	1	2	2	1	1	2	1	2	8	4	1	.327	.299	2
4	6	1	1	1	2	2	1	1	2	1	2	9	2	1	.362	.311	1
4	7	1	1	1	2	2	1	1	2	0	2	9	0	0	.255	.228	0
4	8	1	1	1	2	2	1	1	2	1	2	8	2	1	.313	.244	2
4	9	1	1	1	1	2	1	0	2	2	2	7	11	1	.183	.153	2
4	10	1	1	1	1	2	1	1	1	1	2	8	5	1	.183	.148	2
4	47	1	1	1	1	2	1	0	1	1	2	8	2	1	.212	.179	2
4	48	1	1	1	1	2	1	1	2	1	2	8	3	1	.200	.166	2
5	12	1	1	1	1	2	1	1	1	2	2	10	15	1	.374	.367	3
5	13	1	1	1	2	2	1	1	2	2	2	10	9	1	.376	.346	3
5	14	1	1	1	1	2	1	1	2	1	2	9	7	1	.298	.254	3
5	15	2	1	0	1	2	1	1	3	2	1	9	13	2	.374	.321	1
5	17	1	1	1	2	2	1	1	2	1	2	11	4	1	.295	.221	1
5	18	1	1	1	2	2	1	1	2	1	2	9	5	1	.278	.245	1
5	19	1	1	1	2	2	1	1	1	0	2	10	0	0	.280	.235	0
5	20	1	1	1	1	2	1	1	2	2	2	10	9	1	.335	.282	2
5	21	1	1	1	1	2	1	1	2	1	2	8	1	1	.236	.225	1
5	22	1	1	1	1	2	1	0	1	1	2	8	7	1	.283	.240	2
5	23	1	1	1	1	2	1	0	2	1	2	9	5	1	.295	.245	2
5	24	1	1	1	1	2	1	0	1	1	2	8	3	1	.258	.237	1
5	26	1	1	1	1	2	1	0	2	2	2	7	9	1	.326	.290	3
5	27	1	1	1	1	2	1	0	2	2	2	9	12	1	.281	.250	3
5	46	1	1	1	1	2	1	1	2	2	2	10	5	1	.351	.316	3
6	108	1	1	1	2	3	1	0	1	3	1	10	25	2	.413	.379	3
6	109	1	1	1	2	2	1	1	1	2	2	8	7	1	.219	.208	3
6	110	1	1	1	2	2	1	1	1	2	2	9	10	1	.277	.237	2
6	111	1	1	1	2	2	1	2	2	1	2	10	7	1	.384	.282	1
6	112	1	1	1	2	2	1	2	2	1	1	10	1	1	.272	.218	1
6	113	1	1	1	1	2	1	2	2	1	2	9	4	1	.280	.230	1
6	114	4	1	1	3	2	1	3	1	1	2	11	5	1	.330	.306	1
6	115	4	1	1	2	3	1	0	2	1	2	10	3	1	.348	.290	2
6	116	4	1	1	3	3	1	2	2	1	2	11	2	1	.382	.328	2
6	117	4	1	1	2	3	1	0	2	1	2	11	3	1	.359	.313	2
6	118	4	1	1	1	3	1	0	1	0	2	9	0	0	.304	.278	2
6	119	4	1	1	2	3	1	1	2	1	2	10	5	1	.357	.294	2
6	120	4	1	0	1	3	1	0	2	2	2	9	16	2	.444	.370	2
6	121	2	1	0	1	3	1	0	3	2	1	10	15	1	.358	.321	2
6	122	2	1	0	1	3	1	0	3	2	2	10	12	1	.423	.340	2
6	123	2	1	0	1	3	1	0	3	2	2	7	12	2	.450	.373	3
6	124	1	1	1	2	2	1	1	2	1	2	11	1	1	.240	.185	2
6	125	4	1	1	1	3	1	1	2	2	2	11	15	1	.384	.322	2
6	126	4	1	0	1	3	1	0	2	1	2	9	5	1	.278	.207	2
6	127	4	1	0	1	3	1	0	2	1	2	12	1	1	.401	.317	2
6	353	5	0	1	3	2	2	1	1	1	2	11	3	1	.320	.273	3
6	473	1	1	1	2	2	1	2	1	0	2	9	0	1	.252	.199	0
6	514	4	1	0	2	3	1	0	1	2	2	10	9	1	.382	.344	1
6	515	1	1	1	2	2	1	1	1	1	2	10	2	1	.311	.243	2
6	516	1	1	1	2	2	1	2	1	1	2	10	4	1	.337	.291	2
6	517	4	1	0	2	3	1	0	2	2	2	8	5	1	.316	.240	1
6	519	1	1	1	2	2	1	1	2	1	2	10	2	1	.250	.209	3
6	520	2	1	0	1	3	1	0	2	3	2	8	14	2	.339	.320	3
6	521	1	1	1	2	2	1	1	2	2	2	10	7	1	.271	.239	3
7	128	1	1	1	2	2	1	1	2	3	2	12	35	2	.533	.442	3
7	129	1	1	1	2	2	1	1	2	1	2	10	7	1	.333	.299	3
7	130	1	1	1	1	2	1	0	2	2	2	10	15	1	.341	.295	3
7	131	8	0	1	1	3	1	0	2	4	1	10	35	3	.438	.395	3
7	132	8	0	1	1	3	1	0	2	4	1	10	41	3	.500	.450	3
7	133	1	0	1	2	2	1	1	1	2	2	11	13	1	.417	.349	3
7	134	1	1	1	2	2	1	1	2	3	2	10	21	2	.433	.368	2
7	135	2	1	0	2	3	1	1	2	3	2	11	31	2	.524	.444	2
7	136	4	1	0	1	3	1	3	2	1	1	9	4	1	.374	.270	1
7	137	3	1	0	3	3	1	3	3	1	1	10	14	1	.377	.346	1
7	138	3	1	0	3	2	1	3	2	2	2	10	23	2	.526	.452	2
7	139	3	1	0	3	3	1	4	2	2	2	13	24	2	.462	.377	1
7	140	2	1	0	2	2	2	0	2	2	1	10	22	2	.350	.285	3
7	142	7	1	1	3	2	2	1	1	2	1	11	19	1	.344	.306	3
7	143	1	1	1	2	3	1	1	1	3	1	10	19	2	.358	.302	3
7	145	1	1	1	2	2	1	1	1	2	2	11	20	2	.409	.334	2
7	146	1	1	1	2	2	1	2	2	1	1	10	9	1	.294	.275	2
7	147	1	1	1	3	2	1	1	1	2	2	11	15	1	.381	.309	3
7	149	3	1	0	3	3	1	4	3	2	2	10	22	2	.378	.320	1
7	150	1	1	1	2	1	1	1	2	1	2	9	5	1	.252	.219	2

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7	151	4	1	0	2	3	1	3	1	1	2	11	9	1	.365	.333	1
7	152	1	1	1	2	2	1	0	2	2	2	10	23	2	.475	.383	2
7	153	6	1	0	3	1	2	3	1	4	1	9	30	2	.245	.258	3
7	154	6	1	0	3	1	2	4	1	4	1	11	30	2	.334	.262	3
7	155	1	1	1	2	2	1	1	2	3	2	10	25	2	.500	.451	3
7	156	7	1	1	3	2	2	1	2	4	1	10	22	2	.407	.309	3
7	157	6	1	0	3	1	2	4	1	4	1	12	42	2	.691	.548	3
7	158	1	1	1	2	2	1	1	2	3	2	10	21	2	.823	.557	3
7	159	1	1	1	3	2	1	0	1	2	2	10	13	1	.621	.569	3
7	160	7	1	1	3	4	2	1	1	4	1	12	35	2	.429	.311	3
7	162	7	1	1	3	4	2	3	2	4	1	15	55	2	.537	.524	3
7	163	7	1	1	3	4	2	1	2	4	1	13	57	3	.549	.443	3
7	164	7	1	1	3	4	2	3	2	4	1	13	50	3	.405	.379	3
7	166	1	1	1	2	2	1	1	1	3	1	10	23	2	.420	.375	2
7	167	8	0	1	2	2	1	0	2	2	1	10	19	2	.443	.364	2
7	168	3	1	1	3	3	2	3	2	2	2	11	15	1	.441	.370	2
7	170	3	1	0	3	3	2	2	1	3	2	12	21	1	.475	.413	1
7	171	3	1	1	3	3	2	3	1	2	2	10	7	1	.316	.283	2
7	172	6	1	0	3	1	2	4	1	4	1	12	34	2	.346	.277	3
7	173	8	1	1	2	2	1	0	1	4	1	11	30	2	.445	.381	3
7	174	1	1	1	2	2	1	3	2	1	2	10	3	1	.308	.245	2
7	175	5	0	1	3	3	2	1	1	3	2	12	29	2	.532	.488	2
7	176	6	1	0	3	1	2	4	2	4	1	11	34	2	.331	.288	3
7	177	3	1	1	2	3	1	3	2	3	1	12	23	2	.429	.396	2
7	180	6	1	0	3	1	2	3	1	4	1	11	30	2	.355	.271	3
7	181	8	0	1	2	2	1	0	2	4	2	10	27	2	.441	.367	3
7	182	4	1	0	1	3	1	3	2	2	2	11	21	2	.478	.415	2
7	184	6	1	1	3	1	2	3	2	4	1	10	31	2	.281	.260	3
7	185	1	1	1	2	2	1	2	2	1	2	11	3	1	.259	.235	1
7	227	3	1	0	2	3	1	3	2	2	2	12	15	1	.507	.358	2
7	229	1	0	1	2	2	1	2	1	2	2	10	13	1	.399	.339	3
7	230	5	0	1	3	2	2	1	1	3	1	11	18	2	.373	.362	3
7	231	6	0	0	3	1	2	1	2	4	1	10	23	1	.347	.274	3
7	232	2	1	0	1	2	1	1	2	2	2	9	15	2	.341	.279	2
7	233	3	1	0	3	3	2	4	2	3	2	10	23	2	.535	.461	2
7	234	1	1	0	2	2	1	1	1	3	2	10	23	1	.416	.354	3
7	235	1	1	1	2	3	1	1	1	1	2	11	7	2	.355	.329	1
7	237	5	0	1	3	2	2	1	1	3	2	11	20	1	.424	.332	3
7	238	5	0	1	3	2	2	1	1	3	2	11	13	2	.402	.345	3
7	239	3	1	0	3	3	2	3	3	3	2	11	22	2	.433	.377	2
7	240	5	0	1	3	3	2	2	2	3	2	11	30	2	.569	.459	2
7	242	5	0	1	3	2	2	1	2	2	2	10	13	1	.442	.330	3
7	243	2	1	1	1	2	1	0	2	3	2	9	13	1	.369	.290	2
7	245	1	1	1	2	2	1	2	2	3	2	10	22	2	.400	.391	3
7	246	1	1	1	2	2	1	1	2	3	2	11	13	1	.353	.295	3
7	249	3	1	1	3	3	2	4	2	3	2	13	32	2	.605	.541	3
7	252	1	1	1	2	2	1	1	2	1	2	7	4	1	.262	.234	3
7	254	2	1	0	1	2	1	1	2	2	1	9	12	1	.353	.278	2
7	255	4	1	1	2	3	1	3	2	1	2	11	5	1	.345	.305	3
7	257	5	1	1	3	2	2	1	1	2	2	11	11	1	.431	.375	2
7	258	5	1	1	3	2	2	1	2	1	2	9	3	1	.372	.343	2
7	260	7	1	1	3	4	2	2	3	4	1	12	30	2	.372	.298	3
7	638	1	1	1	2	2	1	1	2	2	2	10	13	2	.409	.361	3
7	639	4	1	1	1	3	1	1	2	2	2	10	10	1	.281	.241	1
7	640	6	1	0	3	1	2	3	3	3	1	11	30	2	.330	.288	3
7	642	1	1	1	2	2	1	2	3	1	2	9	3	1	.367	.362	2
7	643	7	1	0	3	4	2	0	2	4	1	13	45	2	.536	.460	3
7	644	1	0	1	2	2	1	1	1	2	2	11	3	1	.357	.340	3
7	645	4	1	1	2	3	1	3	2	1	2	11	5	1	.390	.333	1
7	647	3	1	1	2	3	1	3	2	4	2	11	44	3	.474	.415	3
7	648	1	1	1	2	2	1	1	3	3	1	11	30	2	.483	.441	3
7	649	1	1	1	2	2	1	1	1	2	2	10	7	1	.391	.339	3
7	650	5	0	1	2	2	2	1	1	3	2	12	33	3	.429	.365	3
7	651	4	1	1	2	3	1	1	1	1	2	11	4	1	.339	.244	1
7	652	1	1	1	2	2	1	1	1	1	2	10	5	1	.445	.332	2
7	653	1	1	1	2	2	1	1	1	2	2	9	9	1	.381	.335	3
7	655	1	0	1	2	3	1	0	2	3	1	10	34	2	.441	.370	3
7	656	4	1	0	2	3	1	0	2	1	2	9	5	1	.315	.267	1
7	657	1	0	1	2	2	1	2	1	2	2	10	17	1	.432	.370	2
7	658	1	1	1	2	2	1	1	1	2	2	10	21	2	.383	.330	2
7	659	1	1	1	2	2	1	1	1	2	2	9	13	1	.410	.351	3
7	660	1	1	1	2	2	1	1	1	2	2	9	10	1	.345	.250	1
7	663	1	1	1	2	2	1	0	1	2	2	10	7	1	.410	.370	3
7	654	5	0	1	3	2	2	0	1	2	2	10	9	1	.449	.360	3
7	664	1	1	1	2	2	1	1	1	3	2	10	13	2	.448	.413	3
7	665	1	1	1	2	2	1	0	1	3	2	10	14	1	.444	.399	3
7	666	3	1	0	2	3	1	2	2	3	2	11	20	2	.476	.442	2
7	667	3	1	0	2	3	1	2	2	2	2	14	14	1	.593	.495	1
7	668	6	1	0	3	1	2	4	2	4	1	11	43	3	.456	.391	3
7	669	7	1	0	3	4	2	1	3	3	1	12	25	3	.333	.313	3
7	670	6	1	0	3	1	2	3	2	4	1	12	34	3	.365	.319	3
7	671	1	1	1	2	2	1	1	1	1	2	10	5	1	.309	.243	3
7	672	8	0	1	2	2	1	0	2	2	2	10	15	1	.434	.360	3
7	673	4	1	0	2	3	1	0	2	2	2	12	10	1	.597	.451	2
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8	51	5	1	1	3	2	2	2	2	2	2	12	17	1	.459	.349	3
8	52	5	1	1	2	2	2	1	2	1	2	12	4	1	.404	.313	3
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8	54	1	1	1	2	2	1	1	1	1	2	9	3	1	.401	.377	2
8	55	1	1	1	2	3	1	1	3	3	2	10	23	2	.295	.246	3
8	56	1	1	1	2	2	1	1	3	3	2	9	15	1	.479	.359	2
8	57	1	1	1	2	3	1	2	2	2	2	9	12	1	.361	.287	2
8	58	1	1	1	3	3	1	2	2	2	2	9	14	1	.417	.330	1
8	59	3	0	1	3	3	2	3	2	2	2	9	10	1	.365	.313	1
8	60	4	0	1	1	3	1	4	2	1	2	9	7	1	.395	.317	2
8	61	4	1	0	1	3	1	0	2	1	2	9	7	1	.320	.265	2
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8	63	2	1	0	1	3	1	2	3	2	2	10	15	1	.417	.350	2
8	64	2	1	0	1	3	1	1	3	3	1	11	33	2	.404	.353	2
8	65	2	1	0	1	3	1	0	2	2	1	9	13	1	.373	.274	2
8	505	4	1	0	1	3	1	1	2	1	2	9	3	1	.320	.256	3
8	507	4	1	0	2	3	1	3	1	2	2	9	12	1	.427	.353	2
8	508	4	1	0	2	3	1	2	1	1	2	9	5	1	.284	.245	1
8	509	4	1	0	2	3	1	2	2	2	2	9	13	1	.345	.242	1
8	510	1	0	1	2	2	1	0	2	2	2	9	7	1	.283	.235	3
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8	512	4	1	0	2	3	1	2	2	1	2	10	4	1	.349	.306	2
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9	30	5	0	1	3	2	2	1	2	3	2	13	43	2	.543	.442	1
9	31	1	0	1	2	2	1	1	2	2	2	11	14	1	.415	.353	3
9	32	1	0	1	2	2	1	1	1	3	2	11	21	3	.478	.339	1
9	33	1	0	1	2	2	1	1	2	2	2	10	15	1	.400	.335	3
9	34	1	1	1	2	3	1	1	2	2	2	10	19	2	.459	.352	2
9	35	1	1	1	2	3	1	1	2	2	2	10	22	2	.459	.324	2
9	37	3	1	0	3	3	2	2	2	3	1	10	26	2	.462	.369	2
9	38	3	1	0	3	3	2	4	2	3	2	14	37	2	.231	.135	2
9	39	3	1	0	3	3	1	4	2	2	2	11	20	2	.460	.363	2
9	40	3	0	0	2	3	1	3	3	3	1	11	42	3	.640	.509	3
9	41	1	1	1	2	3	1	2	1	1	2	11	15	1	.375	.355	2
9	42	2	1	1	1	3	1	2	1	1	2	10	12	1	.424	.342	2
9	43	2	1	0	1	3	1	0	2	2	2	9	15	2	.443	.340	1
9	44	1	1	1	2	2	1	1	2	3	2	10	11	1	.330	.270	2
9	199	4	1	0	2	3	1	3	2	1	2	9	11	1	.331	.292	1
9	200	3	1	0	2	3	1	3	2	3	2	11	24	2	.454	.435	2
9	201	5	0	1	3	2	2	1	1	1	2	10	5	1	.365	.313	3
9	202	5	1	1	3	2	2	1	2	1	2	11	3	1	.387	.319	2
9	203	4	1	0	1	2	1	0	2	1	2	9	5	1	.409	.341	2
9	205	8	0	1	1	2	1	0	1	2	2	11	9	1	.293	.279	3
9	206	4	1	1	1	3	1	1	2	1	1	10	5	1	.293	.272	2
9	207	4	1	1	1	3	1	0	2	1	2	11	9	1	.354	.340	2
9	208	4	1	1	1	3	1	0	2	1	1	10	10	1	.335	.294	2
9	209	9	0	1	1	4	1	0	2	4	1	12	65	3	.415	.380	3
9	212	2	1	0	1	3	1	2	3	2	1	9	15	2	.344	.302	3
9	214	5	1	1	3	3	2	1	1	2	2	10	15	1	.390	.297	3
9	244	5	1	1	3	2	2	3	1	3	2	12	25	2	.505	.404	3
9	296	1	1	1	1	3	1	1	1	1	2	11	15	1	.398	.304	2
9	297	9	1	1	1	4	1	3	2	4	1	13	82	3	.513	.442	3
9	298	5	1	1	3	3	2	0	1	3	2	13	23	2	.512	.394	3
9	300	4	1	1	1	3	1	1	2	2	2	11	17	1	.295	.265	2
9	331	5	0	0	3	2	2	0	2	3	2	10	35	3	.411	.319	3
9	332	9	1	0	1	4	1	0	2	4	2	12	111	4	.547	.452	3
10	92	4	1	0	1	3	1	0	2	1	2	7	9	1	.270	.215	1
10	93	2	1	1	2	3	1	1	1	1	1	8	7	1	.258	.233	1
10	94	2	1	0	2	4	1	3	2	1	2	10	11	1	.389	.345	2
10	95	2	1	0	1	2	1	0	2	2	1	9	12	1	.360	.289	1
10	96	2	1	0	1	2	1	0	1	3	2	9	17	2	.382	.305	3
10	97	2	1	0	1	3	1	0	2	2	2	9	17	2	.358	.342	3
10	98	3	1	0	2	3	1	2	3	4	1	10	40	3	.590	.493	3
10	99	3	1	0	3	3	2	2	2	4	1	11	49	3	.553	.473	3
10	100	3	1	0	3	3	2	4	3	4	1	11	30	2	.531	.523	3
10	101	3	1	0	3	4	2	4	2	3	2	11	25	2	.435	.355	1
10	103	2	1	0	1	4	1	2	3	4	1	9	38	3	.451	.396	2
10	104	4	1	0	1	3	1	0	2	3	1	9	10	1	.390	.339	2
10	102	3	1	0	2	3	1	4	2	3	1	9	15	1	.540	.507	2
10	105	4	1	0	1	3	1	0	2	2	1	9	10	1	.352	.338	1
10	106	2	0	0	1	3	1	2	2	3	1	9	31	2	.251	.206	2
10	217	1	1	1	2	2	1	1	1	1	2	9	7	1	.381	.319	1
10	221	4	1	1	1	3	1	1	3	2	1	9	10	1	.282	.260	2
10	222	3	1	1	2	4	1	3	2	2	1	10	21	2	.404	.342	3
10	223	3	1	0	2	3	1	4	2	4	1	10	23	2	.398	.323	3
10	224	4	1	0	2	3	1	0	3	2	2	8	11	1	.308	.230	2
10	225	2	1	0	1	3	1	2	3	3	1	9	25	2	.352	.352	2
10	226	1	0	1	2	2	1	4	2	2	2	9	15	1	.340	.293	3
10	522	2	1	0	2	2	1	0	2	2	2	10	9	1	.387	.353	3
10	524	2	1	0	1	3	1	1	2	2	1	9	9	1	.321	.262	2
10	525	4	1	1	1	2	1	0	1	1	2	8	5	1	.247	.225	2
10	526	4	1	0	2	3	1	0	1	3	2	10	24	2	.446	.369	2
10	527	2	1	0	1	2	1	0	2	2	1	8	3	1	.326	.265	2
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10	529	2	1	1	1	2	1	0	2	1	1	8	2	1	.247	.195	2
10	530	4	1	1	1	2	1	0	1	1	2	8	5	1	.297	.238	2
10	531	1	1	1	1	2	1	0	2	1	2	8	5	1	.297	.233	2
10	532	1	1	1	2	2	1	1	2	2	2	8	3	1	.290	.255	2
10	534	3	1	0	2	4	1	3	3	4	1	9	50	3	.706	.589	3
10	535	2	1	0	2	3	1	0	1	2	2	8	10	1	.393	.348	3
10	536	2	1	0	1	3	1	0	3	3	1	10	44	3	.447	.333	1
10	537	2	1	0	1	3	1	0	2	3	2	9	13	2	.400	.343	3
10	538	2	1	0	2	3	1	1	2	2	2	8	11	1	.390	.298	2
10	539	3	1	0	2	3	1	0	3	3	2	9	22	2	.420	.357	2
10	540	2	1	0	1	3	1	0	2	3	1	9	32	3	.455	.403	2
10	542	1	1	1	1	2	1	1	1	2	2	9	7	1	.305	.279	2
10	543	2	1	0	1	3	1	0	3	3	1	9	24	2	.467	.356	1
10	544	1	1	1	2	3	1	0	3	2	2	9	15	1	.370	.289	2
10	545	4	1	0	1	3	1	1	2	2	2	8	10	1	.325	.273	1
10	547	2	1	0	1	3	1	1	2	2	2	10	15	1	.570	.459	2
10	549	3	1	0	2	3	1	4	2	4	1	10	47	3	.524	.475	2
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10	551	3	1	1	1	3	1	3	1	4	2	11	29	2	.505	.507	3
10	553	3	1	0	2	3	1	2	2	4	2	8	23	2	.465	.365	3
10	556	1	0	1	2	2	1	1	1	2	2	10	9	1	.317	.298	3
10	557	3	1	0	2	3	1	3	3	4	1	10	51	3	.530	.470	3
10	558	3	1	0	2	3	1	3	3	4	2	10	30	2	.510	.413	3
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10	565	3	1	0	2	3	1	2	2	3	1	10	35	2	.601	.558	3
11	261	2	1	0	1	2	1	0	2	2	2	10	34	2	.505	.392	2
11	262	2	1	0	1	3	1	3	2	3	2	9	22	2	.402	.337	2
11	263	9	0	1	1	3	1	1	3	4	2	11	45	3	.450	.417	2
11	266	2	1	0	1	4	1	3	3	3	2	10	31	2	.530	.422	2
11	267	2	1	0	1	3	1	3	3	3	2	9	27	2	.465	.374	2
11	269	5	1	0	3	2	2	2	1	3	2	12	12	1	.432	.357	2
11	270	9	1	0	1	4	1	2	1	4	2	14	75	3	.375	.336	3
11	272	2	0	0	1	2	1	0	2	3	2	10	31	2	.410	.393	3
11	273	2	1	1	1	3	1	1	3	3	1	11	39	2	.500	.475	1
11	274	2	1	0	1	4	1	4	3	4	2	13	45	2	.523	.410	3
11	275	9	0	1	1	3	1	0	2	3	2	13	45	2	.470	.410	3
11	276	1	0	1	1	2	1	1	2	2	2	11	11	1	.345	.281	2
11	277	2	1	0	1	4	1	2	2	3	2	10	31	2	.437	.395	2
11	278	3	1	0	3	4	1	2	2	3	2	10	29	2	.449	.370	2
11	279	9	1	0	1	4	1	1	1	4	1	11	35	2	.271	.256	3
11	280	2	1	0	1	4	1	0	2	3	1	10	25	2	.415	.402	1
11	281	1	0	1	2	2	1	2	1	2	2	11	12	1	.332	.253	3
11	282	1	1	1	1	2	1	1	2	2	2	10	15	1	.375	.294	3

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11	283	1	1	1	1	2	1	1	1	2	2	8	7	1	.265	.246	2
11	284	4	1	1	1	3	1	1	2	1	2	9	3	1	.297	.261	2
11	285	8	0	1	1	3	1	1	2	2	2	11	24	2	.288	.245	3
11	286	2	1	1	1	2	1	1	2	2	2	10	14	1	.335	.296	2
11	287	5	1	1	2	4	2	2	3	2	2	12	14	1	.401	.338	3
11	289	1	0	1	1	2	1	1	2	1	2	9	5	1	.274	.235	3
11	291	1	1	1	1	2	1	1	2	2	2	13	12	1	.300	.269	2
11	292	1	1	1	2	2	1	2	1	1	2	9	7	1	.312	.259	1
11	293	4	1	1	1	3	1	0	2	1	2	11	9	1	.311	.274	2
11	294	1	1	1	2	2	1	1	2	1	2	9	3	1	.220	.177	1
12	301	1	1	1	2	2	1	1	2	1	2	9	1	1	.199	.162	2
12	304	10	1	0	1	3	2	4	2	1	1	10	5	1	.333	.258	2
12	305	4	1	0	1	2	1	1	1	0	1	8	0	0	.214	.184	0
12	306	4	1	0	1	2	1	1	1	0	1	7	0	0	.172	.132	0
12	307	2	1	1	1	2	1	1	1	1	1	9	5	1	.197	.153	3
12	308	1	1	1	1	2	1	1	2	2	1	10	19	2	.309	.279	3
12	309	1	1	1	1	2	1	1	2	2	1	9	3	1	.269	.228	3
12	310	1	1	1	2	2	1	1	2	1	2	10	5	1	.201	.164	2
12	311	3	1	1	2	2	1	3	3	1	2	10	9	1	.331	.254	2
12	312	10	1	0	2	2	2	3	2	2	2	9	15	1	.334	.265	3
12	313	3	1	0	1	2	2	3	2	2	2	10	10	1	.212	.165	2
12	314	10	1	0	1	2	2	1	2	3	1	10	13	2	.342	.289	3
12	315	10	1	0	1	2	2	3	1	3	2	10	15	1	.370	.308	3
12	316	10	1	0	1	2	2	3	2	2	2	10	13	2	.290	.250	2
12	317	10	1	0	1	2	2	3	2	2	2	9	7	1	.204	.159	2
12	319	10	1	0	1	2	2	3	1	2	1	9	5	1	.263	.211	3
12	321	10	1	0	1	3	2	3	3	3	1	10	23	2	.449	.371	2
12	322	4	1	0	1	2	1	1	2	1	2	3	3	1	.213	.163	2
12	323	1	1	1	1	2	1	1	2	3	2	10	25	2	.424	.374	3
12	327	4	1	0	1	2	1	0	3	1	2	8	1	1	.238	.201	1
12	328	4	1	0	1	2	1	0	3	1	2	9	5	1	.258	.194	2
12	352	10	1	0	3	3	2	3	2	3	2	9	17	2	.302	.266	3
12	353	10	1	0	3	3	2	3	1	3	1	9	12	1	.341	.280	3
12	355	3	1	0	3	3	2	3	2	3	2	10	13	1	.383	.323	2
12	356	3	1	0	2	3	1	3	1	3	2	10	15	1	.311	.259	2
12	357	3	1	0	2	3	1	3	1	3	2	9	17	2	.383	.316	2
12	358	1	1	1	2	2	1	1	2	2	2	8	7	1	.271	.223	3
12	359	4	1	0	1	2	1	2	1	1	2	9	7	1	.225	.194	1
12	303	4	1	0	1	3	1	0	2	0	2	8	0	1	.243	.208	0
12	360	3	1	0	3	3	2	3	3	2	2	9	11	1	.399	.341	2
12	783	4	1	0	1	2	1	0	2	0	2	9	0	0	.270	.228	0
12	784	6	1	0	3	1	2	3	2	2	1	11	22	2	.218	.193	3
12	785	4	1	0	1	2	1	0	1	0	2	9	0	0	.210	.138	0
12	786	6	1	0	2	1	2	3	2	1	2	9	7	1	.204	.163	3
12	787	4	1	0	1	2	1	1	1	0	2	9	0	0	.164	.130	0
12	788	4	1	0	1	2	1	0	2	0	2	7	0	0	.130	.110	0
12	789	1	0	1	2	2	1	1	2	1	2	8	2	1	.202	.171	1
12	790	4	1	0	1	2	1	0	3	0	2	8	0	0	.155	.129	0
12	791	4	1	0	1	2	1	0	1	0	2	8	0	0	.146	.123	0
12	792	4	1	0	1	2	1	0	3	0	2	7	0	0	.165	.138	0
12	793	4	1	0	1	2	1	0	1	0	2	7	0	0	.242	.190	0
13	16	4	1	0	1	1	1	1	2	0	2	7	0	0	.141	.104	0
13	75	4	1	0	1	1	1	2	1	0	2	9	0	0	.242	.200	0
13	204	4	1	0	1	1	1	4	2	0	2	9	0	0	.249	.189	0
13	247	4	1	0	1	2	1	3	1	0	2	10	0	0	.347	.253	0
13	259	4	1	0	1	2	1	3	1	1	2	9	1	1	.397	.243	2
13	265	4	1	0	1	2	1	2	3	0	2	8	0	0	.293	.230	0
13	290	2	1	0	1	4	1	0	3	1	1	9	1	1	.288	.249	1
13	299	8	0	1	1	2	1	0	2	4	1	8	19	2	.163	.134	3
13	329	8	0	1	1	2	1	0	1	4	2	9	40	3	.349	.309	3
13	330	8	0	1	1	2	1	0	3	4	2	10	41	3	.351	.292	3
13	333	8	0	1	1	2	1	0	3	4	2	9	47	3	.375	.289	3
13	338	4	1	1	1	2	1	3	2	0	2	9	0	0	.303	.232	0
13	339	4	1	1	1	2	1	3	2	0	2	9	0	0	.301	.245	0
13	340	4	1	0	1	1	1	1	2	0	2	8	0	0	.233	.175	0
13	341	4	1	0	1	1	1	1	3	1	2	7	2	0	.275	.223	1
13	342	4	1	0	1	2	1	4	2	1	2	9	1	1	.355	.275	1
13	343	4	1	0	1	1	1	3	2	0	2	9	0	1	.299	.240	0
13	344	8	0	1	1	2	1	0	3	4	2	9	43	0	.318	.255	3
13	345	8	0	1	1	2	1	0	2	2	2	10	60	3	.410	.312	3
13	346	8	0	1	1	2	1	0	3	4	2	11	53	3	.426	.353	3
13	347	8	0	1	1	2	1	0	2	4	2	11	55	3	.347	.296	3
13	348	8	0	1	1	2	1	0	2	4	2	10	27	2	.260	.215	3
13	349	8	0	1	1	2	1	0	1	4	2	10	55	3	.338	.282	3
13	350	8	0	1	1	2	1	0	1	4	2	10	42	3	.255	.205	3
13	541	8	0	1	2	2	1	0	1	4	2	11	50	3	.327	.297	3
13	548	8	0	1	2	2	1	0	1	4	2	11	52	3	.385	.338	3
13	566	8	0	1	2	2	1	0	1	4	2	12	60	3	.425	.361	3
13	567	8	0	1	2	2	1	0	2	4	2	11	70	3	.471	.426	3
13	568	8	0	1	2	2	1	0	1	4	2	10	49	3	.345	.301	3
13	569	8	0	1	2	2	1	0	2	4	2	9	33	3	.330	.273	3
13	570	8	0	1	2	2	1	0	2	4	2	10	43	3	.338	.309	3
13	571	8	0	1	2	2	1	0	1	4	2	12	47	3	.290	.228	3
13	572	8	0	1	2	2	1	0	2	4	2	10	39	2	.311	.263	3
13	573	4	1	0	3	2	1	4	2	0	1	10	0	0	.298	.243	0
13	574	4	1	0	2	2	1	3	3	0	1	8	0	0	.433	.358	0
13	575	8	0	1	2	2	1	0	2	4	2	10	49	3	.359	.317	3
13	576	8	0	1	2	2	1	0	2	4	2	10	47	3	.342	.275	3
13	577	8	0	1	2	2	1	0	2	4	2	10	55	3	.329	.299	3
13	578	8	0	1	2	2	1	0	2	4	2	11	64	3	.448	.395	3
13	579	4	1	0	2	2	1	4	2	0	2	10	0	0	.500	.399	0
13	580	8	0	1	2	2	1	0	2	4	2	10	57	3	.431	.379	3
13	581	8	0	1	1	2	1	0	2	4	2	9	55	3	.423	.354	3
13	582	4	1	0	1	2	1	2	3	0	1	9	0	0	.255	.198	0
13	583	4	1	0	2	2	1	4	2	0	1	9	0	0	.277	.245	0
13	584	8	0	1	2	2	1	0	1	4	2	10	59	3	.288	.256	3
13	585	4	1	0	2	2	1	2	2	0	2	9	0	0	.330	.270	0
13	586	8	0	1	2	2	1	0	2	4	2	9	54	3	.377	.325	3
13	587	8	0	1	2	2	1	0	2	4	2	10	52	3	.314	.255	3
13	588	8	0	1	2	2	1	0	3	4	2	10	64	3	.397	.342	3
13	589	8	0	1	2	2	1	0	1	4	2	10	52	3	.318	.265	3
13	590	8	0	1	2	2	1	0	2	4	2	11	58	3	.328	.283	3
13	591	8	0	1	2	2	1	0	1	4	2	10	50	3	.313	.259	3
13	592	8	0	1	1	1	1	0	2	4	2	9	55	3	.357	.320	3
13	593	8	0	1	2	2	1	0	2	4	2	9	42	3	.347	.259	3
13	594	8	0	1	2	2	1	0	1	4	2	10	65	3	.434	.397	3
13	595	4	1	0	2	2	1	0	1	0	2	8	0	0	.271	.215	0
13	605	8	0	1	2	2	1	0	1	4	2	9	50	3	.393	.348	3

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13	606	4	1	0	3	2	1	3	2	0	1	9	0	0	.315	.253	0
13	607	4	1	0	2	2	1	2	3	0	2	11	0	0	.490	.415	0
13	608	4	1	0	3	2	1	4	2	0	2	11	0	0	.400	.305	0
13	609	3	0	1	2	2	1	0	2	4	2	11	54	3	.347	.311	3
13	610	3	0	1	2	2	1	0	2	4	2	10	55	3	.342	.306	3
13	611	4	1	0	2	2	1	4	3	0	2	10	0	0	.455	.419	0
13	612	4	1	0	2	2	1	3	2	0	2	9	0	0	.339	.324	0
13	613	4	1	0	2	2	1	3	2	0	2	9	0	0	.399	.368	0
14	479	1	1	1	1	2	1	1	3	2	2	10	5	1	.357	.303	2
14	480	5	1	1	3	2	2	1	2	0	2	11	0	0	.304	.259	0
14	481	1	1	1	2	2	1	1	1	1	2	9	1	1	.291	.250	2
14	483	1	1	1	2	1	1	1	1	0	2	9	0	0	.215	.178	0
14	484	1	1	1	2	2	1	1	2	0	2	9	0	0	.284	.260	0
14	485	1	1	1	3	2	2	1	2	0	2	10	0	0	.270	.227	0
14	486	5	1	1	3	2	2	1	2	1	1	10	5	1	.324	.253	1
14	488	1	1	1	2	3	1	1	3	1	2	10	2	1	.322	.262	1
14	489	4	1	1	2	2	1	2	2	1	2	9	5	1	.243	.207	1
14	490	5	1	1	3	2	2	1	1	0	2	10	0	0	.260	.234	0
14	491	5	1	1	3	2	2	1	2	1	2	9	4	1	.301	.271	2
14	492	1	1	1	2	1	1	1	2	1	2	9	2	1	.304	.254	2
14	493	1	1	1	3	2	1	1	2	1	2	10	2	1	.298	.269	2
14	494	5	1	1	3	2	2	1	3	1	2	11	5	1	.285	.253	2
14	495	2	1	0	1	2	1	1	3	0	2	9	0	1	.275	.225	2
14	496	5	1	1	3	2	2	1	2	1	2	9	5	0	.288	.254	0
14	497	1	1	1	2	2	1	1	2	0	2	9	0	1	.260	.214	3
14	498	5	1	1	2	2	1	1	2	1	2	11	4	0	.310	.266	0
14	499	5	1	1	3	2	2	1	2	1	2	10	3	1	.317	.277	1
14	500	1	1	1	1	2	1	1	3	1	2	9	0	1	.250	.231	2
14	501	5	1	1	3	2	2	1	1	0	2	9	0	0	.213	.194	0
14	502	1	1	1	2	2	1	1	2	0	2	10	0	0	.255	.217	0
14	503	1	1	1	2	2	1	1	2	0	2	9	0	0	.287	.244	0
14	504	5	1	1	3	2	2	1	1	0	2	9	0	0	.264	.237	0
14	596	1	1	1	2	2	1	0	2	1	2	9	3	1	.325	.274	3
14	597	5	1	1	2	2	2	1	1	0	2	10	0	0	.241	.216	0
14	598	5	1	1	2	2	2	1	1	1	2	9	4	1	.277	.237	3
14	599	5	1	1	3	2	2	1	1	0	2	9	0	0	.202	.183	0
14	600	5	0	0	2	2	2	1	1	1	2	9	5	1	.293	.246	2
14	601	5	0	1	3	2	2	1	1	0	2	10	0	0	.257	.222	0
14	602	5	1	1	3	2	2	0	1	0	2	11	0	0	.135	.170	0
14	604	1	1	1	2	2	1	1	2	1	2	10	1	1	.279	.243	3
15	335	9	1	0	2	4	1	1	2	4	1	11	49	3	.353	.313	3
15	336	9	1	0	1	4	1	1	2	4	2	11	58	3	.395	.335	3
15	337	9	1	0	1	4	1	2	1	4	2	12	54	3	.375	.331	3
15	361	9	1	0	1	4	1	2	2	4	2	12	69	3	.489	.431	3
15	375	9	1	0	1	4	1	0	2	4	1	11	59	3	.404	.332	3
15	376	9	1	0	1	4	1	0	2	4	2	12	62	3	.410	.353	3
15	377	9	1	0	1	4	1	0	2	4	2	13	74	3	.500	.443	3
15	378	9	1	0	1	4	1	0	1	4	2	11	45	3	.390	.320	3
15	386	9	1	0	1	4	1	0	1	4	2	13	62	3	.377	.335	3
15	389	9	1	0	1	4	1	0	1	4	2	13	67	3	.454	.392	3
15	390	9	1	0	1	4	1	0	2	4	2	13	62	3	.485	.407	3
15	391	9	1	0	1	4	1	0	2	4	2	11	35	2	.290	.248	3
15	392	9	1	0	1	4	1	0	2	4	2	9	29	2	.300	.250	3
15	393	9	1	0	1	4	1	0	2	4	2	9	33	3	.314	.256	2
15	394	9	1	0	1	4	1	0	1	4	2	12	57	3	.315	.271	3
15	395	9	1	0	1	4	1	0	2	4	2	11	57	3	.342	.303	3
15	396	9	1	0	2	4	1	1	3	4	2	11	59	3	.472	.401	3
15	397	9	1	0	1	4	1	0	2	4	2	10	35	3	.304	.265	3
15	398	9	1	0	1	4	1	0	1	4	2	12	53	3	.324	.253	3
15	399	9	1	0	1	4	1	0	3	4	2	11	63	3	.383	.316	3
15	400	9	1	0	1	4	1	0	2	4	2	13	63	3	.420	.350	3
15	401	9	1	0	1	4	1	0	2	4	2	11	55	3	.392	.342	3
15	402	9	1	0	1	4	1	0	2	4	2	13	81	3	.503	.419	3
15	403	9	1	0	1	4	1	0	2	4	2	11	60	3	.347	.287	3
15	404	9	1	0	1	4	1	0	1	4	2	11	52	3	.371	.306	3
15	405	9	1	0	1	4	1	0	1	4	2	13	75	3	.483	.413	3
15	406	9	1	0	1	4	1	0	3	4	2	9	40	3	.359	.298	3
15	407	9	1	0	1	4	1	0	2	4	2	13	51	3	.340	.285	3
15	408	9	1	0	1	4	1	0	2	4	2	14	72	3	.452	.360	3
15	409	9	1	0	1	4	1	1	2	4	2	13	60	3	.339	.274	3
15	410	9	1	0	1	4	1	0	2	4	2	10	39	3	.318	.256	3
15	411	9	1	0	1	4	1	0	3	4	2	12	63	3	.351	.299	3
15	412	9	1	0	1	4	1	0	2	4	2	11	53	3	.359	.310	3
15	413	9	1	0	1	4	1	0	2	4	2	11	45	3	.341	.300	3
15	414	9	1	0	1	4	1	0	2	4	2	12	63	3	.410	.326	3
15	415	9	1	0	1	4	1	0	2	4	2	10	54	3	.348	.239	3
15	416	9	1	0	1	4	1	0	2	4	2	11	62	3	.443	.384	3
15	417	9	1	0	1	4	1	2	2	4	2	11	53	3	.425	.366	3
15	418	9	1	0	1	4	1	1	2	4	2	13	70	3	.449	.379	3
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15	420	9	1	0	1	4	1	0	1	4	2	13	100	3	.504	.457	3
15	421	9	1	1	1	4	1	0	2	4	2	14	91	3	.485	.449	3
15	422	9	1	1	1	4	1	0	2	4	2	13	52	3	.351	.302	3
15	423	9	1	1	1	4	1	1	2	4	2	12	57	3	.362	.321	3
15	424	6	1	0	3	1	1	4	1	3	1	10	25	3	.349	.310	3
15	425	6	1	0	3	1	1	4	2	4	1	12	43	3	.363	.302	2
15	426	6	1	0	2	1	1	3	3	3	1	11	29	2	.321	.294	3
16	364	4	1	0	3	2	1	4	2	0	1	10	0	0	.454	.405	0
16	366	6	1	0	3	1	2	1	2	3	1	9	28	2	.280	.239	3
16	367	8	0	0	2	3	1	0	1	4	1	9	51	3	.390	.312	3
16	368	8	0	0	1	2	1	0	2	4	2	8	42	3	.329	.287	3
16	369	4	1	0	2	2	1	4	1	0	2	9	0	0	.351	.315	0
16	370	8	0	0	2	2	1	0	3	4	1	8	33	3	.327	.272	3
16	371	8	0	0	1	3	1	0	2	3	1	10	49	3	.420	.354	3
16	372	4	1	0	1	2	1	3	3	0	2	9	0	0	.224	.187	0
16	374	6	1	0	2	1	2	2	3	2	1	10	17	2	.259	.242	2
16	379	8	0	0	2	3	1	0	1	4	1	9	45	3	.395	.295	3
16	380	8	0	0	1	3	1	0	3	4	1	9	64	4	.597	.542	3
16	381	6	1	0	2	1	2	1	1	2	1	9	15	2	.160	.119	2
16	384	8	0	0	2	4	1	0	1	3	2	9	45	3	.339	.298	3
16	385	8	0	0	1	3	1	0	3	4	1	9	51	3	.381	.326	4
16	614	6	1	0	2	1	2	2	2	2	2	9	9	1	.275	.249	3
16	615	6	1	0	3	1	2	3	2	3	2	9	15	2	.239	.207	3
16	616	8	0	1	2	3	1	0	3	4	2	11	55	3	.411	.333	3
16	617	6	1	0	2	1	2	2	2	3	2	10	13	2	.143	.155	3
16	618	4	1	0	1	2	1	2	3	0	2	8	0	0	.370	.308	0
16	619	6	1	0	2	1	2	3	3	2	1	10	9	1	.249	.189	3
16	620	4	1	0	1	2	1	0	2	0	2	8	0	0	.271	.225	0
16	621	6	1	0	2	1	2	3	3	3	1	11	19	2	.276	.223	3

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16	622	6	1	0	2	1	2	3	1	3	2	10	13	2	.245	.225	3
16	623	4	1	0	1	2	1	1	2	0	1	7	0	0	.223	.194	0
16	624	6	1	0	2	1	2	3	3	4	1	11	41	3	.359	.305	3
16	626	6	1	0	2	1	2	1	2	3	1	9	21	2	.279	.195	3
16	627	8	0	1	1	2	1	0	3	4	1	8	40	3	.267	.235	3
16	628	6	1	0	2	1	2	2	3	3	1	11	19	1	.305	.263	2
16	629	5	1	0	3	1	2	4	3	4	1	11	35	2	.205	.177	3
16	630	8	0	1	2	2	1	0	3	4	2	9	35	3	.228	.191	3
16	631	6	1	0	2	1	2	3	2	2	2	9	11	1	.248	.188	2
16	632	5	1	0	3	2	2	3	2	2	1	9	13	1	.270	.234	3
16	633	4	1	0	1	1	1	1	2	0	1	7	0	0	.195	.155	0
16	634	6	1	0	2	1	2	1	3	3	1	8	23	2	.225	.150	3
16	635	8	0	1	1	2	1	0	3	4	2	8	45	3	.342	.248	3
16	637	4	1	0	1	3	1	0	3	0	2	7	0	0	.299	.277	0
17	427	9	1	0	1	4	1	2	2	4	2	13	77	3	.405	.345	3
17	428	9	1	0	1	4	1	0	2	4	2	12	71	3	.422	.367	3
17	429	9	1	0	1	4	1	0	2	4	2	13	65	3	.344	.352	3
17	430	9	1	0	1	4	1	0	1	4	2	12	61	3	.375	.325	3
17	431	9	1	0	1	4	1	0	2	4	2	12	75	3	.457	.425	3
17	432	9	1	0	1	4	1	0	1	4	2	14	83	3	.415	.379	3
17	433	9	1	0	2	4	1	0	1	4	2	15	84	3	.440	.404	3
17	434	9	1	0	1	4	1	1	2	4	2	13	70	3	.407	.362	3
17	435	9	1	0	1	4	1	1	3	4	2	14	75	3	.369	.328	3
17	436	9	1	0	1	4	1	1	2	4	2	13	80	3	.381	.326	3
17	437	9	1	0	2	4	1	1	2	4	2	13	49	3	.353	.290	3
17	438	9	1	0	2	4	1	1	2	4	2	9	27	3	.243	.194	3
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17	440	9	1	0	2	4	1	1	2	4	2	14	81	3	.357	.286	3
17	441	9	1	0	1	4	1	2	2	4	2	12	54	3	.299	.251	3
17	442	9	1	0	2	4	1	1	3	4	2	14	83	3	.433	.356	3
17	443	9	1	0	2	4	1	1	2	4	2	10	39	3	.277	.238	3
17	444	9	1	0	2	4	1	0	2	4	2	14	73	3	.412	.358	3
17	445	1	1	1	2	2	1	1	1	2	2	10	13	1	.364	.282	3
17	446	9	1	0	2	4	1	1	2	4	2	12	65	3	.399	.315	3
17	447	9	1	0	2	4	1	1	1	4	2	12	45	3	.292	.228	3
17	448	9	1	0	2	4	1	1	2	4	2	13	63	3	.351	.314	3
17	449	9	1	0	2	4	1	1	2	4	2	14	73	3	.388	.336	3
17	450	9	1	0	2	4	1	1	1	4	2	12	47	3	.346	.259	3
17	451	9	1	0	2	4	1	1	1	4	2	13	65	3	.390	.329	3
17	452	9	1	0	2	4	1	1	1	4	2	12	57	3	.335	.283	3
17	453	9	1	0	2	4	1	1	2	4	2	10	37	3	.275	.224	3
17	454	9	1	0	2	4	1	1	2	4	2	14	55	3	.359	.308	3
17	455	9	1	0	2	4	1	1	2	4	2	13	64	3	.335	.291	3
17	456	9	1	0	2	4	1	1	2	4	2	11	45	3	.339	.307	3
17	457	9	1	0	1	4	1	0	1	4	2	12	51	3	.328	.262	3
17	458	9	1	0	2	4	1	1	2	4	2	14	79	3	.392	.348	3
17	459	9	1	0	2	4	1	1	2	4	2	14	80	3	.441	.358	3
17	460	9	1	0	2	4	1	1	2	4	2	10	39	3	.255	.235	3
17	461	9	1	0	2	4	1	1	1	4	2	10	31	2	.246	.203	3
17	462	9	1	0	2	4	1	1	2	4	2	13	80	3	.427	.351	3
17	463	9	1	0	2	4	1	2	3	4	2	14	74	3	.385	.340	3
17	464	9	1	0	2	4	1	1	3	4	2	12	52	3	.325	.277	3
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17	470	9	1	0	2	4	1	1	2	4	2	14	92	3	.429	.379	3
17	471	9	1	0	2	4	1	2	2	4	2	13	62	3	.350	.298	3
17	472	9	1	0	2	4	1	0	2	4	2	15	80	3	.410	.354	3
17	474	9	1	0	2	4	1	1	2	4	2	13	60	3	.334	.299	3
17	475	9	1	0	2	4	1	1	2	4	2	13	75	3	.425	.388	3
17	476	9	1	0	2	4	1	1	2	4	2	14	62	3	.355	.316	3
17	477	4	1	1	2	2	1	2	2	1	2	9	1	1	.240	.205	1
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18	675	4	1	0	2	1	1	3	2	1	2	9	5	1	.242	.218	2
18	676	4	1	0	2	1	1	4	3	1	2	11	5	1	.311	.278	1
18	677	4	1	0	1	1	1	0	3	0	2	7	0	0	.209	.190	0
18	678	6	1	0	3	1	2	4	2	4	2	10	33	2	.284	.259	3
18	679	4	1	0	2	1	1	4	1	1	2	10	7	1	.254	.212	1
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18	681	8	0	1	2	2	1	0	2	4	2	8	32	3	.263	.214	3
18	682	6	1	0	3	1	2	3	2	4	2	9	31	2	.173	.159	3
18	683	4	1	0	2	1	1	2	3	0	2	8	0	0	.201	.165	0
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18	685	4	1	1	2	1	1	1	2	1	2	9	5	1	.175	.144	1
18	686	4	1	0	1	1	1	2	2	0	1	8	0	0	.189	.166	0
18	687	4	1	0	2	1	1	4	2	2	2	11	5	1	.267	.229	1
18	688	6	1	0	3	1	2	3	2	4	1	9	29	2	.189	.158	3
18	690	8	0	1	2	2	1	0	1	4	2	7	23	3	.244	.188	3
18	691	6	1	0	2	2	2	3	3	3	2	10	31	2	.215	.190	3
18	692	6	1	0	3	1	2	4	2	4	1	10	40	3	.280	.227	3
18	693	4	1	0	1	3	1	0	3	0	2	6	0	0	.191	.149	0
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18	695	4	1	0	2	1	1	4	3	1	2	8	7	1	.217	.191	1
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18	698	6	1	0	3	1	2	4	1	4	1	12	64	3	.430	.392	3
18	699	7	0	0	3	4	2	1	1	4	2	14	74	3	.613	.521	3
18	700	7	1	0	3	4	2	1	1	4	2	14	57	3	.532	.443	3
18	701	7	1	0	3	4	2	1	1	4	2	14	55	3	.463	.409	3
18	702	6	1	0	3	1	2	4	2	4	1	11	53	3	.455	.429	3
18	703	6	1	0	3	1	2	4	1	4	1	11	53	3	.370	.317	3
18	704	6	1	0	3	1	2	4	1	2	2	10	14	1	.269	.234	1
18	705	4	0	0	3	1	1	4	1	2	2	12	13	1	.339	.288	1
18	706	6	1	0	3	1	2	4	1	4	1	10	29	2	.261	.230	3
18	707	6	1	0	3	1	2	3	2	4	1	12	54	3	.332	.282	3
18	708	6	1	0	3	1	2	4	2	4	1	11	39	2	.292	.251	3
18	709	4	1	0	3	2	1	4	2	2	2	11	12	1	.314	.276	1
18	711	6	1	0	3	1	2	3	1	4	1	10	32	2	[illegible]	.225	3
18	712	4	1	0	3	2	2	4	3	0	1	10	0	0	.287	.258	0
18	713	6	1	0	3	1	2	3	3	4	1	13	70	3	.538	.465	3
18	714	6	1	0	3	1	2	4	2	4	1	11	44	3	.349	.307	3
18	715	6	1	0	3	1	2	4	2	4	1	11	47	3	.349	.305	3
18	716	6	1	0	3	1	2	3	2	4	1	9	29	2	.253	.189	3
18	717	4	1	0	2	1	1	4	3	1	1	11	3	1	.265	.237	1
18	718	4	1	0	2	1	1	4	2	0	1	9	0	0	.255	.223	0

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
18	719	6	1	0	2	1	1	3	2	3	1	9	35	3	.277	.244	3
18	720	7	1	1	3	4	2	1	2	4	2	14	57	3	.514	.438	3
18	721	6	1	0	3	1	2	4	1	4	1	13	59	3	.540	.453	3
18	722	4	1	0	2	2	1	4	3	1	2	10	5	1	.295	.273	1
18	723	6	1	0	3	1	2	4	1	4	1	10	41	3	.253	.267	3
18	724	6	0	0	2	1	1	3	2	4	1	10	40	3	.285	.250	2
18	725	8	0	1	1	2	1	0	2	3	2	9	32	3	.278	.229	3
18	726	8	0	0	1	3	1	0	3	4	2	3	45	3	.283	.225	3
18	727	4	1	0	2	2	1	1	2	3	1	9	30	2	.240	.215	2
18	728	4	1	0	2	2	1	3	2	1	1	10	12	1	.273	.243	1
18	729	6	1	0	3	1	2	4	2	4	1	12	50	3	.497	.423	3
18	730	6	1	0	3	1	2	4	1	4	1	17	91	3	.529	.492	3
18	731	7	1	0	3	4	2	1	2	2	2	13	13	1	.245	.206	2
18	732	6	1	0	3	1	2	2	1	4	1	10	40	3	.245	.222	3
18	733	6	1	0	3	1	1	3	2	3	1	10	33	3	.245	.209	2
18	734	7	1	0	3	4	2	1	2	2	2	13	30	2	.287	.239	2
18	735	4	1	0	2	1	1	4	1	1	2	10	3	1	.260	.233	1
18	736	1	0	1	2	2	1	3	1	0	2	9	0	0	.270	.240	0
18	737	8	0	1	2	2	1	0	1	3	2	7	23	2	.234	.191	3
18	738	4	1	0	3	1	2	4	1	0	2	9	0	0	.227	.197	0
18	739	8	0	1	1	3	1	0	2	4	2	9	44	3	.268	.215	3
18	740	4	1	0	1	2	1	3	3	1	1	9	12	1	.317	.275	1
18	741	6	1	0	3	1	2	3	2	4	1	10	51	3	.303	.270	3
18	742	8	0	0	2	2	1	0	3	4	1	9	49	3	.303	.259	3
18	743	6	1	0	3	1	2	4	2	4	1	13	63	3	.309	.414	3
18	744	6	1	0	3	1	2	4	2	4	1	10	49	3	.309	.272	3
18	745	6	1	0	3	1	2	4	3	4	1	12	43	2	.359	.304	3
18	746	6	1	0	3	1	2	3	3	4	1	12	60	3	.341	.288	3
18	747	8	0	0	2	3	1	0	2	4	1	9	55	3	.355	.322	3
18	748	7	1	0	3	4	2	1	2	4	1	15	63	3	.522	.463	3
18	750	4	1	0	2	2	1	3	2	3	1	9	29	2	.213	.199	3
18	795	7	1	0	3	4	2	1	2	4	1	13	95	3	.697	.577	3
18	796	7	1	0	3	4	2	1	2	4	1	17	73	3	.631	.539	3
18	797	7	1	0	3	4	2	1	2	4	1	14	44	2	.419	.344	3
18	900	7	1	0	3	4	2	1	2	4	1	15	52	2	.505	.459	3
19	771	1	1	1	2	3	1	1	2	2	2	11	23	1	.333	.273	2
19	901	1	0	1	2	2	1	1	2	2	2	10	12	1	.389	.362	2
19	902	5	0	1	3	3	2	1	2	2	2	12	19	1	.500	.453	3
19	903	5	0	1	3	3	2	1	2	2	2	12	15	1	.519	.455	3
19	905	5	1	1	3	3	2	2	2	2	2	12	15	1	.539	.451	2
19	907	5	1	1	3	3	2	2	2	2	2	12	15	1	.573	.449	3
19	908	5	0	1	3	3	2	1	2	3	2	11	31	1	.623	.513	3
19	909	5	0	1	3	3	2	1	2	1	2	13	5	1	.563	.458	2
19	911	5	1	1	3	3	2	1	1	1	2	11	12	1	.476	.425	3
20	751	2	1	0	2	3	1	0	3	2	2	9	15	1	.365	.309	1
20	752	2	1	0	2	2	1	2	1	3	2	10	10	1	.355	.289	3
20	753	4	0	0	2	2	1	3	2	1	2	9	9	1	.300	.272	3
20	754	3	1	0	2	2	1	4	3	2	2	11	17	1	.374	.304	3
20	756	4	1	0	1	2	1	0	3	2	2	8	10	1	.319	.265	1
20	759	6	1	0	3	1	2	3	3	3	1	9	23	2	.297	.253	3
20	760	4	1	0	1	2	1	0	2	1	2	7	4	1	.227	.138	2
20	761	3	1	0	2	3	1	0	2	3	1	9	19	2	.345	.276	3
20	762	4	1	0	1	2	1	0	3	1	2	8	4	1	.239	.193	1
20	763	6	1	0	2	1	1	2	3	3	1	8	23	2	.253	.168	3
20	764	4	1	0	1	2	1	2	2	0	2	7	0	0	.194	.155	0
20	765	1	1	0	2	3	1	2	2	1	2	10	14	1	.301	.249	2
20	766	2	1	0	1	3	1	0	3	2	2	8	13	2	.375	.311	2
20	767	2	1	0	1	3	1	0	2	2	2	9	17	2	.365	.321	3
20	768	2	1	0	2	3	1	0	2	2	2	9	13	2	.303	.241	3
20	770	4	1	0	1	2	1	0	2	1	2	10	3	1	.320	.275	1
20	773	6	1	0	3	1	2	2	2	2	1	7	14	2	.220	.211	3
20	774	9	1	0	2	4	1	1	1	3	2	8	13	1	.160	.122	3
20	775	4	1	0	1	2	1	0	2	1	2	9	2	1	.219	.134	2
20	776	4	1	0	2	3	1	3	2	2	2	10	12	1	.332	.255	2
20	777	4	1	0	1	2	1	0	3	1	2	8	5	1	.257	.219	2
20	778	4	1	0	2	3	1	1	2	1	2	9	1	1	.305	.241	1
20	779	4	1	0	2	3	1	1	2	1	2	8	5	1	.324	.268	2
20	780	4	1	0	1	2	1	0	2	1	2	7	7	1	.261	.217	2
20	781	4	1	0	2	2	1	0	1	1	2	7	5	1	.185	.149	3

Table A3: Data of three additional species of Elphidiidae used in the analysis. FORM 11 is *Haynesina orbiculare*, 12 is *Elphidium bartletti* and 13 is *Elphidium subarcticum*.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
25	800	11	1	0	1	4	2	0	3	0	2	9	0	0	.530	.446	0
25	801	11	1	0	1	4	2	0	3	0	1	9	0	0	.387	.353	0
25	802	11	1	0	1	4	2	0	2	0	2	10	0	0	.524	.469	0
25	803	11	1	0	1	4	2	0	2	0	2	10	0	0	.367	.342	0
25	804	11	1	0	1	4	2	0	2	0	2	10	0	0	.441	.394	0
25	805	11	1	0	1	4	2	0	3	0	1	11	0	0	.472	.428	0
25	806	11	1	0	1	4	2	0	2	0	2	9	0	0	.386	.345	0
25	807	11	1	0	1	4	2	0	2	0	1	10	0	0	.442	.398	0
25	808	11	1	0	1	4	2	0	1	0	1	9	0	0	.364	.314	0
25	809	11	0	0	1	4	2	0	2	0	2	10	0	0	.542	.452	0
25	810	11	1	0	1	4	2	0	1	0	2	9	0	0	.439	.358	0
25	811	11	1	0	1	4	2	0	2	0	2	11	0	0	.490	.442	0
25	812	11	1	0	1	4	2	0	2	0	2	10	0	0	.462	.401	0
25	813	11	1	0	1	4	2	0	2	0	1	9	0	0	.400	.366	0
25	814	11	0	0	1	4	2	0	1	0	2	11	0	0	.540	.503	0
25	815	11	1	0	1	4	2	0	1	0	2	10	0	0	.439	.376	0
25	816	11	1	0	1	4	2	0	2	0	2	10	0	0	.482	.426	0
25	817	11	1	0	1	4	2	0	1	0	2	10	0	0	.440	.378	0
25	818	11	1	0	1	4	2	0	2	0	2	8	0	0	.385	.349	0
25	819	11	1	0	1	4	2	0	2	0	2	8	0	0	.365	.323	0
25	820	11	1	0	1	4	2	0	3	0	2	9	0	0	.466	.368	0
25	821	11	1	0	1	4	2	0	2	0	2	9	0	0	.468	.417	0
25	822	11	1	0	1	4	2	0	2	0	2	8	0	0	.294	.259	0
25	823	11	1	0	1	4	2	0	1	0	1	9	0	0	.387	.321	0
25	824	11	1	0	1	4	2	0	2	0	1	9	0	0	.409	.392	0
25	825	11	1	0	1	4	2	0	2	0	2	9	0	0	.351	.327	0
25	826	11	1	0	1	4	2	0	2	0	2	9	0	0	.454	.414	0
25	827	11	1	0	1	4	2	0	2	0	1	9	0	0	.451	.401	0
25	828	11	1	0	1	4	2	0	2	0	2	8	0	0	.307	.238	0
25	829	11	1	0	1	4	2	0	2	0	2	8	0	0	.283	.248	0
41	830	12	1	0	1	4	1	1	1	0	2	8	0	0	.500	.410	0
41	831	12	1	0	1	4	1	1	1	0	2	8	0	0	.425	.347	0
41	832	12	1	0	1	4	1	0	3	0	2	9	0	0	.453	.376	0
41	833	12	1	0	1	4	1	0	1	0	2	8	0	0	.404	.342	0
41	834	12	1	0	1	4	1	0	2	0	2	9	0	0	.503	.423	0
41	835	12	1	0	1	4	1	0	2	0	2	9	0	0	.441	.365	0
41	836	12	1	0	1	4	1	0	2	0	2	8	0	0	.359	.307	0
41	837	12	1	0	1	4	1	0	1	0	2	9	0	0	.342	.291	0
41	838	12	1	0	1	4	1	0	2	0	2	9	0	0	.452	.391	0
41	839	12	1	0	1	4	1	0	1	0	2	7	0	0	.233	.190	0
41	840	12	1	0	1	4	1	0	1	0	2	9	0	0	.404	.341	0
41	841	12	1	0	1	4	1	0	1	0	2	9	0	0	.403	.343	0
41	842	12	1	0	1	4	1	0	1	0	2	8	0	0	.470	.397	0
41	843	12	1	0	1	4	1	0	2	0	2	9	0	0	.596	.492	0
41	844	12	1	0	1	4	1	0	3	0	2	8	0	0	.555	.434	0
41	846	12	1	0	1	4	1	0	2	0	2	8	0	0	.316	.273	0
41	847	12	1	0	1	4	1	0	1	0	2	8	0	0	.365	.309	0
41	848	12	1	0	1	4	1	0	2	0	2	7	0	0	.309	.237	0
41	849	12	1	0	1	4	1	0	2	0	2	7	0	0	.232	.190	0
41	850	12	1	0	1	4	1	0	1	0	2	8	0	0	.321	.252	0
41	851	12	1	0	1	4	1	0	1	0	2	8	0	0	.343	.243	0
41	852	12	1	0	1	4	1	0	1	0	2	8	0	0	.292	.249	0
41	853	12	1	0	1	4	1	0	1	0	2	8	0	0	.365	.313	0
41	855	12	1	0	1	4	1	0	1	0	2	7	0	0	.320	.254	0
41	856	12	1	0	1	4	1	0	3	0	2	8	0	0	.281	.227	0
41	857	12	1	0	1	4	1	0	2	0	2	8	0	0	.374	.280	0
41	858	12	1	0	1	4	1	0	2	0	2	8	0	0	.329	.252	0
41	859	12	1	0	1	4	1	0	1	0	2	8	0	0	.242	.201	0
41	860	12	1	0	1	4	1	0	2	0	2	8	0	0	.334	.258	0
41	861	12	1	0	1	4	1	0	3	0	2	8	0	0	.344	.307	0
42	863	13	1	0	1	4	1	0	1	0	2	9	0	0	.631	.491	0
42	865	13	1	0	1	4	1	0	1	0	2	9	0	0	.489	.395	0
42	866	13	1	0	1	4	1	0	1	0	2	9	0	0	.543	.475	0
42	867	13	1	0	1	4	1	0	1	0	2	11	0	0	.449	.362	0
42	868	13	1	0	1	4	1	0	1	0	2	9	0	0	.522	.428	0
42	870	13	1	0	1	4	1	0	1	0	2	10	0	0	.713	.631	0
42	872	13	1	0	1	4	1	0	1	0	2	11	0	0	.635	.545	0
42	873	13	1	0	1	4	1	0	1	0	2	11	0	0	.722	.553	0
42	874	13	1	0	1	4	1	0	1	0	2	11	0	0	.635	.530	0
42	875	13	1	0	1	4	1	0	1	0	2	11	0	0	.525	.452	0
42	876	13	1	0	1	4	1	0	1	0	2	11	0	0	.601	.487	0
42	877	13	1	0	1	4	1	0	1	0	2	13	0	0	.582	.453	0
42	878	13	1	0	1	4	1	0	1	0	2	9	0	0	.437	.357	0
42	879	13	1	0	1	4	1	0	1	0	2	9	0	0	.475	.358	0
42	880	13	1	0	1	4	1	0	1	0	2	9	0	0	.483	.375	0
42	881	13	1	0	1	4	1	0	1	0	2	10	0	0	.511	.401	0
42	882	13	1	0	1	4	1	0	1	0	2	10	0	0	.423	.335	0
42	884	13	1	0	1	4	1	0	1	0	2	10	0	0	.607	.500	0
42	885	13	1	0	1	4	1	0	1	0	2	9	0	0	.409	.331	0
42	886	13	1	0	1	4	1	0	1	0	2	9	0	0	.373	.315	0
42	887	13	1	0	1	4	1	0	1	0	2	9	0	0	.455	.362	0
42	888	13	1	0	1	4	1	0	1	0	2	10	0	0	.657	.555	0
42	889	13	1	0	1	4	1	0	1	0	2	9	0	0	.755	.628	0
42	890	13	1	0	1	4	1	0	1	0	2	10	0	0	.645	.543	0
42	891	13	1	0	1	4	1	0	1	0	2	10	0	0	.649	.507	0
42	892	13	1	0	1	4	1	0	1	0	2	10	0	0	.807	.538	0
42	893	13	1	0	1	4	1	0	1	0	2	10	0	0	.425	.322	0
42	894	13	1	0	1	4	1	0	1	0	2	9	0	0	.630	.493	0
42	895	13	1	0	1	4	1	0	1	0	2	9	0	0	.747	.560	0
42	896	13	1	0	1	4	1	0	1	0	2	8	0	0	.470	.418	0

APPENDIX B: DERIVATION OF FUNCTIONS

DERIVATION OF THE DISCRIMINANT FUNCTION

The statistical decision rule that forms the basis of discriminant analysis, is that a ratio of the between group to the within group variance, of a linear combination of variables, be formed, and maximized. The ratio is:

$$\lambda = \frac{\underline{w}'B\underline{w}}{\underline{w}'W\underline{w}} \qquad \text{(equation 4)}$$

where

B is the between groups variance-covariance matrix and

W is the within groups variance-covariance matrix.

The latter can be expressed as:

$$W = \frac{A_1 + A_2 + \ldots + A_g}{n_1 + n_2 \ldots n_g - g} \qquad \text{(equation 5)}$$

where

g is the number of groups

n_i is the number of specimens in the i^{th} group and

A_i is the sum of squares and cross product matrix for the i^{th} group.

A_i can be represented as:

$$A_i = \begin{bmatrix} a_{11} & a_{21} \ldots a_{1p} \\ a_{21} & a_{22} \ldots a_{2p} \\ a_{p1} & a_{p2} \ldots a_{pp} \end{bmatrix}$$

where

p is the number of variables

and

$$a_{1p} = \sum_{j=1}^{n_i} (x_{1j} - \bar{x}_1)(x_{pj} - \bar{x}_p)$$

where

$\bar{x}_1$ is the mean for the 1st variable in the ith group.

A_i can also be expressed as:

$$A_i = X_i'X_i - n_i\underline{\bar{x}_i}\underline{\bar{x}_i}' \qquad \text{(equation 6)}$$

where

$\underline{\bar{x}}_i$ is the mean vector for the ith group

X_i is the independent variables matrix ($n_i x_i$) and

n_i is the number of specimens in the ith group.

Equation 6 will be used to calculate A for each group and then these values substituted into equation 5 to calculate W. W will then be used in equation 4. The between groups variance-covariance matrix B can be calculated as (Gnanadesikan 1977):

$$B = \frac{1}{g-1} \sum_{i=1}^{g} n_i(\underline{x}_i - \underline{\bar{x}}..)(\underline{x}_i - \underline{\bar{x}}..)' \qquad \text{(equation 7)}$$

where

$\underline{\bar{x}}..$ is the pooled variable means vector.

To maximize $\lambda = \dfrac{\underline{w}'B\underline{w}}{\underline{w}'W\underline{w}}$,

$\dfrac{d\lambda}{d\underline{w}}$ is set to zero and the resulting equations are solved

for $\underline{w}$.

The derivative is

$$\frac{d\lambda}{d\underline{w}} = \frac{\underline{w}'W\underline{w}\ 2B\underline{w} - \underline{w}'B\underline{w}\ 2W\underline{w}}{(\underline{w}'W\underline{w})^2}$$

$$= \frac{2B\underline{w}}{\underline{w}'W\underline{w}} - \frac{\underline{w}'B\underline{w}}{\underline{w}'W\underline{w}} \times \frac{2W\underline{w}}{\underline{w}'W\underline{w}}$$

$$= 2\left(\frac{B\underline{w}}{\underline{w}'W\underline{w}} - \frac{W\underline{w}}{\underline{w}'W\underline{w}}\right)$$

Equating this to zero gives

$$B\underline{w} - \lambda W\underline{w} = \underline{0}$$

$$\text{or } (B - \lambda W)\underline{w} = \underline{0}$$

$$(W^{-1}B - \lambda \underline{I})\underline{w} = \underline{0}$$

$$W^{-1}B\underline{w} = \lambda \underline{w} \qquad \text{(equation 8)}$$

Therefore, λ is the largest eigenvalue of the matrix $W^{-1}B$, and the discriminant function coefficients are contained in the corresponding eigenvector $\underline{w}$. Now $W^{-1}B$ is not necessarily a symmetric matrix, and many programs including MINITAB cannot calculate the eigenvectors and values of a non-symmetric matrix. However, the problem can be re-expressed using two algebraic manipulations so that λ and $\underline{w}$ can be obtained from eigenvectors and eigenvalues of a symmetric matrix. The first manipulation is to find a matrix R such that $W = R'R$. But W is symmetric so it can be written as the product:

$W = TDT'$

where

D is a diagonal matrix with the eigenvalues of W on the diagonal and

T has the eigenvectors of W in its columns.

Therefore $R'R = TD^{1/2}D^{1/2}T'$

where

$D^{1/2}$ has the square root of the eigenvalues of W on its diagonal

and R is chosen to be:

$R = D1/2T'$ (equation 9)

The second is to let $\underline{\gamma} = R\underline{w}$, so that $\underline{w} = R\text{-}1\,\underline{\gamma}$ and

$$\lambda = \frac{\underline{\gamma}'(R-1)'B(R-1)\underline{\gamma}}{\underline{\gamma}'(R-1)'R'R(R-1)\underline{\gamma}}$$

$$= \frac{\underline{\gamma}'(R-1)'B(R-1)\underline{\gamma}}{\underline{\gamma}'\underline{\gamma}} \qquad \text{(equation 10)}$$

To maximize this ratio, set $\frac{d\lambda}{d\underline{\gamma}} = 0$ and solve.

The $\underline{\gamma}$ which maximizes this ratio can be converted to the desired $\underline{w}$ using the fact that $\underline{w} = R\text{-}1\,\underline{\gamma}$.

Now

$$\frac{d\underline{\gamma}}{d\lambda} = \frac{\underline{\gamma}'\underline{\gamma} \times 2(R-1)'B(R-1)\underline{\gamma} - 2\underline{\gamma}'(R-1)'B(R-1)\underline{\gamma}}{(\underline{\gamma}'\underline{\gamma})2}$$

$$= \frac{2(R-1)'B(R-1)}{\underline{\gamma}'\underline{\gamma}} - \frac{2\underline{\gamma}}{\underline{\gamma}'\underline{\gamma}} \times \frac{\underline{\gamma}'(R-1)'B(R-1)}{\underline{\gamma}'\underline{\gamma}}$$

$$= \frac{2(R-1)'B(R-1)}{\underline{\gamma}'\underline{\gamma}} - \frac{2\underline{\gamma}\lambda}{\underline{\gamma}'\underline{\gamma}}.$$

Equating to zero gives

$$[(R-1)'B(R-1) - I]\underline{\gamma} = 0 \qquad \text{(equation 11)}$$

or $(R-1)'B(R-1)\underline{\gamma} = \lambda\underline{\gamma}$.

Therefore λ is the largest eigenvalue of $(R-1)'BR-1$ and is the corresponding eigenvector. In general, $(R-1)'BR-1$ has g-1 nonzero eigenvalues and corresponding eigenvectors. The second and subsequent largest eigenvectors gives the second and subsequent discriminant functions. Writing the eigenvectors of $(R-1)'BR-1$ in the columns of a matrix Γ, the discriminant function coefficients are obtained by pre-multiplying by R^{-1}.

To summarize:

$$\frac{\underline{w}'B\underline{w}}{\underline{w}'W\underline{w}} = \lambda = \frac{\underline{\gamma}'(R^{-1})BR^{-1}\underline{\gamma}}{\underline{\gamma}'\underline{\gamma}}$$

$$W = R'R$$

$$\underline{w}'W\underline{w} = \underline{w}'R'R\underline{w} = \underline{\gamma}'\underline{\gamma}$$

$$\underline{\gamma} = R\underline{w}$$

$$\underline{w} = R^{-1}$$

and $Z = \underline{x}'\underline{w}$ (equation 2)

For the two group case there is only one discriminant function, which also can be expressed in terms of the pooled within groups variance-covariance matrix (W) and a difference between the group mean vectors, ie:

$$Z = \underline{x}'W^{-1}(\bar{\underline{x}}_i - \bar{\underline{x}}_j) \qquad \text{(equation 12)}$$

where:

$\underline{x}'$ is the transpose of the independent variable vector and

$\bar{\underline{x}}_i$ is the mean vector for the i^{th} group.

The vector of coefficients $\underline{w} = W^{-1}(\bar{\underline{x}}_i - \bar{\underline{x}}_j)$ does maximize λ as is shown below. For the two group case, equation 7 simplifies to:

$$B = 1/2\ \frac{n_i^2 + n_j^2}{n_i + n_j}\ (\bar{\underline{x}}_i - \bar{\underline{x}}_j)(\bar{\underline{x}}_i - \bar{\underline{x}}_j)'$$

$$\text{or} = k\underline{dd}'$$

where

$d = \bar{\underline{x}}_i - \bar{\underline{x}}_j$ and

$$k = \frac{1}{2}\ \frac{n_i^2 + n_j^2}{n_i + n_j}$$

To maximize $$\lambda = \frac{\underline{w}'B\underline{w}}{\underline{w}'W\underline{w}}$$

it has been shown that $\underline{w} = R^{-1}\underline{\gamma}$ where $\underline{\gamma}$ is the eigenvector associated with the largest eigenvalue of $(R^{-1})'BR^{-1}$.

But $(R^{-1})'BR^{-1} = k(R^{-1})'\underline{d}\underline{d}'R^{-1}$

$= k\underline{h}\underline{h}'$

where

$\underline{h} = (R^{-1})'\underline{d}$

so B has the single nonzero eigenvector

$$\underline{\gamma} = \frac{\underline{h}}{||h||}.$$

Therefore the discriminant function coefficients are given up to a scale factor by

$$\underline{w} = R^{-1}\underline{h} = R^{-1}(R^{-1})'\ \underline{d} = W^{-1}(\overline{\underline{x}}_i - \overline{\underline{x}}_j)$$

For the two group case Z will be calculated from equation 12 rather than equations 4, 7, 8, 9, 10, and 11.

DERIVATION OF THE CLASSIFICATION FUNCTION

The *a priori* probability that a specimen with measurements $\underline{x}$ will belong to group i is usually taken to be 1/g where g is the number of groups. The probability density for $\underline{x}$ in group i is:

$$\frac{1}{(2\pi)^{p/2}} \left|V\right|^{-1/2} \exp\left\{-1/2[(\underline{x} - \underline{u}_i)'V^{-1}(\underline{x} - \underline{u}_i)]\right\}$$

where:

$\underline{u}_i$ is the true mean vector (which is estimated by $\overline{\underline{x}}_i$)

V is the true within group variance-covariance matrix
(which is estimated by W) and
p is the number of variables.

Using Bayes rule, the *posterior* probability for group i is the *a priori* probability times the likelihood (where the likelihood has the same form as the density for $\underline{x}$).

Therefore the estimated ln *posterior* probability is

$$\ln 1/g - p/2 \ln 2\pi - 1/2 \ln|W| - 1/2\,(\underline{x} - \bar{\underline{x}}_i)'W^{-1}(\underline{x} - \bar{\underline{x}}_i). \qquad \text{(equation 13)}$$

Expanding the last term $[\,1/2\,(\underline{x} - \bar{\underline{x}}_i)'W^{-1}(\underline{x} - \bar{\underline{x}}_i)]$ gives:

$$1/2\underline{x}'W^{-1}(\underline{x} - \bar{\underline{x}}_i) - 1/2\,\bar{\underline{x}}_i'W^{-1}(\underline{x} - \bar{\underline{x}}_i)$$

$$= 1/2\underline{x}'W^{-1}(\underline{x}) - 1/2\underline{x}'W^{-1}\bar{\underline{x}}_i - 1/2\bar{\underline{x}}_i'W^{-1}(\underline{x}) + 1/2\bar{\underline{x}}_i'W^{-1}\bar{\underline{x}}_i\,. \qquad \text{(equation 14)}$$

Omitting terms constant for all groups, (the second and third terms of equation 13, the first term of equation 14), leaves:

$$\ln \frac{1}{g} + 1/2\underline{x}'W^{-1}\bar{\underline{x}}_i + 1/2\bar{\underline{x}}_i'W^{-1}\underline{x} - 1/2\bar{\underline{x}}_i'W^{-1}\bar{\underline{x}}_i \quad \text{(equation 15).}$$

In equation 15, terms 2 and 3 are constants and the transpose of one another; they combine to: $\underline{x}'W^{-1}\bar{\underline{x}}_i$.

The result is the classification function:

$$\ln \frac{1}{g} + \underline{x}'W^{-1}\bar{\underline{x}}_i - \frac{\bar{\underline{x}}_i'W^{-1}\bar{\underline{x}}_i}{2}$$

or

$$\ln \frac{1}{g} + (\underline{x} - \frac{\bar{\underline{x}}_i}{2})'W^{-1}\bar{\underline{x}}_i. \qquad \text{(equation 3)}$$

The classification rule is to evaluate these g functions for each specimen, and classify the specimen with independent variables $\underline{x}$ into the group which gives the largest function value.

For the two group case this is equivalent to calculating the discriminant score and classifying the specimen according to its proximity to the group centroids. Applying equation 3, the specimen is classified as belonging to group one instead of group three, if:

$\ln\frac{1}{g} + (x-\frac{\bar{x}_1}{2})'W^{-1}\bar{x}_1 - (\frac{x-\bar{x}_3}{2})' W^{-1}\bar{x}_3 - \ln\frac{1}{g} > 0$ (equation 16).

ln 1/g cancels, and expanding the remaining terms gives:

$$x'W^{-1}\bar{x}_1-\frac{\bar{x}_1}{2}W^{-1}\bar{x}_1 - x'W^{-1}\bar{x}_3 + \frac{\bar{x}_3}{2}'W^{-1}\bar{x}_3 > 0$$

$$x'W^{-1}(\bar{x}_1-\bar{x}_3)-\frac{\bar{x}_1}{2}'W^{-1}\bar{x}_1+\frac{\bar{x}_3}{2}'W^{-1}\bar{x}_3 > 0$$

or $x'W^{-1}(\bar{x}_1 -\bar{x}_3) > \frac{1}{2}\bar{x}_1'W^{-1}\bar{x}_1 - \frac{1}{2}\bar{x}_3'W^{-1}\bar{x}_3$ (equation 17).

The left hand side is simply the discriminant score. The right hand side is the average of the two group centroids:

$\frac{1}{2}\bar{x}_1'W^{-1}(\bar{x}_1 -\bar{x}_3) +\frac{1}{2}\bar{x}_3'W^{-1}(\bar{x}_1 -\bar{x}_3)$. (equation 18)

Therefore it is not necessary to evalute the classification functions but simply use the discriminant scores and the midpoint between the group centroids, the critical Z value, $(Z_1 + Z_3)/2$ to determine if a specimen is correctly classified. For two groups of equal size, if $Z > (Z_1 + Z_3)/2$ the specimen is classified as belonging to group one, if $(Z_1 + Z_3)/2 > Z$, then the specimen is classified as belonging to group three. If the groups are not of equal size, then a weighed average of the group centroids provides the optimal cutting score (Hair et al. 1979). If the group size in the analysis is irrelevant, or unrelated to the actual group size, then the unweighed method is employed.

APPENDIX C: ILLUSTRATIVE EXAMPLE - TEST

TEST ONE

The SPSS output of the options and statistics calculated in subprogram DISCRIMINANT gives the group means, group standard deviations, and the pooled within groups variance-covariance matrix.

```
GROUP MEANS:

 FORM                NOBO           GSD
       1              1.00000         .34148
       3              3.24138         .45893

  TOTAL               1.45455         .36530

GROUP STANDARD DEVIATIONS:

 FORM                NOBO           GSD
       1               .56443         .09522
       3               .73946         .09229

 TOTAL                1.08594         .10555

POOLED WITHIN-GROUPS COVARIANCE MATRIX:

             NOBO            GSD
NOBO          .3639032
GSD          -2731719E-03     .8957548E-02       (matrix 1)
```

The calculation of this covariance matrix can be illustrated with the aid of MINITAB. Recall that:

$A_i = X_i'X_i - n_i\underline{\bar{x}_i\bar{x}_i}'$ (equation 6)

and $W = \dfrac{A_1 + A_3}{n_1 + n - 2}$ (equation 5)

3

X_i for group one is the 2 x 114 matrix, containing the two variables

x_1 (NOBO) and x_2 (GSD) for the 114 group one specimens used in TEST (Appendix A, Table A1).

Now $\quad X_1'X_1 = \begin{bmatrix} 150.000 & 39.303 \\ 39.303 & 14.318 \end{bmatrix}$

and $\quad \bar{\mathbf{x}}_1 = \begin{bmatrix} 1.0000 \\ .34148 \end{bmatrix}$ (mean vector)

so $\quad 114\bar{\mathbf{x}}_1\bar{\mathbf{x}}_1' = \begin{bmatrix} 114.000 & 38.929 \\ 38.929 & 13.293 \end{bmatrix}$

and $A_1 = X1'X1 - 114\bar{\mathbf{x}}_1\bar{\mathbf{x}}_1' = \begin{bmatrix} 36.0000 & .3743 \\ .3743 & 1.0247 \end{bmatrix}$ (matrix 2)

Similarily for group three, X_3 is a 2 x 29 matrix (Appendix A, Table A1). Using the same procedure as above:

$$X3'X3 = \begin{bmatrix} 320.000 & 42.727 \\ 42.727 & 6.346 \end{bmatrix}$$

and $A_3 = X3'X3 - 29\bar{\mathbf{x}}_3\bar{\mathbf{x}}_3' = \begin{bmatrix} 15.3065 & -.4127 \\ -.4127 & .2385 \end{bmatrix}$ (matrix 3)

The pooled variance - covariance matrix is therefore:

$$W = \frac{1}{114 + 29 - 2} \times \begin{bmatrix} 51.3065 & -.0384 \\ -.0384 & 1.2632 \end{bmatrix}$$

$$= \begin{bmatrix} .363876 & -.000272 \\ -.000272 & .008959 \end{bmatrix} \text{ (matrix 4)}$$

which compares quite well to the SPSS output (matrix 1). Based on this pooled variance-covariance matrix the discriminant function can be calculated:

$Z = \mathbf{x}'W^{-1}(\bar{\mathbf{x}}_1 - \bar{\mathbf{x}}_3)$ $\mathbf{x}' = (x_1, x_2)$ (from equation 12)

$$Z = -6.1698x_1 - 13.2972x_2$$

The group centroid for group one is -10.711, for group three it is -26.101, and the Z values can be represented on histograms (Figures C1 and C2).

The SPSS output gives the unstandardized discriminant function coefficients:

```
                 FUNC  1

NOBO             1.572599          (matrix  5)
GSD              3.390245
(CONTSTANT)     -3.525875
```

which can be calculated from the MINITAB coefficients by standardizing the discriminant scores to have zero mean and unit standard deviation. The mean and standard deviation of the discriminant scores for the two groups are:

$\bar{Z}_1 = -10.711$ (s.d. = 3.78)

and $\bar{Z}_3 = -26.101$ (s.d. = 4.46)

which give the pooled mean:

$$\frac{n_1Z_1 + n_3Z_3}{n_1 + n_3}$$

$$= [114(-10.711) + 29(-26.101)]/143$$

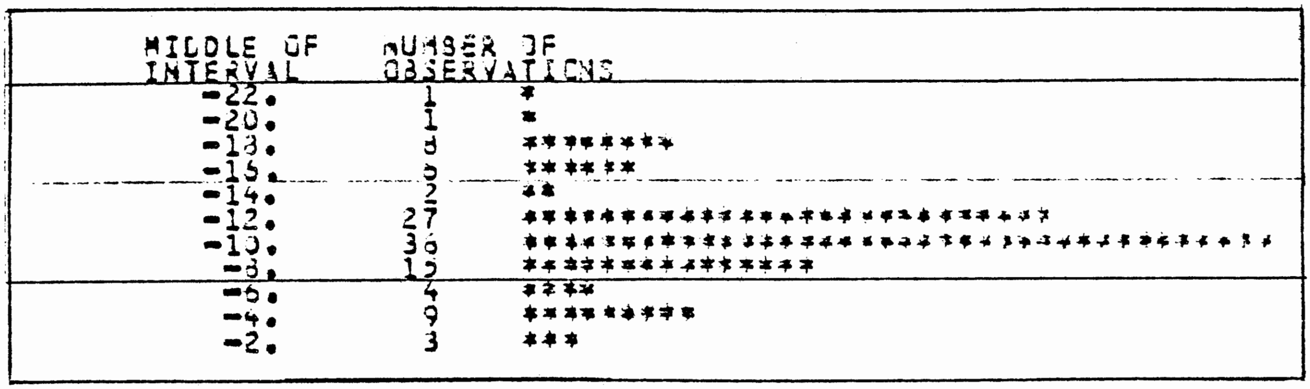
$$= -13.832$$

The pooled variance is $[113(3.78)^2 + 28(4.46)^2]/141$

$$= 15.4011$$

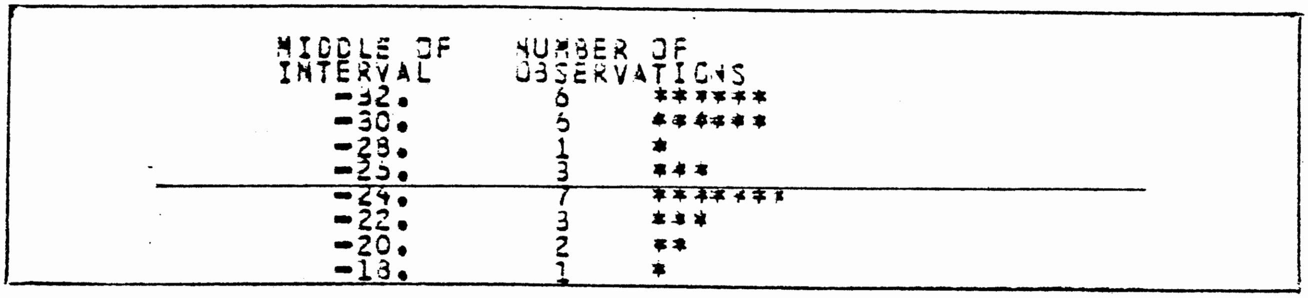
so the standard deviation is 3.9244.

Standardizing the discriminant scores gives:



```
MIDDLE OF     NUMBER OF
INTERVAL      OBSERVATIONS
  -22.            1       *
  -20.            1       *
  -18.            8       ********
  -16.            6       ******
  -14.            2       **
  -12.           27       ***************************
  -10.           36       ************************************
   -8.           15       ***************
   -6.            4       ****
   -4.            9       *********
   -2.            3       ***
```

Figure C1: Histogram of group one Z values (discriminant scores).



```
MIDDLE OF     NUMBER OF
INTERVAL      OBSERVATIONS
  -32.            6       ******
  -30.            6       ******
  -28.            1       *
  -26.            3       ***
  -24.            7       *******
  -22.            3       ***
  -20.            2       **
  -18.            1       *
```

Figure C2: Histogram of group three Z values (discriminant scores).

$$Z_{sz} = \frac{Z - (-13.832)}{3.9244} \qquad \text{(equation 19)}$$

$$= \frac{-6.1698x_1 - 13.2972x_2 + 13.832}{3.9244}$$

$$= -1.5722x_1 - 3.5246x_2 + 3.3883$$

by substituting $\bar{Z}_1$ and $\bar{Z}_3$ in turn into equation 19 the result is the standardized group centroids which, apart from the change in sign, is equivalent to the SPSS result.

GROUP	FUNC 1	
1	-.79557	(matrix 6)
3	3.12740	

SPSS also gives the standardized function coefficients:

	FUNC 1	
NOBO	.94866	(matrix 7)
GSD	.32087	

which can be calculated from the unstandardized functions (matrix 5) by standardizing the independent variables as well:

$$Z_{sz} = +1.5725x_1 + 3.390245x_2 - 3.525875$$

If $x_1 = s_1y_1 + \bar{x}_1$

and $x_2 = s_2y_2 + \bar{x}_2$

where:

$\bar{x}$ is the pooled variable mean

s is the pooled standard deviation

and

$\bar{x}_1 = 1.45455$

$\bar{x}_2 = .36530$

$s_1 = .5999$

$s_2 = .0946,$

the result is:

$$Z_s = +1.5722(.5999y_1 + 1.45455) + 3.39024(.0946y_2 + .3653) - 3.525875$$

$$Z_s = .9431y_1 + 2.2868 + .320716y_2 + 1.23845 - 3.525$$

$$Z_s = .9431y_1 + .320716y_2 + 3.5213 - 3.525$$

$$= .9431y_1 + .320716y_2$$

which compares well with matrix 7 (above).

The SPSS output gives the classification function coefficients:

(FISHER'S LINEAR DISCRIMINANT FUNCTIONS)

```
FORM =             1            3
NOBO          2.776665     8.945923            (matrix 8)
GSD           38.20699     51.50682
(CONSTANT)   -8.604988    -27.01075
```

The calculation of these functions is easily illustrated on MINITAB. Recall the general equation for the classification function:

$$\ln \frac{1}{g} + (\underline{x} - \frac{\underline{\bar{x}}_i}{2})' W^{-1} \underline{\bar{x}}_i \qquad \text{(equation 3)}$$

Then:

$$W = \begin{bmatrix} .3639032 & -.0002731719 \\ -.0002731719 & .00895748 \end{bmatrix} \quad \text{(matrices 1 and 4)}$$

$$W^{-1} = \begin{bmatrix} 2.748 & .084 \\ .084 & 111.640 \end{bmatrix} \quad \text{(matrix 9)}$$

$$W^{-1}\underline{\bar{x}}_1 = \begin{bmatrix} 2.7767 \\ 38.2067 \end{bmatrix} \quad \text{(matrix 10)}$$

(Classification function coefficients for group one, compare to matrix 8).

$$\frac{\bar{X}_1'W^{-1}\bar{X}_1}{2} = 7.9117$$

$$\ln .5-\frac{\bar{X}_1'W^{-1}\bar{X}_1}{2} = -.6931471 - 7.9117 = -8.60484 \quad \text{(constant 1)}$$

Similarily, for group three:

$$W^{-1}\bar{X}_3 = \begin{matrix} 8.9459 \\ 51.5067 \end{matrix} \qquad \text{(matrix 11)}$$

$$\frac{\bar{X}_3'W^{-1}\bar{X}_3}{2} = 26.3176$$

$$\ln .5-\frac{\bar{X}_3'W^{-1}\bar{X}_3}{2} = -.6931471 - 26.3176 = -27.010747 \quad \text{(constant 2)}$$

Combining matrices 10 and 11, and constants 1 and 2 the classification function coefficients from MINITAB are:

	GROUP 1	GROUP 3	
NOBO	2.7767	8.9459	
GSD	38.2067	51.5067	(matrix 12)
CONSTANT	-8.60484	-27.010747	

which compare very well with matrix 8.

As illustrated earlier, for a two group case, the classification function scores are closely related to the discriminant scores, and will not be evaluated separately.

Looking at the discriminant scores from SPSS (Table C1), there are two group one specimens and one group three specimen misclassified.

From the MINITAB discriminant (unstandardized) scores (Table C2) the critical $\bar{Z}$ value is:

$$\begin{array}{r} -10.711 \\ -26.101 \\ \hline -36.812 \end{array} \; / \; 2 = 18.406$$

There are two group one and one group three Z values lying outside

```
           CASE         MIS          ACTUAL         HIGHEST PROBABILITY        2ND HIGHEST
SUBFILE SEQNUM   VAL   SEL     GROUP          GROUP P(X/G) P(G/X)     GROUP P(G/X)    DISCRIMINANT SCORES

SAMPLE1      1                   1.                1  .0824 1.0000         3  .0000        -2.5325
SAMPLE1      2                   1.                1  .0562 1.0000         3  .0000        -2.7054
SAMPLE1      3                   1.                1  .7467  .9999         3  .0001        -1.1159
SAMPLE1      4                   1.                1  .6801  .9997         3  .0003         -.9464
SAMPLE1      5                   1.                1  .9960  .9996         3  .0004         -.8006
SAMPLE1      6                   1.                1  .5664  .9999         3  .0001        -1.3396
SAMPLE1      7                   1.                1  .8217  .9998         3  .0002        -1.0210
SAMPLE1      8                   1.                1  .9716  .9995         3  .0005         -.7599
SAMPLE1      9                   1.                1  .7385  .9999         3  .0001        -1.1294
SAMPLE1     10                   1.                1  .8508  .9998         3  .0002         -.9837
SAMPLE1     11                   1.                1  .9015  .9993         3  .0007         -.6718
SAMPLE1     12                   1.                1  .8138  .9998         3  .0002        -1.0311
SAMPLE1     13                   1.                1  .0892 1.0000         3  .0000        -2.4952
SAMPLE1     14                   1.                1  .9526  .9994         3  .0006         -.7362
SAMPLE1     15                   1.                1  .1013 1.0000         3  .0000        -2.4342
SAMPLE1     16                   1.                1  .3102 1.0000         3  .0000        -1.8104
SAMPLE1     17                   3.                3  .9678  .9995         1  .0005         3.0871
SAMPLE1     18                   1.                1  .6561  .9974         3  .0026         -.3531
SAMPLE1     19                   1.  ***           3  .0741  .6658         1  .3342         1.3416
SAMPLE1     20                   1.                1  .6729  .9976         3  .0024         -.3734
SAMPLE1     21                   1.                1  .0760  .6757         3  .3243          .9788
SAMPLE1     22                   1.                1  .8374  .9990         3  .0010         -.5904
SAMPLE1     23                   1.                1  .9689  .9995         3  .0005         -.7565
SAMPLE1     24                   1.                1  .6508  .9973         3  .0027         -.3429
SAMPLE1     25                   1.                1  .8349  .9996         3  .0002        -1.0043
SAMPLE1     26                   1.                1  .9501  .9996         3  .0004         -.8401
SAMPLE1     27                   1.                1  .8640  .9991         3  .0009         -.6243
SAMPLE1     28                   1.                1  .8296  .9998         3  .0002        -1.0108
SAMPLE1     29                   1.                1  .9365  .9994         3  .0006         -.7158
SAMPLE1     30                   1.                1  .0766 1.0000         3  .0000        -2.5664
SAMPLE1     31                   1.                1  .8934  .9992         3  .0008         -.6616
SAMPLE1     32                   1.                1  .9015  .9993         3  .0007         -.6718
SAMPLE1     33                   1.                1  .9770  .9995         3  .0005         -.7667
SAMPLE1     34                   1.                1  .9608  .9996         3  .0004         -.8447
SAMPLE1     35                   1.                1  .8907  .9992         3  .0008         -.6582
SAMPLE1     36                   1.                1  .7694  .9999         3  .0001        -1.0880
SAMPLE1     37                   1.                1  .9231  .9997         3  .0003         -.8921
SAMPLE1     38                   1.                1  .0349 1.0000         3  .0000        -2.9055
SAMPLE1     39                   1.                1  .5911  .9999         3  .0001        -1.3329
SAMPLE1     40                   1.                1  .0443 1.0000         3  .0000        -2.8071
SAMPLE1     41                   1.                1  .6315  .9999         3  .0001        -1.2752
SAMPLE1     42                   1.                1  .9122  .9993         3  .0007         -.6853
SAMPLE1     43                   1.                1  .9068  .9993         3  .0007         -.6785
SAMPLE1     44                   1.                1  .8028  .9997         3  .0003         -.9430
SAMPLE1     45                   1.                1  .8775  .9998         3  .0002         -.9498
SAMPLE1     46                   1.                1  .8256  .9998         3  .0002        -1.0100
```

Table C1: SPSS discriminant scores for TEST One. The symbol *** indicates those specimens misclassified.

```
          CASE            MIS          ACTUAL             HIGHEST PROBABILITY        2ND HIGHEST
SUBFILE  SEQNUM           VAL   SEL    GROUP              GROUP P(X/G)  P(G/X)      GROUP P(G/X)   DISCRIMINANT SCORES

SAMPLE1     47                          1.                 1   .8349   .9998         3   .0002       -1.0040
SAMPLE1     48                          1.                 1   .9825   .9996         3   .0004        -.6175
SAMPLE1     49                          1.                 1   .7206   .9999         3   .0001       -1.1532
SAMPLE1     50                          1.                 1   .0766  1.0000         3   .0000       -2.5664
SAMPLE1     51                          1.                 1   .0836  1.0000         3   .0000       -2.5258
SAMPLE1     52                          1.                 1   .0635  1.0000         3   .0000       -2.6512
SAMPLE1     53                          1.                 1   .1041  1.0000         3   .0000       -2.4207
SAMPLE1     54                          1.                 1   .0755  1.0000         3   .0000       -2.5732
SAMPLE1     55                          1.                 1   .9743   .9995         3   .0005        -.7633
SAMPLE1     56                          1.                 1   .1835  1.0000         3   .0000       -2.1257
SAMPLE1     57                          1.                 1   .6780   .9999         3   .0001       -1.2108
SAMPLE1     58                          1.                 1   .8270   .9998         3   .0002       -1.0142
SAMPLE1     59                          1.                 1   .0860   .7231         3   .2769          .9212
SAMPLE1     60                          1.                 1   .1812   .9205         3   .0795          .5415
SAMPLE1     61                          1.                 1   .1725   .9124         3   .0876          .5686
SAMPLE1     62                          1.                 1   .7308   .9999         3   .0001       -1.1396
SAMPLE1     63                          1.                 1   .5162   .9942         3   .0058        -.1463
SAMPLE1     64                          1.                 1   .9906   .9996         3   .0004        -.8074
SAMPLE1     65                          1.                 1   .1154  1.0000         3   .0000       -2.3598
SAMPLE1     66                          1.                 1   .7979   .9988         3   .0012        -.5395
SAMPLE1     67                          1.                 1   .7564   .9985         3   .0015        -.4853
SAMPLE1     68                          3.                 3   .5110   .9940         1   .0060        2.4700
SAMPLE1     69                          3.                 3   .8790   .9992         1   .0008        2.9752
SAMPLE1     70                          3.                 3   .2288  1.0000         1   .0000        4.3308
SAMPLE1     71                          1.                 1   .9264   .9994         3   .0006        -.7057
SAMPLE1     72                          1.                 1   .6189   .9989         3   .0011        -.5667
SAMPLE1     73                          1.                 1   .1561   .8963         3   .1037          .6161
SAMPLE1     74                          1.                 1   .8934   .9992         3   .0008        -.6616
SAMPLE1     75                          3.                 3   .3583  1.0000         1   .0000        4.0460
SAMPLE1     76                          1.                 1   .7876   .9998         3   .0002       -1.0650
SAMPLE1     77                          1.                 1   .2642  1.0000         3   .0000       -1.9121
SAMPLE1     78                          1.                 1   .7772   .9999         3   .0001       -1.0786
SAMPLE1     79                          1.                 1   .1026   .7843         3   .2157          .8369
SAMPLE1     80                          1.                 1   .3320  1.0000         3   .0000       -1.4205
SAMPLE1     81                          1.                 1   .7901   .9987         3   .0013        -.5294
SAMPLE1     82                          3.                 3   .6597   .9974         1   .0026        2.6870
SAMPLE1     83                          3.                 3   .0577   .5622         1   .4378        1.2297
SAMPLE1     84                          3.                 3   .3875   .9867         1   .0133        2.2632
SAMPLE1     85                          1.  ***            3   .3728   .9852         1   .0148        2.2361
SAMPLE1     86                          3.                 3   .6305   .9970         1   .0030        2.6463
SAMPLE1     87                          1.                 1   .1972   .9331         3   .0669          .4940
SAMPLE1     88                          3.                 3   .8265   .9989         1   .0011        2.9108
SAMPLE1     89                          1.                 1   .0771   .6815         3   .3185          .9720
SAMPLE1     90                          3.                 3   .1468  1.0000         1   .0000        4.5783
SAMPLE1     91                          1.                 1   .8006   .9988         3   .0012        -.5429
SAMPLE1     92                          1.                 1   .9634   .9995         3   .0005        -.7497
SAMPLE1     93                          3.                 3   .6401   .9972         1   .0028        2.6599
SAMPLE1     94                          1.                 1   .0766   .6786         3   .3214          .9754
SAMPLE1     95                          1.                 1   .9689   .9995         3   .0005        -.7365
SAMPLE1     96                          3.                 3   .0914  1.0000         1   .0000        4.8156
```

Table C1: continued.

```
           CASE        MIS           ACTUAL            HIGHEST PROBABILITY      2ND HIGHEST
SUBFILE SEQNUM        VAL   SEL       GROUP            GROUP P(X/G) P(G/X)     GROUP P(G/X)   DISCRIMINANT SCORES

SAMPLE1       97                       1.                1   .7876   .9998        3   .0002        -1.0620
SAMPLE1       98                       3.                3   .2190  1.0000        1   .0000         4.3545
SAMPLE1       99                       1.                1   .0743   .6669        3   .3331          .9890
SAMPLE1      100                       1.                1   .8461   .9990        3   .0010         -.5938
SAMPLE1      101                       1.                1   .8748   .9998        3   .0002         -.9532
SAMPLE1      102                       1.                1   .6411   .9972        3   .0028         -.3293
SAMPLE1      103                       1.                1   .1013   .7601        3   .2199          .6432
SAMPLE1      104                       1.                1   .0675   .6274        3   .3726         1.0331
SAMPLE1      105                       3.                3   .4852   .9930        1   .0070         2.4294
SAMPLE1      106                       1.                1   .8006   .9988        3   .0012         -.5429
SAMPLE1      107                       1.                1   .6435   .9972        3   .0028         -.3327
SAMPLE1      108                       1.                1   .8427   .9990        3   .0010         -.5972
SAMPLE1      109                       1.                1   .6903   .9978        3   .0022         -.3972
SAMPLE1      110                       1.                1   .6928   .9979        3   .0021         -.4005
SAMPLE1      111                       3.                3   .0522   .5193        1   .4807         1.1856
SAMPLE1      112                       3.                3   .6743   .9999        1   .0001         3.5477
SAMPLE1      113                       3.                3   .2315  1.0000        1   .0000         4.3240
SAMPLE1      114                       3.                3   .8148   .9998        1   .0002         3.3617
SAMPLE1      115                       1.                1   .0918   .7465        3   .2535          .8907
SAMPLE1      116                       1.                1   .9689   .9996        3   .0004         -.8345
SAMPLE1      117                       3.                3   .6919   .9978        1   .0022         2.7311
SAMPLE1      110                       1.                1   .8400   .9990        3   .0010         -.6040
SAMPLE1      119                       1.                1   .9446   .9997        3   .0003         -.8650
SAMPLE1      120                       3.                3   .1316   .8557        1   .1443         1.6196
SAMPLE1      121                       3.                3   .1024   .7837        1   .2163         1.4941
SAMPLE1      122                       3.                3   .1506  1.0000        1   .0000         4.5647
SAMPLE1      123                       3.                3   .3548  1.0000        1   .0000         4.0528
SAMPLE1      124                       3.                3   .1421  1.0000        1   .0000         4.5953
SAMPLE1      125                       1.                1   .8934   .9992        3   .0008         -.6616
SAMPLE1      126                       3.                3   .5715   .9956        1   .0042         2.5616
SAMPLE1      127                       3.                3   .3239  1.0000        1   .0000         4.1138
SAMPLE1      128                       3.                3   .4296  1.0000        1   .0000         3.9172
SAMPLE1      129                       1.                1   .9905   .9995        3   .0005         -.7836
SAMPLE1      130                       3.  ***           1   .0527   .5239        3   .4761         1.1415
SAMPLE1      131                       1.                1   .1235   .8391        3   .1609          .7449
SAMPLE1      132                       1.                1   .9015   .9993        3   .0007         -.6718
SAMPLE1      133                       1.                1   .7960   .9998        3   .0002        -1.0515
SAMPLE1      134                       1.                1   .9190   .9998        3   .0002        -1.0243
SAMPLE1      135                       1.                1   .8862   .9997        3   .0003         -.9362
SAMPLE1      136                       1.                1   .1408   .8719        3   .1281          .6771
SAMPLE1      137                       1.                1   .6804   .9999        3   .0001        -1.2074
SAMPLE1      138                       1.                1   .6076   .9999        3   .0001        -1.3091
SAMPLE1      139                       1.                1   .6243   .9999        3   .0001        -1.2854
SAMPLE1      140                       1.                1   .9123   .9997        3   .0003         -.9057
SAMPLE1      141                       1.                1   .8059   .9998        3   .0002        -1.0413
SAMPLE1      142                       1.                1   .6339   .9999        3   .0001        -1.2718
SAMPLE1      143                       1.                1   .7797   .9986        3   .0014         -.5158
```

Table C1: continued.

Table C2: MINITAB (unstandardized) discriminant scores for TEST One. Group 1 in column C8, group 3 in C9. The scores circled are those specimens misclassified.

COLUMN	C8	C9
COUNT	114	29
ROW		
1	-3.6951	-25.9424
2	-11.1961	-23.9223
3	-2.2179	-25.5036
4	-9.4542	-30.5223
5	-10.1190	-29.7054
6	-10.6903	-24.3733
7	-8.5765	-16.6337
8	-9.8265	-22.7112
9	-10.8504	-24.2136
10	-9.4310	-25.2509
11	-9.9728	-31.7930
12	-9.7866	-24.2669
13	-4.0423	-32.7238
14	-10.9434	-30.9154
15	-4.2817	-23.3627
16	-6.7234	-13.4828
17	-12.4460	-27.7507
18	-19.0945	-30.7957
19	-12.3662	-27.0195
20	-17.6717	-24.5452
21	-11.5152	-20.1849
22	-10.8537	-19.6929
23	-12.4859	-31.7398
24	-9.8930	-29.7319
25	-10.5046	-31.8595
26	-11.3823	-28.8813
27	-9.8664	-29.9713
28	-11.0232	-29.2001
29	-3.7631	-18.3099
30	-11.2360	
31	-11.1961	
32	-10.8238	
33	-10.5179	
34	-11.2493	
35	-9.5605	
36	-10.3315	
37	-2.4334	
38	-8.6031	
39	-2.8190	
40	-6.8292	
41	-11.1429	
42	-11.1695	
43	-10.1323	
44	-10.1057	
45	-9.8664	
46	-9.8930	
47	-10.8243	
48	-9.3079	
49	-3.7631	
50	-3.9227	
51	-3.4307	
52	-4.3349	
53	-3.7365	
54	-10.8371	
55	-5.4917	
56	-9.0810	
57	-9.8531	
58	-17.4456	
59	-15.9563	
60	-16.0627	
61	-9.3611	
62	-13.2572	
63	-10.6642	
64	-4.5343	
65	-11.7147	
66	-11.9274	
67	-11.0631	
68	-11.6033	
69	-16.2459	
70	-11.2360	
71	-9.6526	
72	-6.3295	
73	-9.6004	
74	-17.1133	
75	-8.2576	

C8 continued

76	-11.7546
77	-22.5045
78	-15.7702
79	-17.6431
80	-11.7014
81	-10.8903
82	-17.6564
83	-10.8637
84	-9.6536
85	-17.7116
86	-11.5019
87	-10.0924
88	-12.5391
89	-17.1398
90	-17.8844
91	-11.7014
92	-12.5258
93	-11.4385
94	-12.2732
95	-12.2599
96	-17.3260
97	-10.5578
98	-11.4620
99	-10.4382
100	-11.2360
101	-10.7573
102	-16.7542
103	-11.1961
104	-9.7066
105	-9.8132
106	-10.1589
107	-16.4882
108	-9.0951
109	-8.6962
110	-8.7893
111	-10.2785
112	-9.7467
113	-8.8425
114	-11.9073

their respective territories, with Z scores -19.0945, -22.6048 (group one), and -18.3099 (group three), see Table C3 and Figure C3.

Regardless of whether or not the data is standardized, the classification results are the same, the same specimens are misclassified.

The overall classification results are shown in the following classification matrix:

```
                    NO. OF       PREDICTED GROUP MEMBERSHIP
ACTUAL GROUP        CASES                1           3
------------       ------          -------     --------
GROUP    1            114              112           2
                                      98.2         1.8

GROUP    3             29                1          28
                                       3.4        96.6

PERCENT OF GROUPED CASES CORRECTLY CLASSIFIED -   97.90
```

Table C3: Classification results, TEST One.

TEST FOUR

Adding a third group and a third variable to TEST One results in a case where there are two discriminant functions and three classification functions. The SPSS output is:

GROUP MEANS:

```
    FORM          NOBO         GSD          POSQ
      1         1.00000      .34148       2.78762
      3         3.24137      .45893       4.83609
      4         1.38298      .31909       1.94113
```

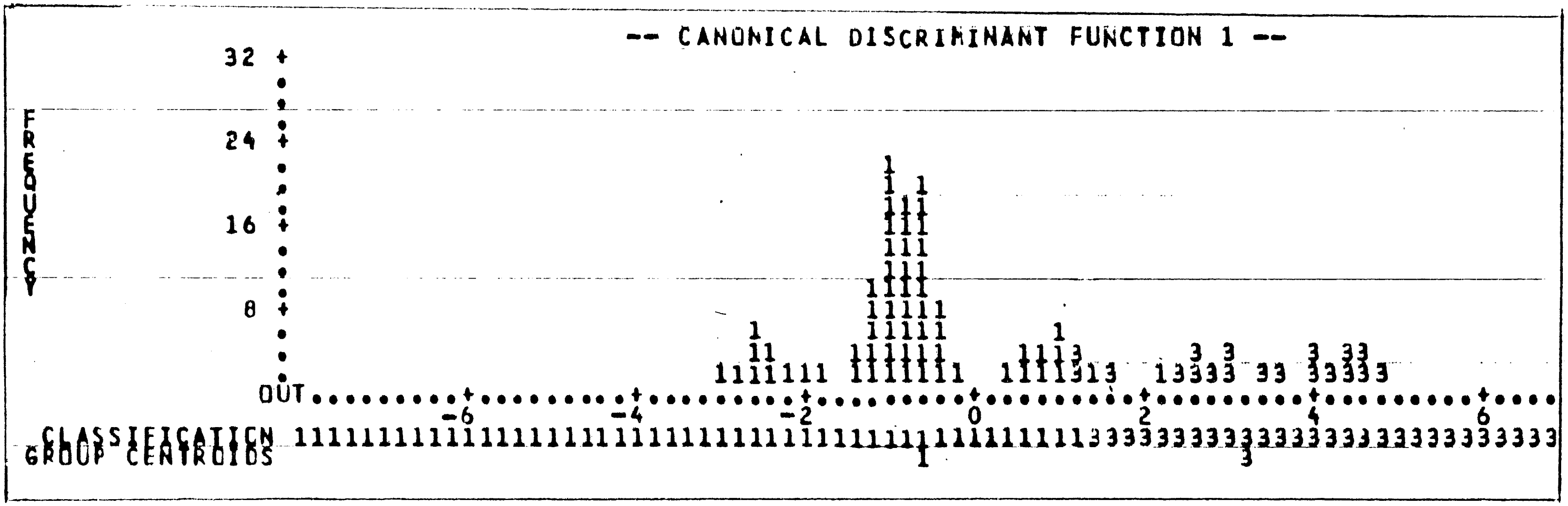


Figure C3: All groups stacked histogram.

TOTAL	1.43684	.35387	2.89089

GROUP STANDARD DEVIATIONS:

FORM	NOBO	GSD	POSQ
1	.56443	.09522	1.44555
3	.73946	.09229	.95904
4	1.36020	.06650	1.39022
TOTAL	1.15640	.09923	1.63320

POOLED WITHIN-GROUPS COVARIANCE MATRIX:

	NOBO	GSD	POSQ
NOBO	.7295012		
GSD	.2898133E-02	.7841989E-02	
POSQ	-.1217422	.6908217E-01	1.875848

(matrix 13)

A_1 and A_3 are calculated as they were for TEST One, except a third variable (POSQ), has been added.

$$A_1 = \begin{bmatrix} 36.000 & .374 & 7.063 \\ .374 & 1.025 & 9.427 \\ 7.063 & 9.427 & 236.164 \end{bmatrix} \quad \text{(matrix 14)}$$

$$A_3 = \begin{bmatrix} 15.3065 & -.4127 & -2.9847 \\ -.4127 & .2385 & 1.1850 \\ -2.9847 & 1.1850 & 25.7478 \end{bmatrix} \quad \text{(matrix 15)}$$

$A_4 = X_4'X_4 - 47\underline{\bar{x}}_4\underline{\bar{x}}_4'$ (again, X_4 is similar to X_1, it is the 3 x 47 matrix, containing the three variables for the 47 group four specimens used in the analysis).

Now $$\underline{x}_4 = \begin{bmatrix} 1.38298 \\ .31909 \\ 1.94113 \end{bmatrix}$$

and $$A_4 = \begin{bmatrix} 85.1036 & .5798 & -26.8409 \\ .5798 & .2033 & 2.3093 \\ -26.8409 & 2.3093 & 88.9096 \end{bmatrix} \quad \text{(matrix 16)}$$

Using equation 6:

$$\frac{A_1 + A_3 + A_4}{190} = \frac{(\text{matrix 14} + \text{matrix 15} + \text{matrix 16})}{190}$$

$$\text{Therefore} \quad W = \begin{matrix} .72947 & .00289 & -.12173 \\ .00289 & .00784 & .06910 \\ -.12173 & .06910 & 1.87605 \end{matrix} \quad \text{(matrix 17)}$$

which compares well with matrix 13.

The SPSS unstandardized discriminant function coefficients are:

	Z_{sz} FUNC 1	Z_{sz} FUNC 2	
NOBO	-.9862163	.5983976	
GSD	-.9753932	1.409323	(matrix 18)
POSQ	-.4136835	-.6320159	
(CONSTANT)	2.958110	.4685691	

There are now 2 discriminant functions, which cannot be calculated from equation 12, but must be calculated from equations 4 (λ), 5(W, above), and 7(B, below):

$$B = \frac{1}{g - 1} \sum_{i=1}^{g} n_i(\bar{x}_i - \bar{x}_{..})(\bar{x}_i - \bar{x}_{..})'$$

B is calculated on MINITAB to be:

$$B = \begin{bmatrix} 58.1627 & 3.1015 & 54.6713 \\ 3.1015 & .1972 & 3.8125 \\ 54.6713 & 3.8125 & 76.6711 \end{bmatrix} \quad \text{(matrix 19)}$$

and W as calculated for matrices 13 and 17.

Employing the two algebraic manipulations, the function coefficients can be calculated:

$$D^{1/2} = \begin{bmatrix} 1.37518 & 0 & 0 \\ 0 & .84667 & 0 \\ 0 & 0 & .07221 \end{bmatrix} \quad \text{(matrix 20)}$$

$$D^{1/2}T' = R \begin{bmatrix} -.14312 & .04992 & 1.36680 \\ .84203 & .01199 & .08773 \\ -.00074 & .07216 & -.00271 \end{bmatrix} \quad \text{(matrix 21)}$$

$$(R-1)' = \begin{bmatrix} -.0757 & .0264 & .7227 \\ 1.1746 & .0167 & .1224 \\ -.1428 & 13.8380 & -.5203 \end{bmatrix} \quad \text{(matrix 22)}$$

$$(R-1)'BR-1 = \begin{bmatrix} 34.5356 & 47.6692 & 3.1945 \\ 47.6692 & 97.2539 & 7.8640 \\ 3.1945 & 7.8640 & .6702 \end{bmatrix} \quad \text{(matrix 23)}$$

$$\text{Now} = \begin{bmatrix} 123.533 & 8.931 & -.005 \end{bmatrix} \quad \text{(matrix 24)}$$

$$\text{and} = \begin{bmatrix} -.472958 & .879135 & -.058589 \\ -.878416 & -.465311 & .108952 \\ -.068521 & -.102996 & -.992319 \end{bmatrix} \quad \text{(matrix 25)}$$

giving

$$R-1\,\Gamma = \begin{array}{c} \begin{array}{ccc} Z_{sz1} & Z_{sz2} & \end{array} \\ \begin{bmatrix} -.9862 & -.5984 & .2741 \\ -.9754 & -1.4098 & -13.7314 \\ -.4137 & .6320 & .4873 \end{bmatrix} \end{array} \quad \text{(matrix 26)}$$

The eigenvalues (matrix 24) do not compare at all with those from the SPSS output:

```
AFTER                  PERCENT OF CUMULITIVE   CANONICAL
FUNCTION EIGENVALUE     VARIANCE     PERCENT  CORRELATION

   1       1.32120       93.26        93.26      .7544463
   2        .09552        6.74       100.00      .2952766
```

This is due to the fact that SPSS calculates B differently. SPSS uses the equation:

$$B = \frac{1}{n_1+n_2+..n_g-1} \sum_{i=1}^{g} n_i(\bar{x}_i - \bar{x})(\bar{x}_i - \bar{x})' \quad \text{(equation 20)}$$

rather than equation 7:

$$B = \frac{1}{g-1} \sum_{i=1}^{g} n_i(\bar{x}_i - \bar{x})(\bar{x}_i - \bar{x})'$$

The B calculated from equation 7 can easily be calculated from B (equation 20) by the following:

$$B(\text{eq.}7) \times \frac{g-1}{n_1+n_2..n_{g-1}} \quad . \text{(equation 21)}$$

The same conversion factor can be applied to B·(MINITAB) to result in B (SPSS):

$$\begin{bmatrix}123.533\\ 8.931\end{bmatrix} \times \frac{2}{187} = \begin{bmatrix}1.3212086\\ .095518\end{bmatrix}$$

which agrees reasonably well with those given on the SPSS output (above).

It should be noted that no reference was found to a B matrix calculated from equation 21; though two different equations were found: equation 7 (from Gnanadesikan 1977) and also the following:

$$B = \frac{1}{g}\sum_{i=1}^{g}(x_i - \bar{x})(x_i - \bar{x})'$$

from Lachenbruch (1975).

However it should be remembered that W is calculated using equation 5:

$$\frac{A_i + A_2 + \ldots + A_g}{n_1 + n_2 + \ldots + n_{g-1}}$$

so it is not unreasonable that the same scaling factor is applied by SPSS to both the within groups (W) and between groups (B) pooled variance-covariance matrices.

To arrive at the constants for the functions (matrix 18), the ($\bar{Z}$) means of each group for each function are calculated (on MINITAB) and the means pooled; arriving at a pooled ($\bar{Z}$) mean for each function. These means are then subtracted from matrix 26 to arrive at matrix 18. For function 1 the group ($\bar{Z}_{sz1}$) means are:

group one $\bar{Z}_{sz11}$ -2.4725

group three $\bar{Z}_{sz13}$ -5.6450

group four $\bar{Z}_{sz14}$ -2.4781

the pooled ($\bar{Z}_{sz1}$) mean:

$$= \frac{114(-2.4725) + 29(-5.6450) + 47(-2.4781)}{190}$$

$$= \frac{-281.867 - 163.705 - 116.4707}{190}$$

$$= \frac{-562.0427}{190}$$

$$= -2.9581195$$

For function 2 the group ($\bar{Z}_{sz1}$) means are:

group one $\bar{Z}_{sz21}$ = -.68217

group three $\bar{Z}_{sz23}$ = -.47012

group four $\bar{Z}_{sz24}$ = .050495

the pooled ($\bar{Z}_{sz2}$) mean:

$$= \frac{114(-.68217) + 29(-.47012) + 47(.050495)}{190}$$

$$= \frac{-77.7638 - 13.63348 + 2.373265}{190}$$

$$= \frac{-89.024015}{190}$$

$$= -.4685478$$

Therefore the constants are the pooled $\bar{Z}$ means for the 2 functions,

for function 1: -2.9581195

for function 2: -.4685478

which when subtracted from matrix 26 give matrix 18.

If the pooled $\bar{Z}$ means ($\bar{Z}_{sz1}$, $\bar{Z}_{sz2}$) are each subtracted from the individual group means for the two functions the result is the functions evaluated at the group centroids (from the SPSS output below).

GROUP	FUNC 1	FUNC 2
1	.48562	-.21360
3	-2.68684	-.00150
4	.47995	.51901

(matrix 27)

For function 1:

group one $-2.4725 + 2.958110 = 0.48561$

group three $-5.6450 + 2.958110 = -2.68689$

group four $-2.4781 + 2.958110 = 0.48001$

and for function 2:

group 1 $-.68217 + .4685478 = -.2136222$

group 3 $-.47012 + .4685478 = -.0015722$

group 4 $.050495 + .4685478 = .4180528$

The SPSS output also gives the standardized canonical discriminant function coefficients:

	FUNC 1	FUNC 2
NOBO	-.84234	.51110
GSD	-.08638	.12480
POSQ	-.56659	-.86562

(matrix 28)

which can be calculated from the unstandardized functions (matrix 17) by standardizing the independent variables as well:

$Z_{1sz} = -.9862163x_1 - .9753932x_2 - .4136835x_3 + 2.958110$

$Z_{2sz} = .5983976x_1 + 1.409323x_2 - .6320159x_3 + .4685691$

$x_1 = s1y1 + \bar{x}1$ $\quad\bar{x}1 = 1.43684$ $\quad s1 = .8541$

$x_2 = s2y2 + \bar{x}2$ $\quad\bar{x}2 = .35387$ $\quad s2 = .08855$

$x_3 = s_3y_3 + \bar{x}_3$ $\quad\bar{x}_3 = 2.89089$ $\quad s_3 = 1.3683$

$Z_{1s} = -.9862163\ (.8541y_1 + 1.43684) - .9753932\ (.08855y_2 + .35387) -$
$.4136835\ (1.3683y_3 + 2.89089) + 2.95110$

$= -.8423273y_1 - 1.417037 - .086371068y_2 - .3451623 - .5660431y_3$
$- 1.1959135 + 2.958110$

$= -.8423273y_1 - .086371068y_2 - .5660431y_3 - 2.9581128 + 2.958110$

$= -.84233y_1 - .08637y_2 - .56604y_3$

$Z_{2s} = .5983976\ (.8541y_1 + 1.43684) + 1.409323\ (.08855y_2 + .35387) -$
$.6320159\ (1.3683y_3 + 2.89089) + .4685691$

$= .5110828y_1 + .8598016 + .1247955y_2 + .4987171 - .8647873y_3 -$
$1.8270878 + .4685691$

$= .5110828y_1 + .1247955y_2 - .8647873y_3 + 1.8270878 - 1.8270878$

$= .5110828y_1 + .1247955y_2 - .8647873y_3$

Z_{1s} and Z_{2s} compare very well with matrix 28.

The classification function coefficients from SPSS:

```
(FISHER'S   LINEAR DISCRIMINANT FUNCTIONS)
FORM =              1              3             4

NOBO         1.192389      4.448038      1.636374
GSD         43.41741      46.81071      44.45542
POSQ       -.3549533e-01   1.142855     -.4961663 (matrix 29)
(CONSTANT) -9.058475     -21.81242      -8.841117
```

were calculated on MINITAB. Recall:

$$W = \begin{bmatrix} .7295012 & .002898133 & -.1217422 \\ .002898133 & .007841989 & .06908217 \\ -.1217422 & .06908217 & 1.875848 \end{bmatrix} \text{(matrix 13)}$$

$$\text{so} \quad W\text{-}1 = \begin{bmatrix} 1.406 & -1.959 & .163 \\ -1.959 & 191.484 & -7.179 \\ .163 & -7.179 & .808 \end{bmatrix} \text{(matrix 30)}$$

For group one:

$$W^{-1}\bar{X}_1 = \begin{bmatrix} 1.1924 \\ 43.4169 \\ -.0355 \end{bmatrix} \qquad \text{(matrix 31)}$$

$$\frac{\bar{X}_1 W^{-1} \bar{X}_1}{2} = 7.9598$$

$$\ln .33333 - \frac{\bar{X}_1 W^{-1} \bar{X}_1}{2} = -1.0986124 - 7.9598 = -9.0584 \quad \text{(constant 3)}$$

Similarily for group three:

$$W^{-1}\bar{X}_3 = \begin{bmatrix} 4.4480 \\ 46.8105 \\ 1.1429 \end{bmatrix} \qquad \text{(matrix 32)}$$

$$\frac{\bar{X}_3 W^{-1} \bar{X}_3}{2} = 20.7138$$

$$\ln .33333 - \frac{\bar{X}_3 W^{-1} \bar{X}_3}{2} = -1.0986124 - 20.7138 = -21.8124 \quad \text{(constant 4)}$$

and for group four:

$$W^{-1}\bar{X}_4 = \begin{bmatrix} 1.6364 \\ 44.4563 \\ -.4962 \end{bmatrix} \qquad \text{(matrix 33)}$$

$$\frac{\bar{X}_4 W^{-1} \bar{X}_4}{2} = 7.7427$$

$$\ln .33333 - \frac{\bar{X}_4 W^{-1} \bar{X}_4}{2} = -1.0986124 - 7.7427 = -8.8413 \quad \text{(constant 5)}$$

Combining matrices 31, 32, 33 and constants 3, 4, and 5 results in the classification functions:

	GROUP 1	GROUP 3	GROUP 4	
NOBO	1.1924	4.4480	1.6364	
GSD	43.4169	46.8105	44.4563	(matrix 34)

POSQ	-.0355	1.1429	-.4962
CONSTANT	-9.0584	-21.8124	-8.8413

which compares very well with matrix 29.

Because there are now two discriminant functions and three groups, it is impossible to determine if a specimen is correctly classified solely from the discriminant scores and critical ($\bar{Z}$) values ($\bar{Z}_1$ + $\bar{Z}_3$)/2, ($\bar{Z}_3$ + $\bar{Z}_4$)/2, ($\bar{Z}_1$ + $\bar{Z}_4$)/2.

The discriminant scores will not be calculated on MINITAB; instead, the classification scores for all three groups must be evaluated on MINITAB for each specimen and the highest function score taken as the theoretical classification. The theoretical classification and the actual classification are then compared; if they differ, the specimen is misclassified, if they agree the specimen is correctly classified.

The classification functions have been evaluated for all the groups in turn and the three sets of classfication scores are listed on Table C4 (group one), Table C5 (group three), and Table C6 (group four).

For the group one specimens, 74 specimens were correctly classified, and the 40 remaining specimens misclassified; three into group three and 37 into group four (Table C4). All of the group three specimens were correctly classified (Table C5). Of the group four specimens, 21 were correctly classified and 26 were misclassified; six into group three and 20 into group four (Table C6).

Looking at the discriminant scores from SPSS, (Table C7) there are 40 group one specimens misclassified, zero group three specimens misclassified, and 26 group four specimens misclassified. The data is

Table C4: MINITAB classification scores, group one, TEST Four. Those specimens circled are specimens misclassified into the group at the head of the column.

Count	Group 1	Group 3	Group 4
1	3.6628	-8.0969	4.1844
2	8.4587	3.1289	8.3844
3	1.4485	-10.4842	1.9171
4	2.8225	-4.6593	3.2796
5	4.9933	-2.3186	5.5024
6	6.8343	.5307	7.0508
7	-.0075	-8.8917	.8417
8	4.0737	-4.4915	5.0206
9	7.4168	-.8870	8.4437
10	2.6843	-5.9894	3.5980
11	4.4898	-1.9971	4.6502
12	3.9434	-4.6319	4.8872
13	4.0465	-4.5580	3.3605
14	7.6705	1.0566	8.0533
15	4.8042	-2.9485	3.8277
16	12.7559	6.8555	11.4907
17	12.4763	9.5794	11.6731
18	15.1911	17.0177	14.3432
19	12.2289	8.8756	11.5899
20	10.5992	10.2810	10.3366
21	9.5166	3.7392	9.6741
22	7.4247	.3026	7.9920
23	12.6065	9.7198	11.8065
24	4.2406	-2.6414	4.5412
25	6.2524	-.9613	6.7916
26	9.0825	3.2711	9.2296
27	4.2039	-4.3510	5.1539
28	7.8690	3.3352	7.4526
29	3.1576	-6.2793	2.7474
30	8.5637	4.0842	8.1639
31	8.4663	2.8855	8.4901
32	7.2798	.6353	7.6532
33	6.2604	.2284	6.3399
34	8.6691	2.1333	9.0758
35	3.2053	-5.4277	4.1314
36	5.6733	-1.0967	6.0083
37	-1.2308	-9.4552	-2.3517
38	-.0076	-5.9992	-.2846
39	.0958	-10.2726	-.1182
40	.7559	-6.0228	.8269
41	8.2345	4.5691	7.5000
42	8.3523	3.6650	8.0221
43	4.9784	-.3908	4.7301
44	4.9145	-1.2227	4.9617
45	4.1170	-1.5522	3.9387
46	4.2907	-4.2574	5.2428
47	6.5722	1.7458	6.1993
48	2.3449	-5.1742	2.7906
49	3.1347	-5.5410	2.4269
50	3.6627	-5.2044	3.0581
51	2.0817	-7.7558	1.7690
52	4.9891	-3.1236	4.1629
53	3.0189	-4.6998	1.9321

Count	Group 1	Group 3	Group 4
54	7.2865	1.8650	7.1840
55	8.6919	3.3478	6.9890
56	1.5484	-4.0888	1.2181
57	4.0483	-.7841	3.5405
58	9.9046	8.0829	10.1897
59	5.1003	.9590	6.0274
60	5.4122	2.4764	5.8868
61	2.5186	-4.9870	2.9684
62	15.0624	14.4428	13.5131
63	6.7150	1.4816	6.5084
64	5.6094	-1.4237	4.3965
65	10.0883	7.0048	9.2280
66	10.7709	8.1423	9.7706
67	7.9568	4.8436	6.9921
68	9.7329	6.8920	8.7587
69	5.9845	4.2746	6.0130
70	8.5384	4.8968	7.8112
71	3.4223	-2.3011	3.2274
72	11.4379	5.9506	9.9401
73	3.1582	.4271	1.7838
74	27.7035	26.3984	27.1086
75	17.7756	11.3781	16.9768
76	10.1990	7.7772	9.0870
77	7.7909	9.1814	8.3571
78	4.4665	1.1402	5.0418
79	10.5218	9.8822	10.3802
80	10.0253	7.5900	8.9091
81	7.4531	2.2774	7.2641
82	10.5268	11.1679	9.8868
83	7.3096	4.0089	6.3828
84	3.4383	-2.8143	3.4502
85	10.7294	10.4214	10.4700
86	9.4439	4.6387	9.2188
87	4.7542	2.4928	3.2838
88	12.7933	9.4842	12.1679
89	8.8770	7.9412	8.7613
90	11.2985	10.8803	11.1129
91	10.0627	6.3854	9.4321
92	12.7247	10.2488	11.7711
93	9.3589	5.9313	8.5928
94	11.9077	9.1034	11.0376
95	11.8526	9.4349	10.8289
96	9.4658	9.2091	9.1178
97	6.3439	1.8740	5.8198
98	9.2720	5.8377	8.5039
99	5.9770	.6858	5.7526
100	8.5820	3.4945	8.4200
101	6.9952	2.5761	6.4866
102	7.6179	6.5836	7.4721
103	8.4037	4.9015	7.6148
104	3.5890	-1.8887	3.3075
105	3.9509	-1.9828	3.8666
106	5.0362	.6377	4.4131

Count	Group 1	Group 3	Group 4
107	6.7786	4.7126	6.9889
108	1.5854	-3.8340	1.1722
109	.3477	-7.3275	.7456
110	.6078	-5.5872	.4435
111	5.3952	2.0818	4.3691
112	3.7128	-1.5403	3.3506
113	.7815	-5.4000	.6213
114	10.3654	8.1976	9.1636

Count	Group 1	Group 3	Group 4
1	18.6045	23.6371	18.3406
2	10.7542	13.4559	10.9711
3	17.1859	21.6352	17.0721
4	15.5960	23.2051	15.8121
5	11.9564	19.0342	12.1815
6	13.5237	16.7466	13.6882
7	13.7868	14.5564	13.2741
8	8.1447	9.3479	8.8031
9	12.9745	17.0946	12.7598
10	16.3893	19.8361	16.6224
11	18.7515	27.0714	18.8624
12	13.1519	17.1607	12.9902
13	21.7777	30.7653	21.7932
14	15.9191	22.9156	16.3913
15	10.2538	12.2313	10.7254
16	13.2112	14.3090	12.5394
17	5.5247	13.7450	4.9552
18	15.5243	22.6235	15.9351
19	22.0757	28.8973	21.3040
20	14.0563	18.3826	13.8201
21	18.7180	21.9305	17.5222
22	17.0876	20.9699	15.5424
23	18.5713	27.0956	18.5928
24	12.0287	19.5952	12.0675
25	19.0189	25.6838	19.7888
26	11.8966	15.6809	11.7541
27	12.8034	20.6584	12.7719
28	10.3355	16.3216	10.8975
29	12.6295	14.2559	11.7203

Table C5: MINITAB classification scores, group three specimens, TEST Four. All specimens correctly classified.

Count	Group 1	Group 3	Group 4
1	11.0247	11.9688	11.9406
2	5.9504	-2.2903	5.2263
3	9.2971	5.9728	10.1342
4	6.0806	-2.1499	5.3596
5	4.1404	-7.5820	4.6734
6	7.5470	2.1459	7.4508
7	7.2547	.5002	6.0229
8	8.6687	5.0372	7.9445
9	2.9246	-6.0002	2.3024
10	8.3163	-1.8985	8.4895
11	10.6858	11.3246	11.7021
12	10.2866	11.1730	11.1849
13	15.1095	19.1449	15.0438
14	9.4542	10.5270	10.2345
15	12.7670	17.4939	13.9515
16	5.6095	-2.8728	4.9609
17	7.9684	.6366	7.0001
18	8.7721	10.8169	9.1370
19	8.6122	.1320	8.1262
20	4.7758	-1.0934	4.7113
21	6.6450	-1.5414	5.9376
22	5.3741	-2.5171	4.4826
23	4.8391	1.2036	3.9083
24	2.5577	-5.7450	1.6733
25	7.2410	-.5043	6.3942
26	6.1122	-1.7214	5.2383
27	4.2654	-.5501	3.7628
28	6.5811	5.2922	6.4781
29	4.9285	-.2296	4.5953
30	4.3378	-3.8257	3.4960
31	1.4252	-7.3469	2.3087
32	-.3983	-9.3129	.4416
33	1.5374	-5.1802	1.6271
34	1.2394	-9.5286	1.2431
35	2.0638	-7.1798	1.5189
36	-1.7442	-10.7641	-.9366
37	3.8333	-1.5882	5.1899
38	6.5220	7.6356	8.7738
39	9.5845	7.7750	11.4942
40	11.2857	10.7903	12.7762
41	6.0476	.7992	7.4571
42	7.6741	5.7153	9.5381
43	7.5873	5.6217	9.4492
44	2.2501	-6.4575	3.1534
45	4.0235	-2.8755	4.3189
46	11.0887	13.7404	12.9900
47	7.5004	5.5281	9.3602

Table C6. MINITAB classification scores, group four specimens, TEST Four. Those scores circled are specimens misclassified into the group at the head of the column.

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            CASE        MIS          ACTUAL          HIGHEST  PROBABILITY       2ND HIGHEST
SUBFILE SEQNUM    VAL   SEL     GROUP           GROUP  P(X/G)  P(G/X)     GROUP  P(G/X)    DISCRIMINANT SCORES

SAMPL4A      1                  1. ***           4   .0847   .6275        1   .3725      2.6723      .6815
SAMPL4A      2                  1. ***           4   .0776   .6150        1   .3850      2.7221      .6096
SAMPL4A      3                  1. ***           4   .6802   .6122        1   .3876      1.3173      .7631
SAMPL4A      4                  1. ***           4   .6929   .6244        1   .3753      1.2685      .6535
SAMPL4A      5                  1. ***           4   .9042   .5534        1   .4458       .9237      .4515
SAMPL4A      6                  1. ***           4   .3050   .7004        1   .2996      1.7753     1.3221
SAMPL4A      7                  1. ***           4   .3053   .7204        1   .2795      1.7037     1.4545
SAMPL4A      8                  1. ***           4   .2998   .7362        1   .2637      1.6286     1.5630
SAMPL4A      9                  1. ***           4   .3061   .7137        1   .2863      1.7349     1.4694
SAMPL4A     10                  1. ***           4   .8750   .5396        1   .4597       .9764      .3733
SAMPL4A     11                  1.               1   .9602   .5174        4   .4801       .2699      .0216
SAMPL4A     12                  1. ***           4   .3054   .7196        1   .2801      1.7066     1.4563
SAMPL4A     13                  1.               1   .4759   .6650        4   .3349      1.5671     -.7752
SAMPL4A     14                  1. ***           4   .8455   .5942        1   .4053      1.6387      .6751
SAMPL4A     15                  1.               1   .4629   .7261        4   .2733      1.2720    -1.1738
SAMPL4A     16                  1.               1   .3907   .7783        4   .2196       .6614    -1.5732
SAMPL4A     17                  3.               3   .9736   .9886        1   .0064     -2.6953     -.2325
SAMPL4A     18                  1.               1   .5648   .6655        4   .2980      -.2436     -.9492
SAMPL4A     19                  1. ***           3   .3705   .3131        1   .1309     -1.7376    -1.0222
SAMPL4A     20                  1.               1   .7460   .6399        4   .3377      -.0848     -.7241
SAMPL4A     21                  1.               1   .3279   .4006        4   .3061     -1.0076     -.2173
SAMPL4A     22                  1. ***           4   .9528   .5385        1   .4601       .7524      .3695
SAMPL4A     23                  1. ***           4   .7013   .6379        1   .3518      1.2139      .5324
SAMPL4A     24                  1.               1   .5654   .6644        4   .2965      -.2465     -.9450
SAMPL4A     25                  1. ***           4   .6171   .5743        1   .4253      1.1137      .5276
SAMPL4A     26                  1. ***           4   .6960   .6314        1   .3663      1.2402      .8544
SAMPL4A     27                  1. ***           4   .9482   .5359        1   .4627       .7622      .3554
SAMPL4A     28                  1. ***           4   .3052   .7211        1   .2769      1.7007     1.4560
SAMPL4A     29                  1.               1   .9641   .5988        4   .3948       .3077     -.4172
SAMPL4A     30                  1.               1   .3652   .6011        4   .3968      1.8547     -.3966
SAMPL4A     31                  1.               1   .9655   .5946        4   .3984       .2921     -.3547
SAMPL4A     32                  1. ***           4   .9278   .5050        1   .4932       .6782      .1665
SAMPL4A     33                  1. ***           4   .8430   .5919        1   .4076      1.0455      .6664
SAMPL4A     34                  1. ***           4   .9118   .5192        1   .4796       .6256      .2658
SAMPL4A     35                  1. ***           4   .8511   .5999        1   .3995      1.0143      .7115
SAMPL4A     36                  1. ***           4   .3059   .7152        1   .2837      1.7232     1.4263
SAMPL4A     37                  1. ***           4   .6307   .5826        1   .4169      1.6816      .0143
SAMPL4A     38                  1.               1   .3351   .7539        4   .2459      1.4076    -1.3697
SAMPL4A     39                  1.               1   .9575   .5680        4   .4308       .7061     -.2232
SAMPL4A     40                  1.               1   .2427   .5533        4   .4467      2.1663     -.1265
SAMPL4A     41                  1. ***           4   .8159   .5175        1   .4820      1.6605      .2541
SAMPL4A     42                  1.               1   .7256   .6643        4   .3187       .0049     -.6537
SAMPL4A     43                  1.               1   .9890   .5787        4   .4159       .3641     -.2592
SAMPL4A     44                  1.               1   .9945   .5603        4   .4371       .5867     -.1852
SAMPL4A     45                  1. ***           4   .8911   .5113        1   .4877       .6556      .2201
SAMPL4A     46                  1.               1   .9723   .5435        4   .4546       .6674     -.0694
SAMPL4A     47                  1. ***           4   .3051   .7215        1   .2785      1.6782     1.4616
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Table C7: SPSS discriminant scores for TEST Four. The symbol *** indicates those specimens misclassified.

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             CASE      MIS             ACTUAL             HIGHEST  PROBABILITY        2ND HIGHEST
 SUBFILE    SEQNUM     VAL    SEL       GROUP             GROUP  P(X/G)  P(G/X)      GROUP  P(G/X)    DISCRIMINANT  SCORES
SAMPL4A        48                        1.                 1    .9865   .5894         4    .4059        .4041      -.3570
SAMPL4A        49                        1.  ***            4    .6767   .6095         1    .3903       1.3280       .7676
SAMPL4A        50                        1.                 1    .4575   .6690         4    .3301       1.5876      -.0047
SAMPL4A        51                        1.                 1    .4550   .6467         4    .3532       1.6571      -.6038
SAMPL4A        52                        1.                 1    .3222   .5775         4    .4224       1.9899      -.2825
SAMPL4A        53                        1.                 1    .4957   .6934         4    .3044       1.3991      -.9680
SAMPL4A        54                        1.                 1    .4024   .7475         4    .2521       1.2510     -1.3248
SAMPL4A        55                        1.                 1    .9663   .5244         4    .4732        .6162       .0135
SAMPL4A        56                        1.                 1    .1468   .8425         4    .1535        .4459     -2.1720
SAMPL4A        57                        1.                 1    .9809   .5806         4    .4173        .0638      -.2965
SAMPL4A        58                        1.                 1    .9437   .6212         4    .3733        .3935      -.5413
SAMPL4A        59                        1.  ***            4    .6267   .5336         1    .4613       -.4834       .3344
SAMPL4A        60                        1.  ***            4    .6564   .7132         1    .2823        .3067      1.4167
SAMPL4A        61                        1.  ***            4    .8064   .6042         1    .3759       -.1146       .7955
SAMPL4A        62                        4.  ***            3    .1450   .4235         4    .4117      -1.2982      1.3689
SAMPL4A        63                        4.  ***            1    .5266   .6735         4    .3264       1.4480      -.6286
SAMPL4A        64                        4.                 4    .6737   .6903         1    .2989        .0407      1.2916
SAMPL4A        65                        4.  ***            1    .5234   .5728         4    .3271       1.4457      -.0244
SAMPL4A        66                        4.                 4    .0862   .6302         1    .3698       2.6616       .8970
SAMPL4A        67                        4.  ***            1    .9651   .5229         4    .4748        .6104       .0220
SAMPL4A        68                        4.  ***            1    .3826   .7735         4    .2256        .9337     -1.3234
SAMPL4A        69                        1.  ***            4    .6760   .6105         1    .3893       1.3241       .7732
SAMPL4A        70                        4.  ***            1    .7289   .6617         4    .3207       -.0043      -.0356
SAMPL4A        71                        4.  ***            1    .4413   .6507         4    .3492       1.6736      -.6670
SAMPL4A        72                        4.                 4    .2449   .5431         1    .4569       2.1533       .4017
SAMPL4A        73                        1.                 1    .0673   .5712         3    .3074      -1.0301     -1.9740
SAMPL4A        74                        1.                 1    .9945   .5499         4    .4472        .5477      -.1200
SAMPL4A        75                        1.                 1    .3790   .7703         4    .2290       1.0233     -1.4966
SAMPL4A        76                        1.                 1    .5719   .5808         4    .2880       -.1900     -1.0268
SAMPL4A        77                        1.                 1    .4266   .6945         4    .2554       -.3462     -1.2191
SAMPL4A        78                        4.                 4    .1485   .4004         3    .3349      -1.1927      1.5268
SAMPL4A        79                        3.                 3    .6769   .8692         4    .0725      -1.9161       .4303
SAMPL4A        80                        3.                 3    .9820   .9784         1    .0114      -2.4976      -.0280
SAMPL4A        81                        3.                 3    .6773   .9989         4    .0006      -3.4640       .4270
SAMPL4A        82                        1.                 1    .5640   .7015         4    .2673       -.1905     -1.1392
SAMPL4A        83                        1.                 1    .4673   .6965         4    .2629       -.2771     -1.1051
SAMPL4A        84                        1.  ***            4    .5607   .4656         1    .4525       -.5421       .1857
SAMPL4A        85                        1.                 1    .7280   .6625         4    .3201       -.0019      -.0435
SAMPL4A        86                        3.                 3    .7568   .9961         4    .0011      -3.2956       .4505
SAMPL4A        87                        1.                 1    .9716   .5476         4    .4506        .7030      -.1115
SAMPL4A        88                        4.                 4    .1462   .4174         3    .4126      -1.2016      1.3645
SAMPL4A        89                        1.                 1    .2446   .8145         4    .1621        .5095     -1.6916
SAMPL4A        90                        1.                 1    .2239   .7586         4    .1920       -.3482     -1.7255
SAMPL4A        91                        1.                 1    .4323   .5488         4    .3025       -.7266      -.6644
SAMPL4A        92                        1.                 1    .7165   .6890         4    .3099        .6608      -.9350
SAMPL4A        93                        1.                 1    .3387   .7054         4    .2520       -.4217     -1.3722
SAMPL4A        94                        3.                 3    .7026   .9201         4    .0432      -2.0954       .3571
SAMPL4A        95                        3.                 3    .2608   .5744         1    .2662      -1.3733      -.5611
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Table C7: continued.

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           CASE          MIS          ACTUAL          HIGHEST  PROBABILITY      2ND  HIGHEST
SUBFILE  SEQNUM          VAL   SEL    GROUP           GRCUP  P(X/G)  P(G/X)     GROUP  P(G/X)    DISCRIMINANT  SCORES
SAMPL4A      96                          3.               3   .2559   .5316         4   .3085     -1.4033    1.0370
SAMPL4A      97                          1.  ***          3   .3151   .5927         4   .2598     -1.4710     .9102
SAMPL4A      98                          3.               3   .9461   .9715         1   .0158     -2.4029    -.1627
SAMPL4A      99                          4.  ***          3   .9479   .9669         1   .0171     -2.3625     .0412
SAMPL4A     100                          1.  ***          4   .8244   .6318         1   .3554       .0175     .9343
SAMPL4A     101                          3.               3   .7817   .9328         4   .0375     -2.1498     .4502
SAMPL4A     102                          1.               1   .3805   .4175         4   .3624      -.6951    -.0511
SAMPL4A     103                          3.               3   .5780   .9995         4   .0003     -3.6978     .2718
SAMPL4A     104                          1.               1   .3576   .7067         4   .2315      -.4178   -1.3778
SAMPL4A     105                          1.               1   .9931   .5454         4   .4515       .5311    -.1049
SAMPL4A     106                          3.               3   .9452   .9675         1   .0176     -2.3032    -.0904
SAMPL4A     107                          1.  ***          3   .3104   .5543         1   .2918     -1.3446    -.7323
SAMPL4A     108                          1.               1   .5510   .6980         4   .2763      -.1275   -1.1170
SAMPL4A     109                          3.               3   .4646   .9997         4   .0001     -3.9170     .1396
SAMPL4A     110                          1.  ***          4   .8661   .5025         1   .4965       .0890     .1772
SAMPL4A     111                          4.  ***          3   .1984   .4790         4   .3572     -1.3513    1.2033
SAMPL4A     112                          3.               3   .6355   .9976         4   .0015     -3.2474     .7002
SAMPL4A     113                          1.               1   .3205   .3990         4   .3078     -1.0106    -.2131
SAMPL4A     114                          1.               1   .9955   .5536         4   .4419       .4107    -.1355
SAMPL4A     115                          1.               1   .1575   .7496         4   .1723      -.5049   -1.0016
SAMPL4A     116                          1.               1   .7474   .6363         4   .3404      -.0973    -.7058
SAMPL4A     117                          1.               1   .4294   .4380         4   .3901      -.7995    -.0152
SAMPL4A     118                          1.               1   .3454   .4016         4   .3333      -.4683    -.1117
SAMPL4A     119                          3.               3   .4372   .7353         4   .1630     -1.0047     .7198
SAMPL4A     120                          4.  ***          3   .2117   .9636         4   .0279     -2.4665    1.7467
SAMPL4A     121                          4.  ***          1   .5077   .6566         4   .3433      1.5320    -.7244
SAMPL4A     122                          4.  ***          1   .5139   .7245         4   .2751      1.1398   -1.1641
SAMPL4A     123                          1.               1   .7920   .6420         4   .3418       .0183    -.7115
SAMPL4A     124                          1.               1   .4373   .6805         4   .2623      -.3901   -1.1556
SAMPL4A     125                          1.               1   .6772   .5679         4   .3104      -.0730    -.6974
SAMPL4A     126                          1.               1   .5301   .6760         4   .2831      -.2790   -1.0410
SAMPL4A     127                          1.               1   .3887   .6905         4   .2480      -.4152   -1.2320
SAMPL4A     128                          3.               3   .3616   .6649         1   .2218     -1.4918    -.7798
SAMPL4A     129                          3.               3   .4650   .9946         1   .0053     -3.7284    -.6507
SAMPL4A     130                          3.               3   .0609   .9979         4   .0012     -3.2855     .6840
SAMPL4A     131                          3.               3   .5365   .9984         1   .0011     -3.3050    -.9202
SAMPL4A     132                          1.               1   .3125   .4033         3   .3120     -1.0348    -.3342
SAMPL4A     133                          1.               1   .9204   .6236         4   .3693       .2780    -.5541
SAMPL4A     134                          4.  ***          3   .4999   .7599         4   .1417     -1.8954     .0341
SAMPL4A     135                          3.               3   .9551   .9769         1   .0129     -2.4700    -.1526
SAMPL4A     136                          4.  ***          1   .5466   .6192         4   .3807      1.5459    -.5051
SAMPL4A     137                          4.  ***          1   .9257   .5154         4   .4831       .7611     .0667
SAMPL4A     138                          4.  ***          1   .5357   .6698         4   .3300      1.4330    -.6600
SAMPL4A     139                          4.  ***          1   .4930   .7090         4   .2907      1.3232   -1.0579
SAMPL4A     140                          1.               1   .6766   .6684         4   .3100      -.0710    -.9002
SAMPL4A     141                          4.  ***          1   .5819   .7039         4   .2775      -.0225   -1.1217
SAMPL4A     142                          4.  ***          1   .4423   .7076         4   .2922      1.4537   -1.0470
SAMPL4A     143                          1.               1   .9951   .5543         4   .4429       .2645    -.1928
```

Table C7: continued.

SUBFILE	CASE SEQNUM	MIS VAL	SEL	ACTUAL GROUP		HIGHEST PROBABILITY GROUP	P(X/G)	P(G/X)	2ND HIGHEST GROUP	P(G/X)	DISCRIMINANT SCORES	
SAMPL4A	144			3.		3	.2697	.9502	1	.0383	-2.2062	-1.5064
SAMPL4A	145			3.		3	.1375	.9756	1	.0201	-2.4495	-1.9794
SAMPL4A	146			3.		3	.5456	.9996	4	.0002	-3.7765	.1466
SAMPL4A	147			3.		3	.7263	.9989	4	.0005	-3.4066	.1750
SAMPL4A	148			3.		3	.4563	.9960	4	.0027	-3.1157	1.1754
SAMPL4A	149			4.	***	1	.5360	.6997	4	.3000	1.2812	-.9975
SAMPL4A	150			4.	***	1	.5099	.7054	4	.2943	1.3066	-1.0340
SAMPL4A	151			1.		1	.9093	.5306	4	.4561	.5053	-.6682
SAMPL4A	152			4.	***	1	.9454	.6200	4	.3750	.3387	-.5342
SAMPL4A	153			3.		3	.9226	.9593	1	.0218	-2.2903	-.6031
SAMPL4A	154			3.		3	.6789	.9992	1	.0004	-3.5640	.6766
SAMPL4A	155			4.	***	1	.4913	.4592	4	.4143	-.6803	.0033
SAMPL4A	156			3.		3	.6519	.9931	4	.0044	-2.9206	.0935
SAMPL4A	157			1.		1	.9241	.6196	4	.3720	.2634	-.5436
SAMPL4A	158			3.		3	.3276	.7036	1	.1541	-1.6800	-1.1054
SAMPL4A	159			1.		1	.4483	.4505	4	.3843	-.7712	-.0561
SAMPL4A	160			1.		1	.6765	.6737	4	.3060	-.0515	-.9254
SAMPL4A	161			1.		1	.9911	.5685	4	.4291	.6179	-.2563
SAMPL4A	162			4.	***	1	.9957	.5806	4	.4160	.5121	-.3021
SAMPL4A	163			1.		1	.9274	.5204	4	.4763	.7796	.0399
SAMPL4A	164			1.		1	.6635	.5457	4	.3463	.2462	-.6996
SAMPL4A	165			1.	***	4	.6686	.5228	1	.4236	-.4131	.4329
SAMPL4A	166			4.	***	1	.4812	.6967	4	.3011	1.4137	-.9892
SAMPL4A	167			1.		1	.9757	.6003	4	.3971	.5872	-.4166
SAMPL4A	168			1.	***	4	.6600	.5981	1	.4017	1.3729	.7027
SAMPL4A	169			4.		4	.3060	.7075	1	.2924	1.7632	1.5686
SAMPL4A	170			4.		4	.3045	.6984	1	.3015	1.8041	1.3094
SAMPL4A	171			1.		1	.9244	.5404	4	.4565	.8547	-.0866
SAMPL4A	172			1.		1	.4815	.7169	4	.2570	-.1327	-1.2244
SAMPL4A	173			1.		1	.9504	.5876	4	.4091	.5394	-.5415
SAMPL4A	174			1.		1	.9249	.5393	4	.4555	.8508	-.0630
SAMPL4A	175			4.		4	.8294	.5221	1	.4773	1.0427	.2795
SAMPL4A	176			1.		1	.2678	.7067	4	.2124	-.5161	-1.4556
SAMPL4A	177			4.		4	.1757	.5009	1	.4991	2.3123	.1720
SAMPL4A	178			4.	***	1	.4037	.5329	4	.3670	1.7814	-.5611
SAMPL4A	179			4.		4	.3024	.6910	1	.3084	1.8344	1.2657
SAMPL4A	180			4.		4	.3190	.7945	1	.2046	.7490	2.0694
SAMPL4A	181			4.		4	.0082	.7015	3	.2247	-1.2298	3.2131
SAMPL4A	182			4.		4	.0590	.8329	1	.1264	-.5390	2.7526
SAMPL4A	183			4.		4	.1127	.7339	1	.1653	-.7917	2.1772
SAMPL4A	184			4.		4	.2694	.8029	1	.1961	.6999	2.0763
SAMPL4A	185			4.		4	.0700	.8497	1	.1318	-.2961	2.6906
SAMPL4A	186			4.		4	.0705	.8495	1	.1320	-.2941	2.6880
SAMPL4A	187			4.		4	.3061	.7116	1	.2884	1.7446	1.8553
SAMPL4A	188			4.		4	.8148	.5730	1	.4265	1.1186	.5607
SAMPL4A	189			4.	***	3	.0154	.6462	4	.3060	-1.7467	2.7365
SAMPL4A	190			4.		4	.0711	.8493	1	.1323	-.2922	2.6851

Table C7: continued.

represented graphically on Figure C4 and the territorial map on Figure C5.

Comparing the SPSS and MINITAB outputs it can be seen that not only are the same number of specimens from each group misclassified but in each case the same specimens are misclassified and misclassified into the same (incorrect) groups.

The overall classification results (64.74 %, Table C8) are not nearly as good as those obtained for TEST One (97.90 %, Table C3). Though these three variables (NOBO, GSD, POSQ) are good discriminators for two groups, they are poor discriminators for these three groups, particularily for groups one and four.

The overall classification results are given on the classification matrix below:

```
                   NO. OF    PREDICTED GROUP MEMBERSHIP
 ACTUAL GROUP      CASES         1          3          4
---------------   ------    -------    --------   --------
GROUP       1        114        74          3         37
                              64.9        2.6       32.5
GROUP       3         29         0         29          0
                                 0      100.0          0
GROUP       4         47        21          6         20
                              44.7       12.8       42.6

PERCENT OF GROUPED CASES CORRECTLY CLASSIFIED -  64.74
```

Table C8: Classification results, TEST Four.

SUMMARY OF TEST RESULTS

There are three major stages to discriminant analysis; derivation, validation, and interpretation. To understand the derivation stage an illustrative example, TEST, was devised and the

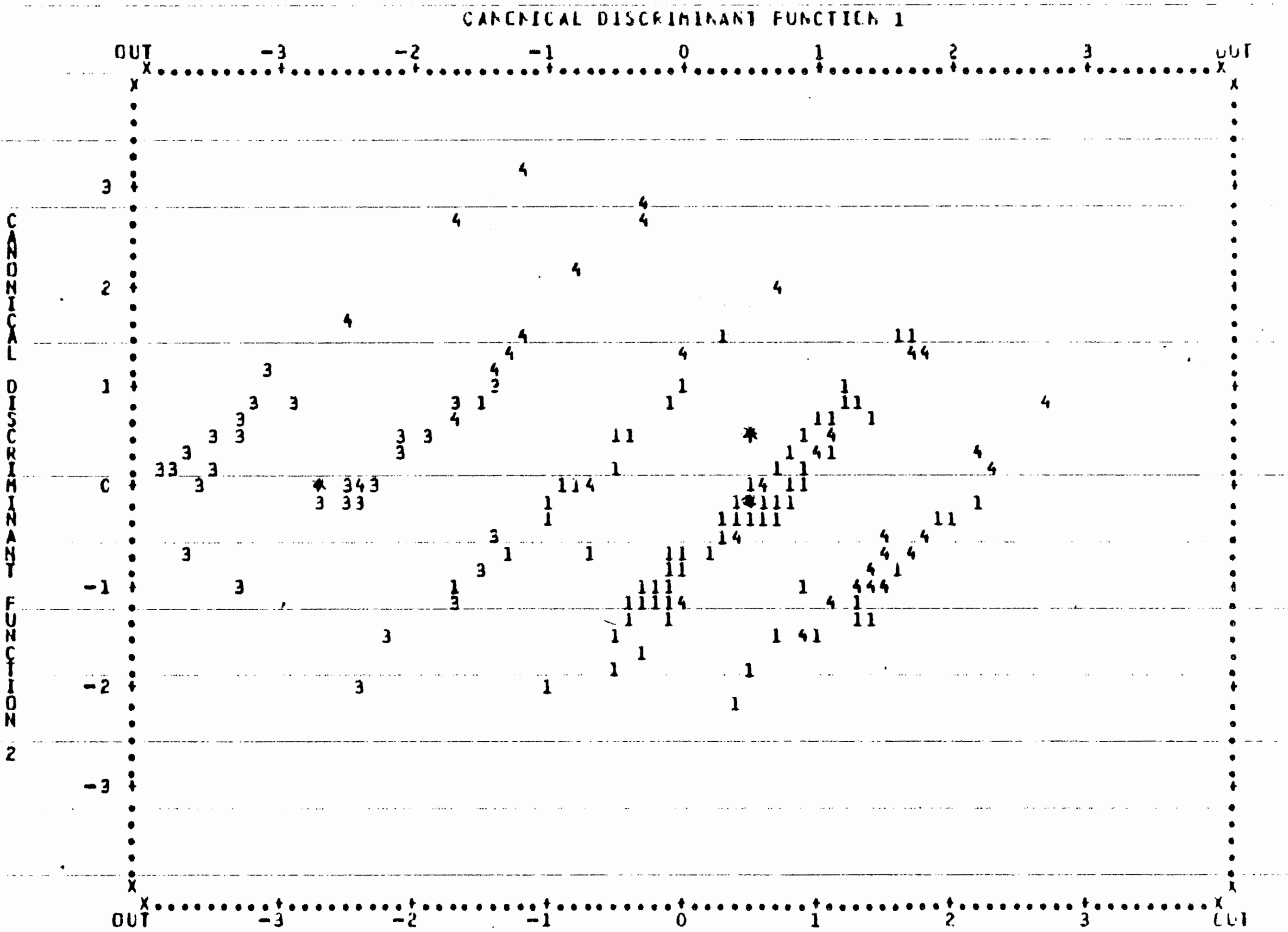


Figure C4: Scatter plot, TEST Four.

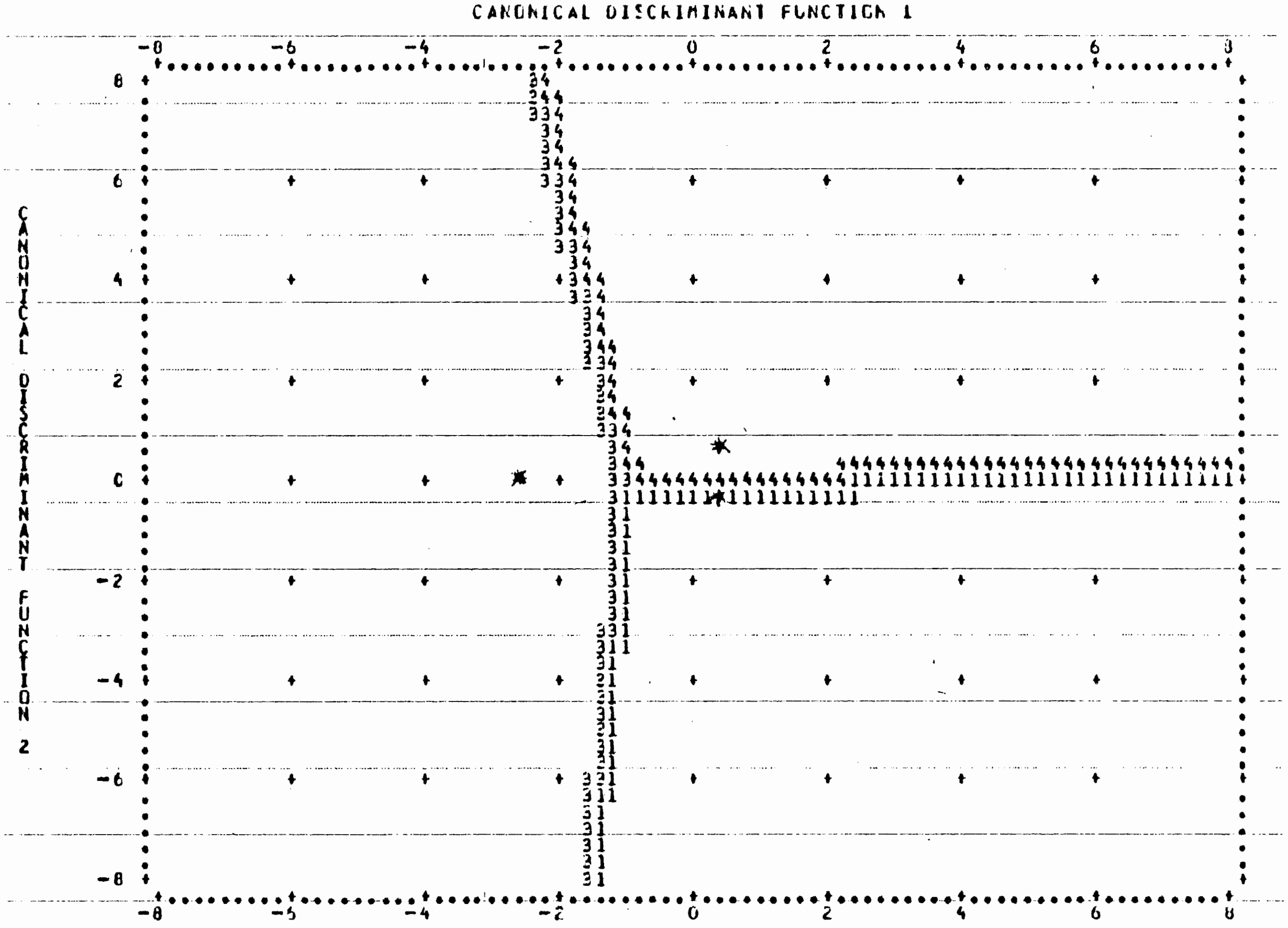


Figure C5: Territorial map, TEST Four.

following derivations / calculations are understood / duplicated with the aid of MINITAB.

1. Calculation of the pooled within group variance matrix (W).

2. Calculation of the pooled within groups variance-covariance matrix (B) for the three group case (TEST Four), and the corresponding eigenvalues (λ).

3. Derivation of the unstandardized (Z only; Z_{SZ}) discriminant functions.

4. Derivation of the standardized (Z and variable, Z_S) discriminant functions.

5. Calculation of $\bar{Z}$ values of the group centroids (= group means).

6. Calculation of critical Z values.

7. Calculation of the discriminant (Z) scores, two group case (TEST One).

8. Derivation of the classification functions.

9. Calculation of the classification scores and classification matrices, three group case (TEST Four).

APPENDIX D: SPSS Output of analysis A-1.

```
- - - - - - - - - - - - - - - - - - - - -   D I S C R I M I N A N T   A N A L Y S I S   - - - - - - - - - - - - - - - - - - - -
ON GROUPS DEFINED BY FORM

          721 (UNWEIGHTED) CASES WERE PROCESSED.
            0 OF THESE WERE EXCLUDED FROM THE ANALYSIS.
          721 (UNWEIGHTED) CASES WILL BE USED IN THE ANALYSIS.


NUMBER OF CASES BY GROUP

             NUMBER OF CASES
  FORM    UNWEIGHTED    WEIGHTED  LABEL

     1          163        163.0
     2           61         61.0
     3           51         51.0
     4          134        134.0
     5           46         46.0
     6           69         69.0
     7           20         20.0
     8           67         67.0
     9          100        100.0
    10           10         10.0

 TOTAL          721        721.0


GROUP MEANS

  FORM         PAP         UMCU         DEUM          POR         AOMA         NOBJ         PERO         REPO

     1      .85890       .99387      1.76687      2.07975      1.00613      1.02454      1.70552      1.49080
     2      .96721       .13115      1.16393      2.73770      1.01639       .80328      2.26230      2.26230
     3      .96078       .19608      2.37255      3.01961      1.31373      3.00000      2.15686      2.84314
     4      .97015       .19403      1.53731      2.20896      1.02239      1.67164      2.01493       .87313
     5      .58696       .93478      2.64783      2.28261      1.97826      1.08696      1.52174      1.58696
     6      .97101       .01449      2.72464      1.05797      1.88405      3.07246      1.95652      3.43478
     7      .95000       .40000      3.00000      3.80000      2.00000      1.20000      1.85000      3.65000
     8      .01493       .63582      1.61194      2.19403      1.00000       .01493      1.91045      3.79104
     9      .97000       .07000      1.39000      3.98000      1.00000       .62000      1.89000      3.98000
    10     1.00000            0      1.50000      2.40000      2.00000      2.00000      1.80000      2.40000

 TOTAL      .83079       .44521      1.84050      2.46741      1.21775      1.34674      1.90430      2.36061

  FORM         SUT         CHAM         POSU         DEPO         POSQ          GSR

     1     1.93865      9.42945      1.03521      1.94479      2.66123       .85221
     2     1.55738      9.21311      1.59016      2.01639      4.07776       .83462
     3     1.68627     10.49020      1.82353      2.23529      4.81855       .85410
     4     1.82090      9.02239       .67910       .99254      1.68390       .84089
     5     1.95652     10.84783      1.06522      1.97826      3.05525       .84931
     6     1.17391     10.42029      2.26037      2.85507      5.56213       .86507
     7     1.30000     13.90000      2.40000      2.90000      6.73353       .85082
     8     1.79104      9.65672      2.79104      3.00000      6.66865       .85074
```

```
 FORM            SUT            CHAM           POSU           DEPO           POSQ           GSR

     9         1.95000       12.23000        2.94000        2.98000        7.76124         .85866
    10         1.50000        9.50000        1.40000        2.60000        3.65683         .82685

   TOTAL       1.75867       10.13037        1.66574        2.16089        4.27089         .85016

GROUP STANDARD DEVIATIONS

 FORM            PAP            UMCO           DEUM           POR            ADMA           NOBO           PERO           REPO

     1          .34920         .13594         .49154         .33299         .07833         .60808         .55481         .86330
     2          .17956         .34036         .37329         .65579         .12804        1.06175         .62985         .79376
     3          .19604         .40098         .56430         .42380         .46862         .93808         .57871         .80926
     4          .17081         .39694         .64490         .69450         .14850        1.53543         .64871         .83551
     5          .49732         .24964         .36316         .50169         .14744         .55080         .58648        1.06617
     6          .16899         .12039         .44997         .29125         .32250         .92861         .71609         .77608
     7          .22361         .50262              0         .61559              0         .69585         .58714         .74516
     8          .12217         .37323         .49079         .46836              0         .12217         .71205         .56508
     9          .17145         .25643         .49021         .14071              0         .67838         .54855         .14071
    10               0              0         .84984         .51640              0         .73786         .63246         .69921

   TOTAL        .37520         .50012         .73848         .92907         .41301        1.29707         .64161        1.38756

 FORM            SUT            CHAM           POSU           DEPO           POSQ           GSR

     1          .24071        1.04804         .54718         .97659        1.49197         .05366
     2          .50082        1.03465         .58013         .69503        1.30820         .05434
     3          .46862        1.23891         .65440         .70960        1.13895         .05322
     4          .38488        1.28301         .55658         .88049        1.49688         .05378
     5          .20618        1.22868         .80006        1.20165        1.91839         .05104
     6          .38181        1.47933         .65646         .39390        1.38734         .07880
     7          .47016        2.26878         .68056         .30779        1.07602         .05372
     8          .40963        1.06086         .59128         .17408        1.07627         .04220
     9          .21904        1.48973         .31205         .14071        1.12508         .03891
    10          .52705         .52705         .51640         .51640         .95894         .03159

   TOTAL        .42819        1.75900        1.00445        1.02153        2.54039         .05396
```

```
POOLED WITHIN-GROUPS COVARIANCE MATRIX WITH       711 DEGREES OF FREEDOM

            PAP            UMCO           DEUM           POR            ADMA           NOBO           PERO           REPO

PAP      .6389658E-01
UMCO    -.3018986E-02   .8893532E-01
DEUM    -.4252759E-02  -.5216680E-02   .2596907
POR      .4523600E-02  -.2512821E-02   .1980124E-03   .2250744
ADMA    -.1060525E-02   .2902498E-03   .2551533E-01  -.1422889E-02   .3367289E-01
NOBO    -.1026763E-01  -.3448370E-02   .1592617      -.4282257E-01   .1522352E-01   .8692382
PERO     .6414417E-02  -.1512785E-01  -.3808780E-01   .2107687E-01  -.3303071E-02   .7626102E-02   .3799354
REPO    -.2698672E-01  -.6712867E-02   .2230493E-01   .8696527E-01  -.2528093E-02   .1452810E-01  -.8947199E-03   .5825896
SUT     -.1068162E-02   .3686006E-02   .4174982E-02  -.1785917E-02   .3387792E-02  -.1129869E-01  -.2437879E-01  -.2606679E-01
CHAM    -.2354988E-01   .8203593E-01   .1459734       .8919795E-01   .1358267E-01   .3078667      -.4314957E-01   .2658095
POSU    -.1546515E-01  -.9425924E-02   .4183047E-02   .5693599E-01  -.1083965E-01   .5492888E-02   .1345274E-01   .3049801
DEPO    -.2483729E-01   .1501327E-01  -.1170347E-01   .6607042E-01  -.4057181E-02  -.7012543E-01  -.1830249E-01   .3357316
POSQ    -.4983730E-01  -.5663800E-02   .4369289E-01   .1938389      -.1020106E-01   .6499169E-01   .2871122E-01   .8578083
GSR     -.5228996E-03   .1370901E-02   .1743561E-02   .7154997E-03   .1528599E-03   .3440857E-02  -.6371782E-03   .2947607E-02

            SUT            CHAM           POSU           DEPO           POSQ           GSR

SUT      .1238344
CHAM     .1902283E-01  1.619841
POSU    -.2203069E-01   .1956435       .3289645
DEPO    -.4617028E-03   .1393849       .2118951       .6588533
POSQ    -.4102440E-01   .8737417       .6256405       .6722890      1.940760
GSR     -.2024894E-02   .9036332E-02   .3163508E-02   .2114171E-02   .8856217E-02   .2670106E-02


WILKS  LAMBDA (U-STATISTIC) AND UNIVARIATE F-RATIO
WITH   9 AND         711 DEGREES OF FREEDOM

  VARIABLE    WILKS  LAMBDA          F          SIGNIFICANCE
  --------    -------------    -------------    ------------

  PAP             .44822           97.25               0
  UMCO            .35113           146.0               0
  DEUM            .47023           89.00               0
  POR             .25749           227.8               0
  ADMA            .19494           326.2               0
  NOBO            .51021           75.84               0
  PERO            .91139           7.680               0
  REPO            .29881           135.4               0
  SUT             .67775           37.56               0
  CHAM            .51698           73.81               0
  POSU            .32197           166.4               0
  DEPO            .52885           70.38               0
  POSQ            .29697           137.0               0
  GSR             .97339           2.160           .0233
```

```
ON GROUPS DEFINED BY FORM


ANALYSIS NUMBER        1

DIRECT METHOD-  ALL VARIABLES PASSING THE TOLERANCE TEST ARE ENTERED.

     MINIMUM TOLERANCE LEVEL..................   .00100

CANONICAL DISCRIMINANT FUNCTIONS

     MAXIMUM NUMBER OF FUNCTIONS.............         9
     MINIMUM CUMULATIVE PERCENT OF VARIANCE...   100.00
     MAXIMUM SIGNIFICANCE OF WILKS  LAMBDA....   1.0000

                                          CANONICAL DISCRIMINANT FUNCTIONS

                          PERCENT OF  CUMULATIVE    CANONICAL  -   AFTER
FUNCTION   EIGENVALUE      VARIANCE      PERCENT    CORRELATION - FUNCTION   WILKS  LAMBDA   CHI-SQUARED    D.F.   SIGNICANCE

                                                               -     0       .0012348      4741.4       126            0
     1*      5.45895        36.87        36.87       .9193346  -     1       .0079755      3420.6       104            0
     2*      3.85768        26.05        62.93       .8911456  -     2       .0387424      2301.6        84            0
     3*      2.70047        18.24        81.17       .8542621  -     3       .1433649      1375.2        66            0
     4*      1.68465        11.39        92.54       .7921565  -     4       .3848345      676.01        50            0
     5*       .49746         3.35        95.90       .5763688  -     5       .5763479      390.14        36            0
     6*       .29001         1.95        97.86       .4741444  -     6       .7434352      207.85        24            0
     7*       .16390         1.11        98.97       .3752631  -     7       .8653568      102.39        14        .0000
     8*       .12908          .87        99.64       .3381142  -     8       .9770549      16.434         6        .0116
     9*       .02348          .16       100.00       .1514764  -

     * MARKS THE    9 FUNCTION(S) TO BE USED IN THE REMAINING ANALYSIS.


STANDARDIZED CANONICAL DISCRIMINANT FUNCTION COEFFICIENTS

                FUNC   1   FUNC   2   FUNC   3   FUNC   4   FUNC   5   FUNC   6   FUNC   7   FUNC   8   FUNC   9

PAP               .10875     .21445     .48611    -.07312    -.67202     .34056     .04500    -.02603     .28446
UMCO             -.10883    -.48591    -.43012    -.39430    -.41306    -.10925     .28362    -.16337    -.02708
OEUM              .12750    -.21327    -.19225    -.19903    -.26794    -.43215    -.69205    -.19888     .45401
POR              -.38491     .54449     .05227    -.57332     .18303    -.49200     .25863    -.19074     .04805
AOMA              .81192     .14563    -.08650    -.31749     .82137     .15935     .83057     .14334     .06930
NUBO              .13039     .03424     .47278     .21895    -.17949    -.68089     .40597     .24500    -.31533
PERO              .01578    -.04546    -.00141     .06531     .05582    -.16538    -.11325    -.31452     .34885
REPO              .08835     .27779    -.23996     .27475    -.23990    -.34148     .08777    -.35516    -.47469
SUT              -.25064    -.00699    -.08179    -.10203    -.04731    -.13111     .03549     .82334     .28316
CHAM              .03659     .25785    -.01468    -.39732    -.13612     .40571    -.48737    -.03553    -.83935
POSU              .12543     .11519    -.33919     .11541    -.02602     .05421    -.17600     .21191    -.42081
DEPO              .17135    -.09173     .09470    -.06526    -.35347     .11558     .45103    -.06342    -.01099
POSQ             -.07270     .05714    -.12734     .34948     .05645     .17004     .02273     .35853    1.23119
GSR              -.03125    -.00885     .05172     .03532    -.08303     .00175    -.09408     .21919     .09655
```

```
UNSTANDARDIZED CANONICAL DISCRIMINANT FUNCTION COEFFICIENTS

               FUNC  1        FUNC  2        FUNC  3        FUNC  4        FUNC  5        FUNC  6        FUNC  7        FUNC  8

PAP           .4302008       .8483675      1.923072      -.2892740     -2.658532      1.347254       .1780140      -.1029888
UMCO         -.3649865     -1.632723      -1.442304     -1.188329      -1.375039      -.3663328       .9510538      -.5478210
DEUM          .2502030      -.4185455      -.3772490      -.3905583      -.5257843      -.7891505     -1.358022       -.3932681
POR          -.8113287      1.147476        .1101685     -1.208463        .3357981      -.8473452       .8451542      -.4020423
AOMA         4.424587        .7990613      -.4386692     -1.730149       1.751318        .8694874      1.801436        .7811518
NOBO          .1398495       .3672877E-01   .5070933      .2348470      -.1925131      -.7302554       .4354575       .2627799
PERO          .2559348E-01  -.7375851E-01  -.2281612E-02   .1059579       .9035376E-01  -.2583032      -.1674949      -.5102633
REPO          .1157577       .3639315      -.3143818       .3599600      -.3143011      -.4473899       .1149944      -.4655678
SUT          -.7065684      -.1970576E-01  -.2305570      -.2876139      -.1333793      -.3696172       .1000294      2.321026
CHAM          .2874916E-01   .2025939      -.1153112E-01  -.3121763      -.1069524       .3195545      -.3829291      -.2791576E-01
POSU          .2186899       .2008272      -.5913856       .2012230      -.4536588E-01   .9451889E-01  -.3103379       .3694748
DEPO          .2292115      -.1227786       .1266729      -.8729524E-01  -.4728337       .1546104       .6167113      -.8483535E-01
POSQ         -.5218228E-01   .4819327E-01  -.9140444E-01   .2508654       .4052143E-01   .1220563       .1635225E-01   .2573604
GSR          -.3832731      -.1554572       .9654178       .6593004     -1.549860        .3266939E-01 -1.756130       3.998117
(CONSTANT)  -3.741379      -5.932150        .8679790      7.098891      5.092652        .4508970      2.161113      -5.924132

               FUNC  9

PAP           1.125334
UMCO         -.9080966E-01
DEUM          .8909217
POR           .1012862
AOMA          .3776765
NOBO         -.3382166
PERO          .5659603
REPO         -.6219086
SUT           .7982353
CHAM         -.6594910
POSU         -.7336024
DEPO         -.1469506E-01
POSQ          .8837699
GSR          1.802171
(CONSTANT)  -1.173932

CANONICAL DISCRIMINANT FUNCTIONS EVALUATED AT GROUP MEANS (GROUP CENTROIDS)

   GROUP     FUNC   1    FUNC   2    FUNC   3    FUNC   4    FUNC   5    FUNC   6    FUNC   7    FUNC   8    FUNC   9

     1       -1.22679    -2.08632     -.09948     -.54599     -.88073      .13919      .13991     -.03849     -.02742
     2       -1.09906      .79276      .92920      .77759      .55744      .60117      .41067     -.69274      .28129
     3         .63231     1.34502      .99582     -.12025     -.40378    -1.79374      .12463     -.12008      .09794
     4       -1.12185     -.73854     2.09544      .13589      .72438     -.00331     -.33314      .12142     -.09417
     5        3.11921    -1.31022    -1.40823    -3.06645      .92709      .07626     -.01411      .43582      .25177
     6        5.52688     -.01316      .40176     1.96955     -.56232      .31346     -.21667      .10366      .02294
     7        3.49874     3.25975    -1.32173    -3.31690      .01174      .21541     -.58962    -1.30069     -.40544
     8       -1.03644    -1.10896    -3.88559     1.66462      .76742     -.32119     -.03006     -.06769     -.08246
     9       -1.81660     3.78843     -.66557     -.10325     -.35238      .29314     -.04881      .37024      .01201
    10        4.13784     1.39414     1.83422     -.28093     1.28208      .13436     2.73960      .47108     -.57972
```

```
PRIOR PROBABILITY FOR EACH GROUP IS   .10000

CLASSIFICATION FUNCTION COEFFICIENTS
(FISHER*S LINEAR DISCRIMINANT FUNCTIONS)

FORM    =         1              2              3              4              5              6              7              8


PAP             16.80364       18.02542       18.77399       17.37733       12.89328       21.06864       19.13090       4.702221
UMCO            5.415272      -3.914166      -2.883572      -3.533101       4.549295      -5.072266      -1.209308       4.342923
DEUM            1.912073      -1.045973       1.799617       .8506688E-01   3.524596       1.732824       3.015640       1.806201
POR             6.523835       9.930137       10.42047       7.778815       7.299190       .1721819       12.39101       5.345884
AOMA            25.03579       28.10658       33.91866       26.32273       53.15531       52.21828       54.75522       26.65139
NOBO           -1.506989      -1.250458       .7837305      -.5221079      -2.465602       .3735250E-01  -2.659938      -2.837859
PERO            7.526853       7.951832       8.040744       7.645329       7.438773       7.810618       7.574920       7.987877
REPO            5.774708       6.520834       7.721449       5.300975       5.112214       7.744424       8.078680       7.856330
SUT             19.61322       17.27771       18.41703       18.91060       18.64487       14.19003       13.79578       13.51891
CHAM            6.069159       5.904320       5.929414       6.113323       6.802439       6.012699       8.660727       5.404785
POSU            5.460443       5.141631       5.672727       4.772715       6.763777       7.691883       7.737360       8.346511
DEPO            3.415375       2.699577       2.992834       2.393298       3.366559       4.195729       3.181631       1.713855
POSQ           -7.814407      -7.232874      -7.866323      -7.757264      -8.084998      -7.372502      -9.011923      -6.925091
GSR             301.1314       297.6939       299.9413       302.3213       295.4073       299.7886       288.6562       296.1737
(CONSTANT)     -214.9818      -209.4777      -236.2932      -210.2677      -257.6789      -249.2740      -289.6322      -207.9859

CLASSIFICATION FUNCTION COEFFICIENTS
(FISHER*S LINEAR DISCRIMINANT FUNCTIONS)

FORM    =         9             10


PAP             19.09032       19.73179
UMCO           -4.864065      -6.044951
DEUM           -.9219218      -1.386767
POR             12.95869       3.043713
AOMA            27.67768       58.91623
NOBO           -1.758962       1.453514
PERO            6.978407       5.620817
REPO            7.711052       5.874491
SUT             20.75124       15.94750
CHAM            7.138652       5.943509
POSU            7.106769       5.928834
DEPO            2.070630       4.985229
POSQ           -7.160445      -8.264663
GSR             301.4712       292.5937
(CONSTANT)     -250.8330      -250.4400
```

```
TEST OF EQUALITY OF GROUP COVARIANCE MATRICES USING BOX*S M

   THE RANKS AND NATURAL LOGARITHMS OF DETERMINANTS PRINTED ARE THOSE
   OF THE GROUP COVARIANCE MATRICES.

     GROUP LABEL                    RANK   LOG DETERMINANT

         1                            14     -30.450691
         2                            14     -27.198444
         3                            14     -25.222006
         4                            14     -26.050209
         5                            14     -27.674586
         6                            14     -29.326704
         7                            12      (SINGULAR)
         8                            13      (SINGULAR)
         9                            13      (SINGULAR)
        10                          < 10    (TOO FEW CASES TO BE NON-SINGULAR)
      POOLED WITHIN-GROUPS
      COVARIANCE MATRIX               14     -25.042928

   SINCE SOME COVARIANCE MATRICES ARE SINGULAR, THE USUAL PROCEDURE WILL
   NOT WORK.  THE NON-SINGULAR GROUPS WILL BE TESTED AGAINST THEIR OWN
   POOLED WITHIN-GROUPS COVARIANCE MATRIX.  THE LOG OF ITS DETERMINANT
   IS       -23.809609

   BOX*S M      APPROXIMATE F  DEGREES OF FREEDOM  SIGNIFICANCE
    2196.9         3.8253      525,     150258.1       .0000

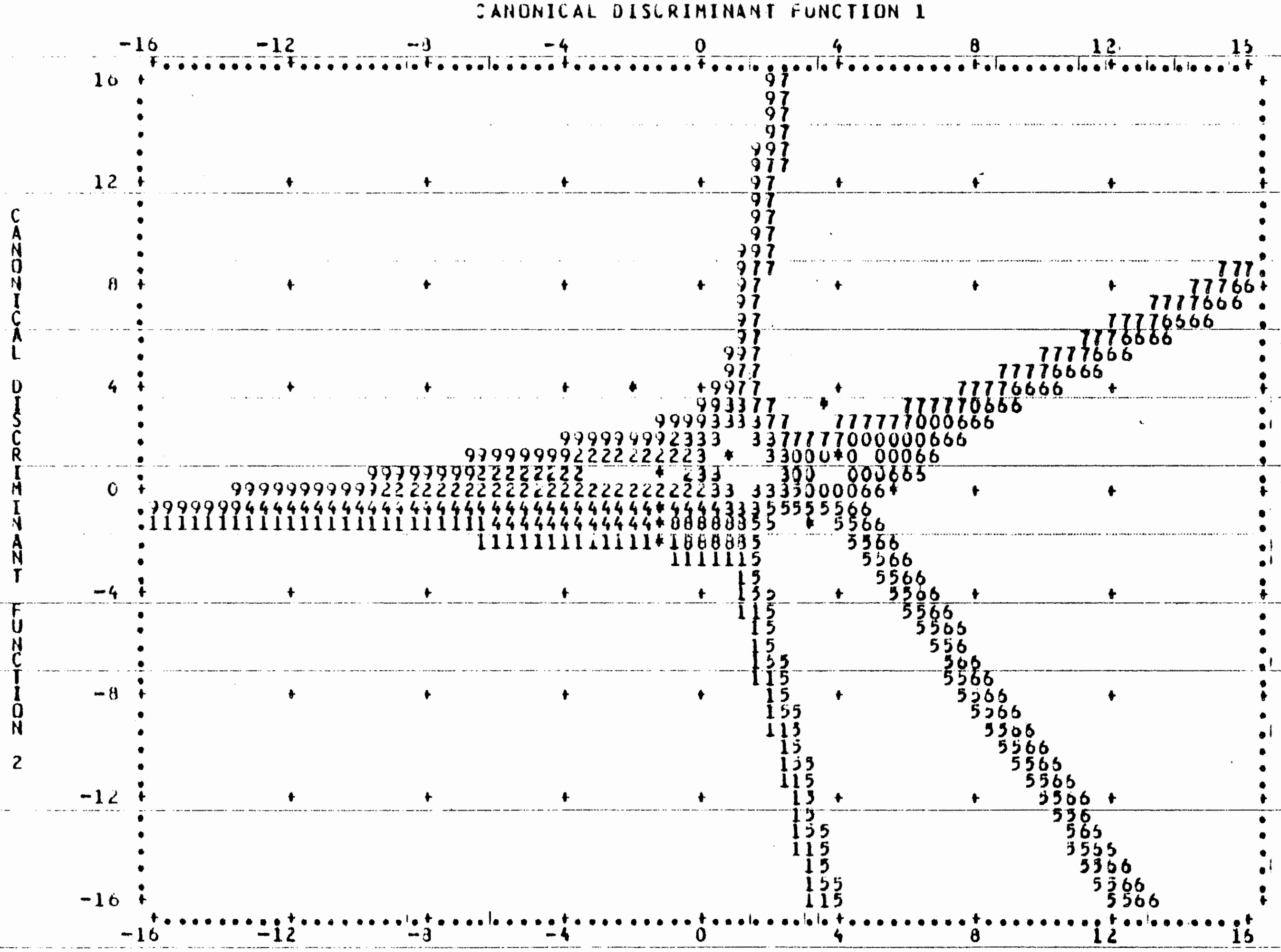

SYMBOLS USED IN TERRITORIAL MAP

SYMBOL  GROUP  LABEL
------  -----  --------------------

   1        1
   2        2
   3        3
   4        4
   5        5
   6        6
   7        7
   8        8
   9        9
   0       10
   *           GROUP CENTROIDS

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

```
TERRITORIAL MAP ASSUMING ALL FUNCTIONS BUT THE FIRST TWO ARE ZERO  * INDICATES A GROUP CENTROID
```



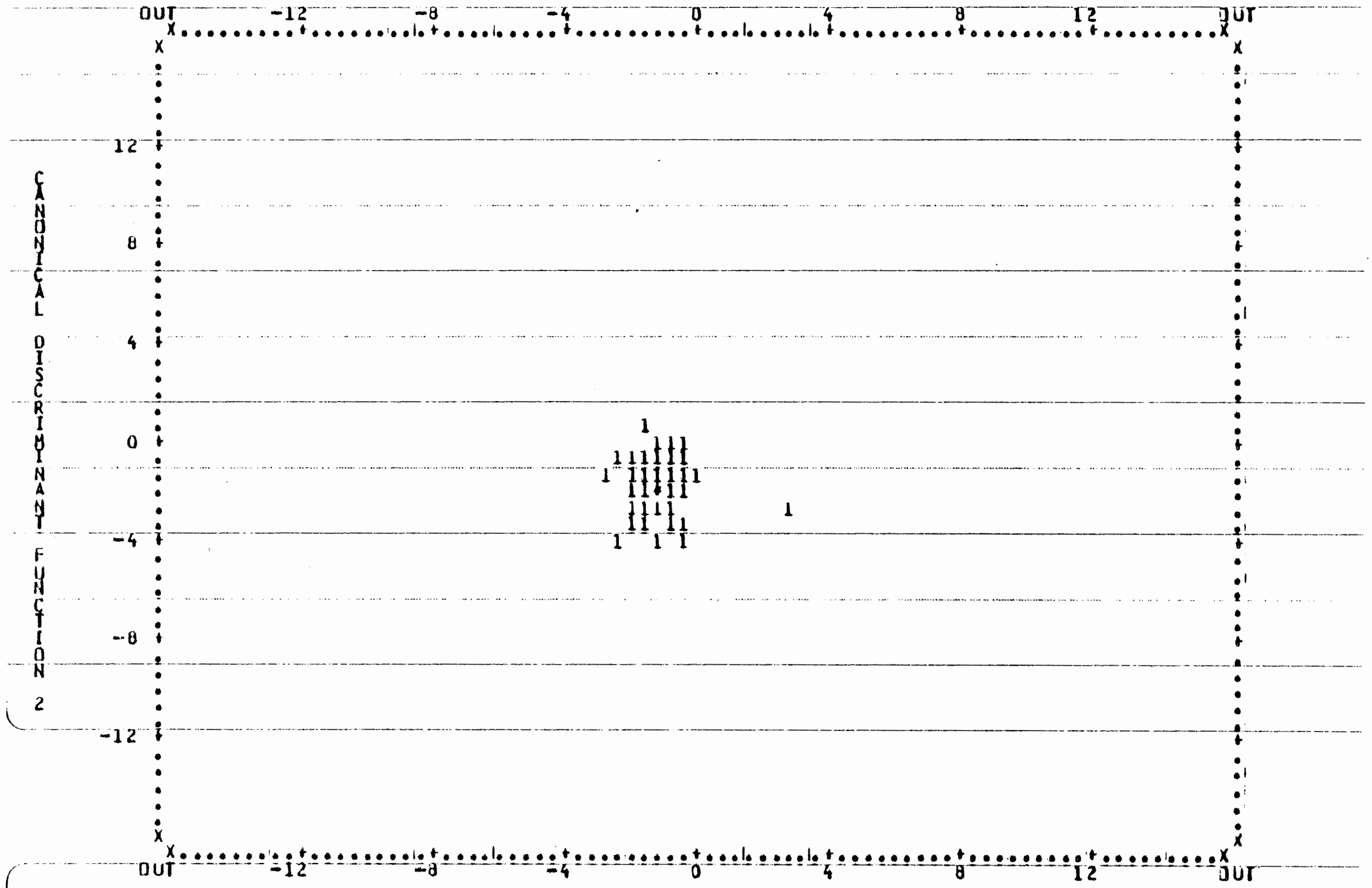
```
SYMBOLS USED IN PLOTS

SYMBOL  GROUP  LABEL
------  -----  ----------------
  1       1
  2       2
  3       3
  4       4
  5       5
  6       6
  7       7
  8       8
  9       9
  0      10
  *            GROUP CENTROIDS
```

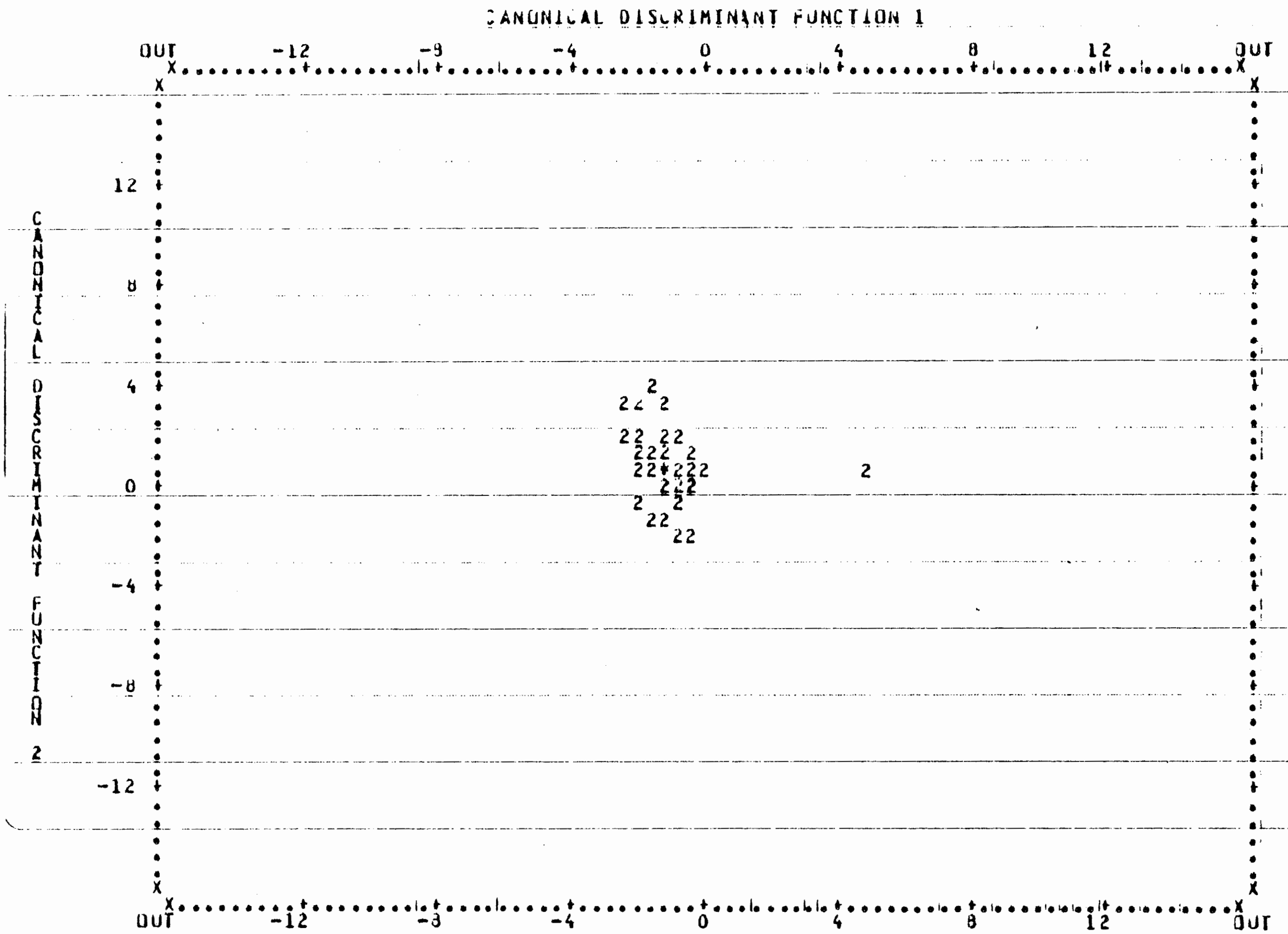
```
                         ALL-GROUPS SCATTERPLOT - * INDICATES A GROUP CENTROID
                                  CANONICAL DISCRIMINANT FUNCTION 1
         OUT       -12        -8        -4         0         4         8        12        OUT
           X.........+.........+.........+.........+.........+.........+.........+.........X
          X                                                                                 X
          .                                                                                 .
          .                                                                                 .
          .                                                                                 .
          .                                                                                 .
          .                                                                                 .
       12 +                                                                                 +
          .                                                                                 .
 C        .                                                                                 .
 A        .                                                                                 .
 N        .                                                                                 .
 O        .                                                                                 .
 N      8 +                                                                                 +
 I        .                                                                                 .
 C        .                                                                                 .
 A        .                                                                                 .
 L        .                                                  7                              .
          .                                   99          7777                              .
 D      4 +                                   *99           7                               +
 I        .                                  29929       73 *                               .
 S        .                                  9 99         7376 3                            .
 C        .                                  89323 33      7333     6                       .
 R        .                                   42883  *  5   3*60    6                       .
 I        .                                  424*242       50 00   66                       .
 M      0 +                                 44844823 4  6555 5  6*666                       +
 I        .                                 4414*244  5665554 46 666                        .
 N        .                                 1444*48444 5 3 *3556 66                         .
 A        .                                   85*4444    555554                             .
 N        .                                   11814       55                                .
 T        .                                   11 11      5                                  .
       -4 +                                  1  1 4                                         +
 F        .                                                                                 .
 U        .                                                                                 .
 N        .                                                                                 .
 C        .                                                                                 .
 T        .                                                                                 .
 I     -8 +                                                                                 +
 O        .                                                                                 .
 N        .                                                                                 .
          .                                                                                 .
 2        .                                                                                 .
          .                                                                                 .
      -12 +                                                                                 +
          .                                                                                 .
          .                                                                                 .
          .                                                                                 .
          .                                                                                 .
          .                                                                                 .
          X                                                                                 X
           X.........+.........+.........+.........+.........+.........+.........+.........X
         OUT       -12        -8        -4         0         4         8        12        OUT
```

GROUP 1 * INDICATES A GROUP CENTROID

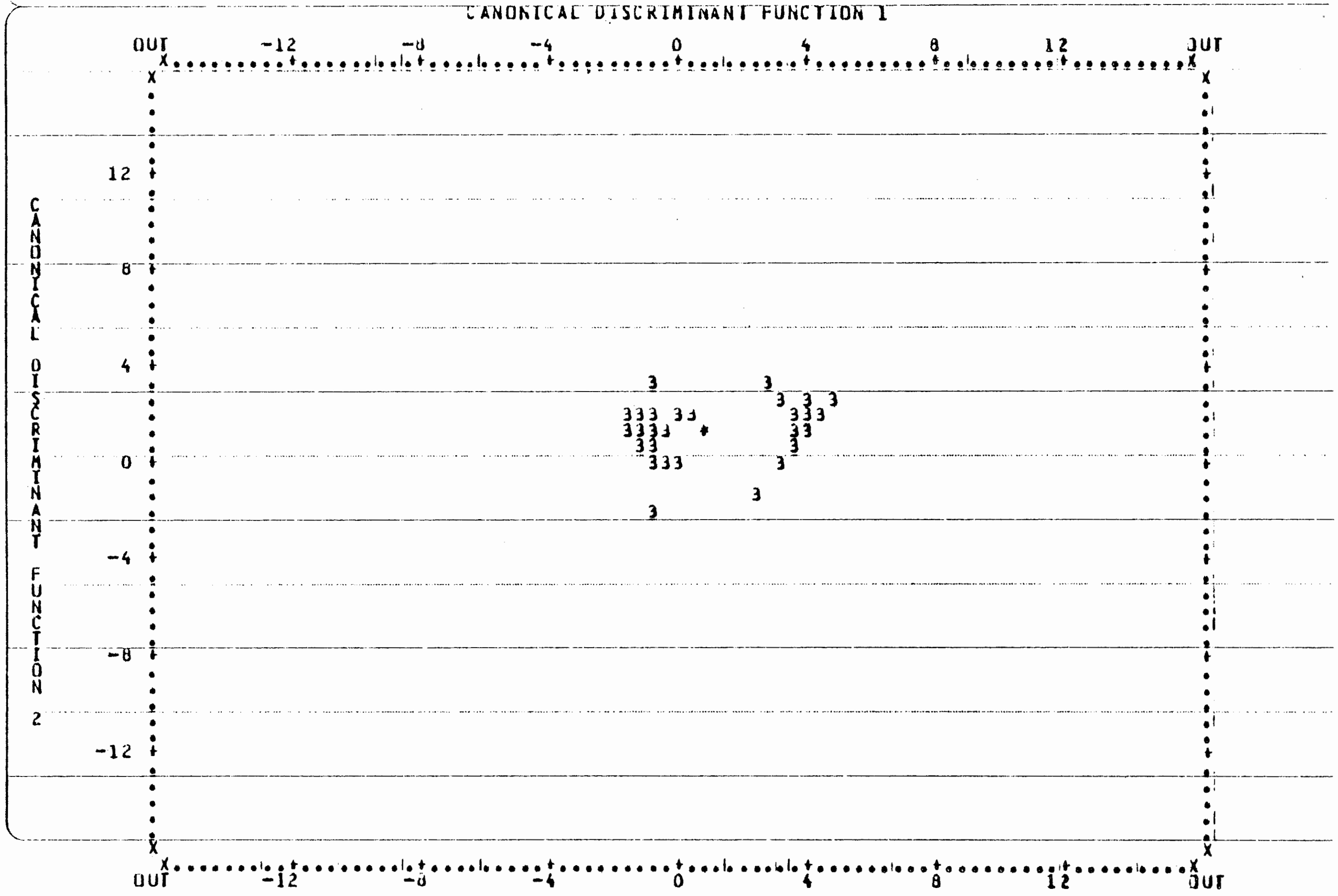
CANONICAL DISCRIMINANT FUNCTION 1



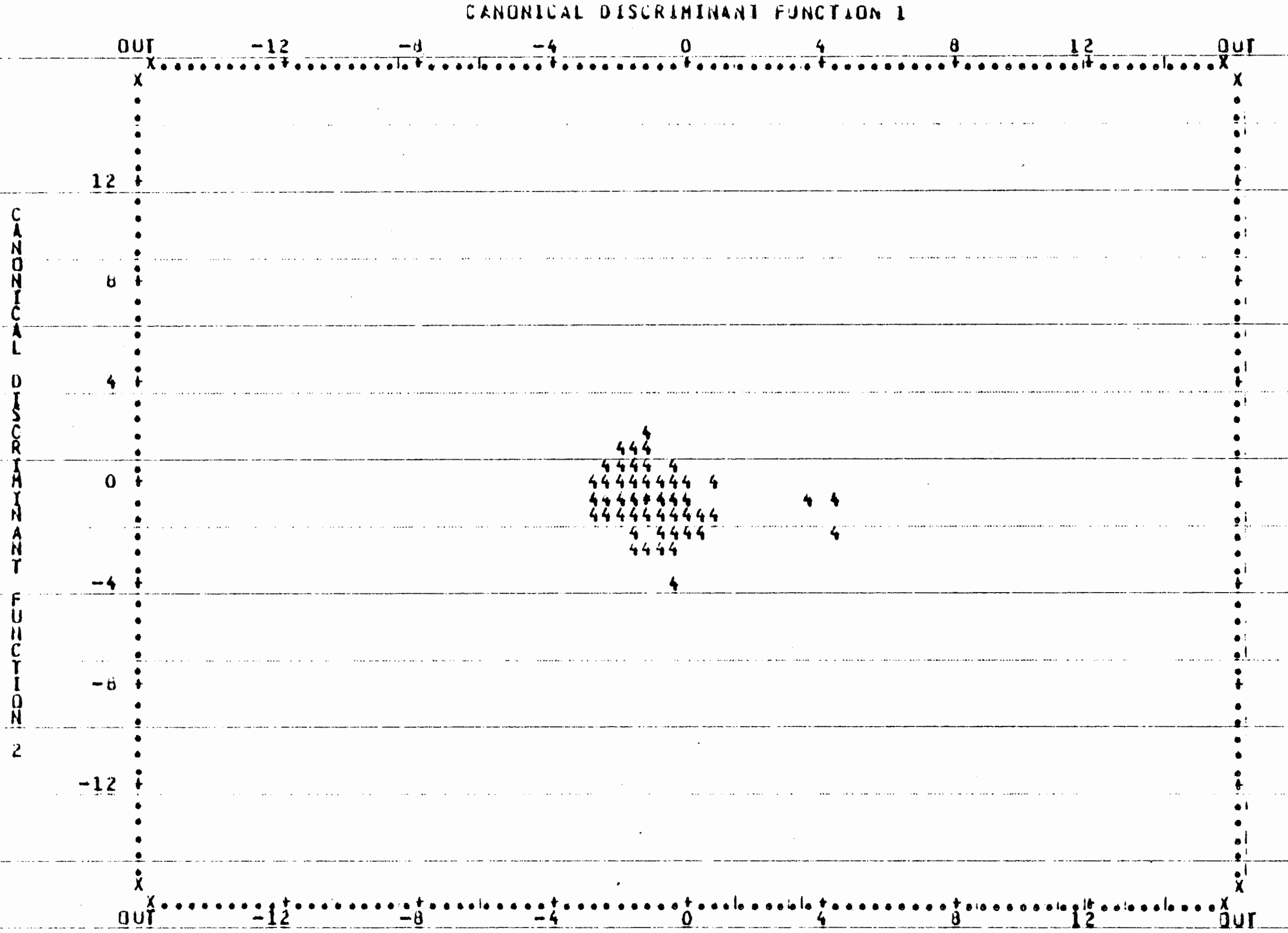
GROUP 2 * INDICATES A GROUP CENTROID



GROUP 3 * INDICATES A GROUP CENTROID

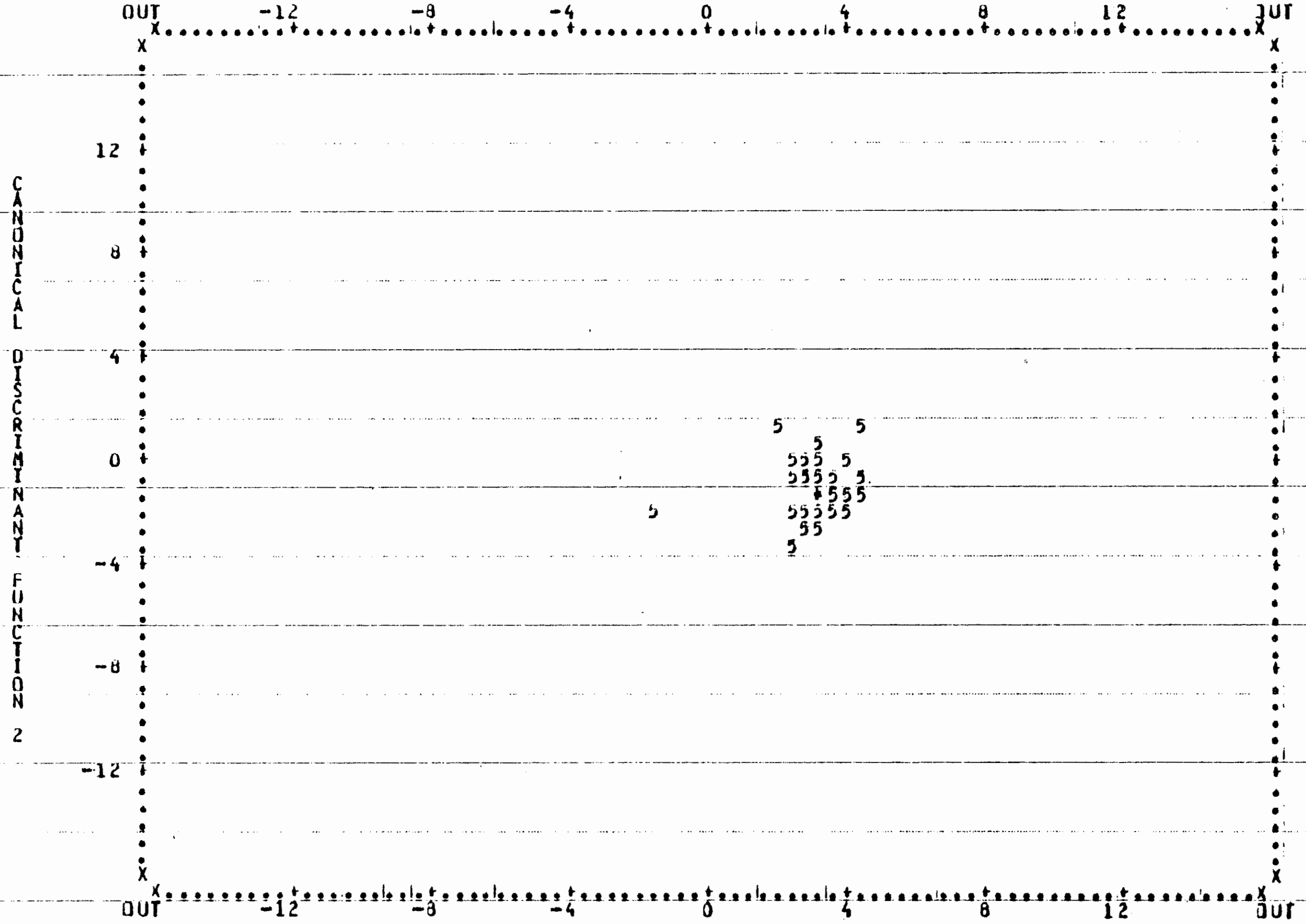


GROUP 4 * INDICATES A GROUP CENTROID

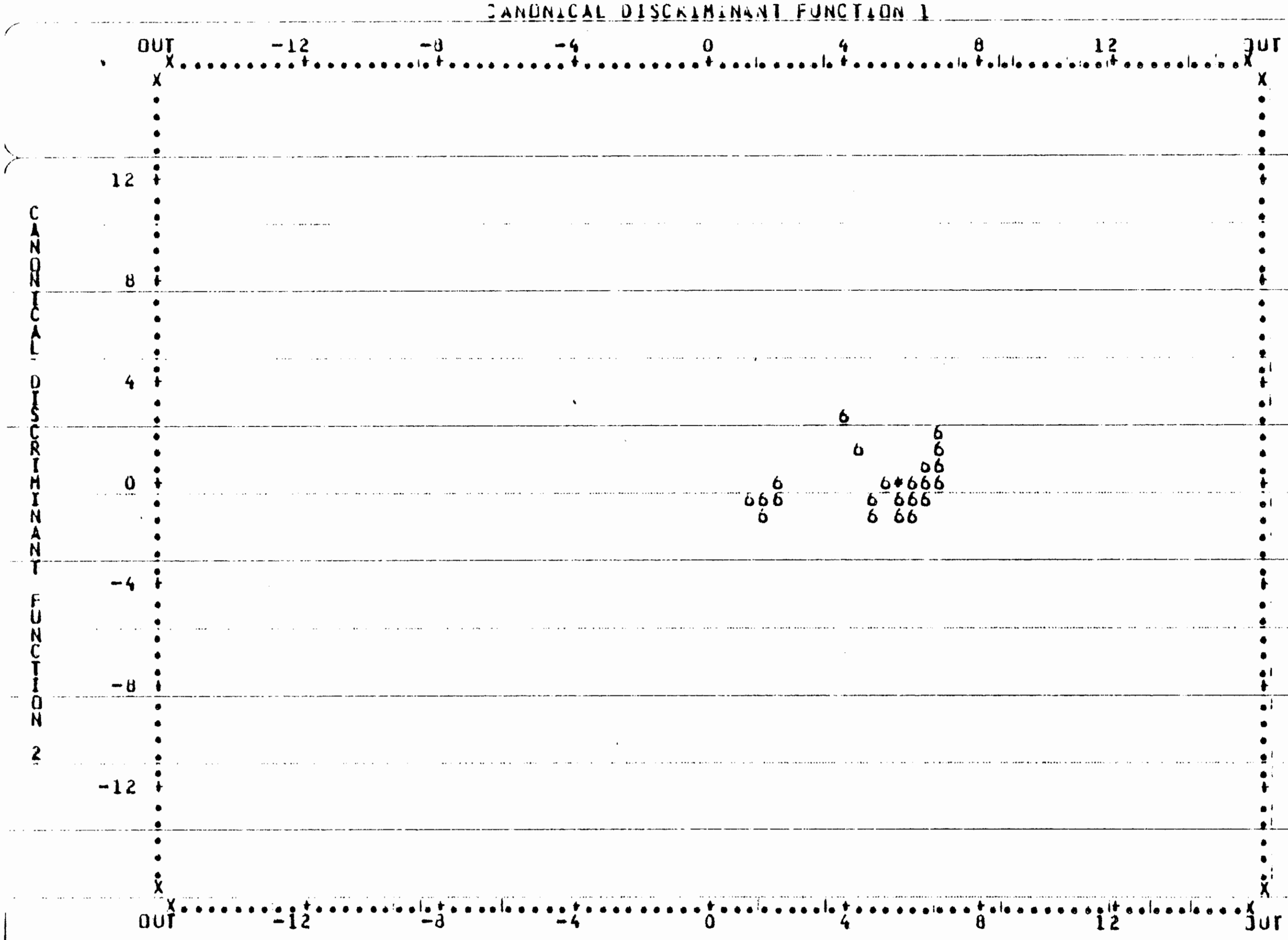


GROUP 5 * INDICATES A GROUP CENTROID

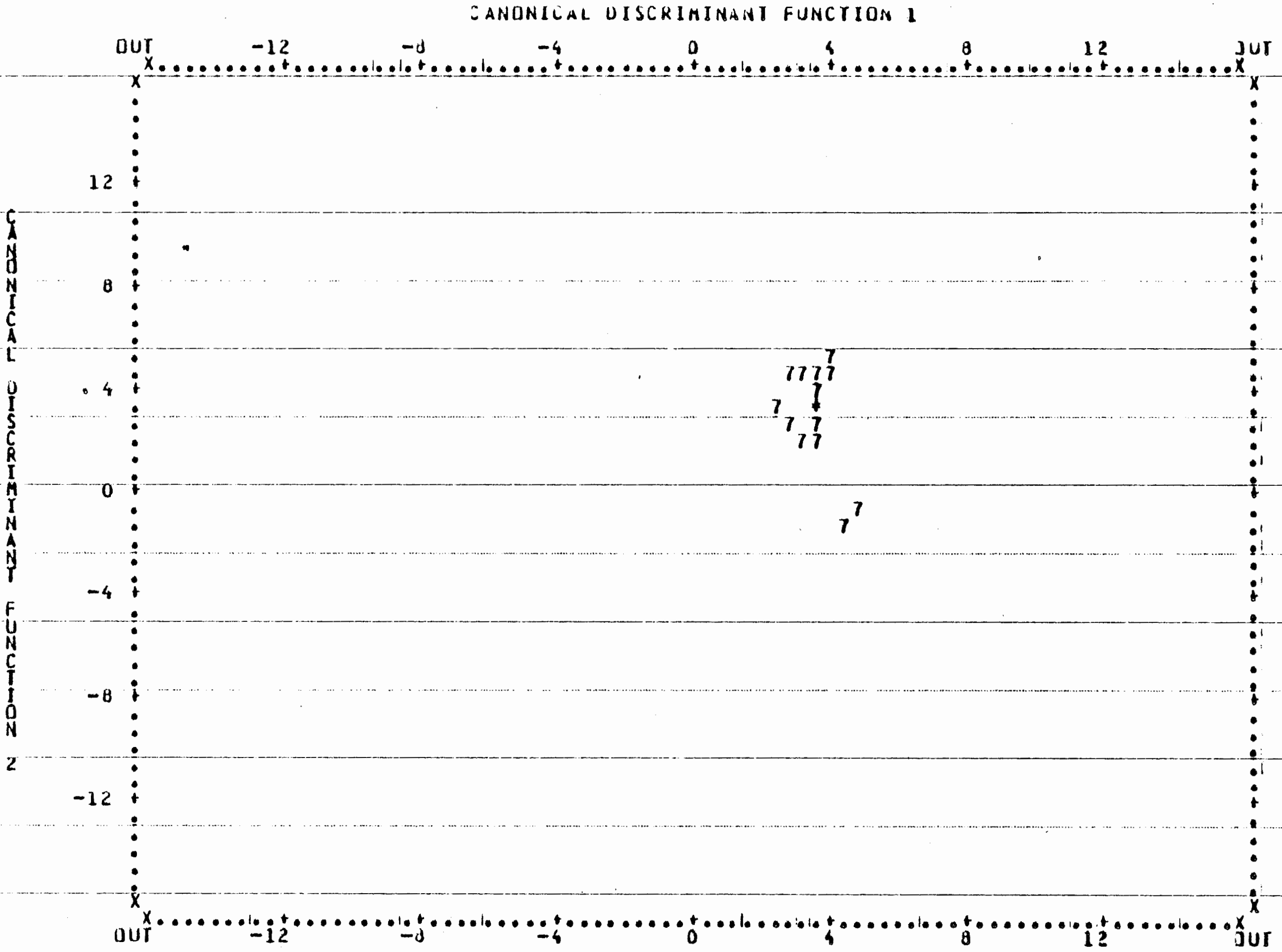
CANONICAL DISCRIMINANT FUNCTION 1



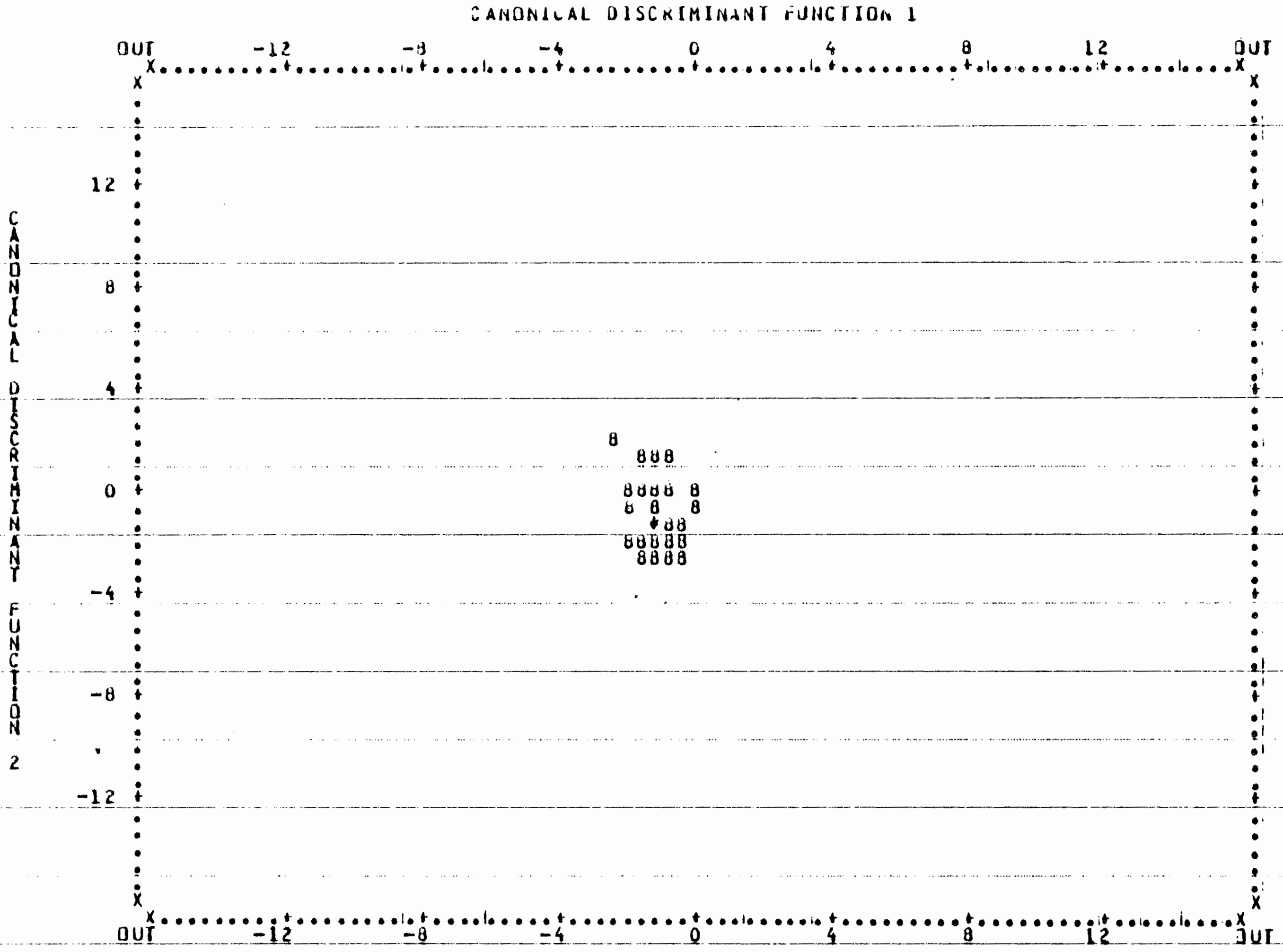
GROUP 6 * INDICATES A GROUP CENTROID

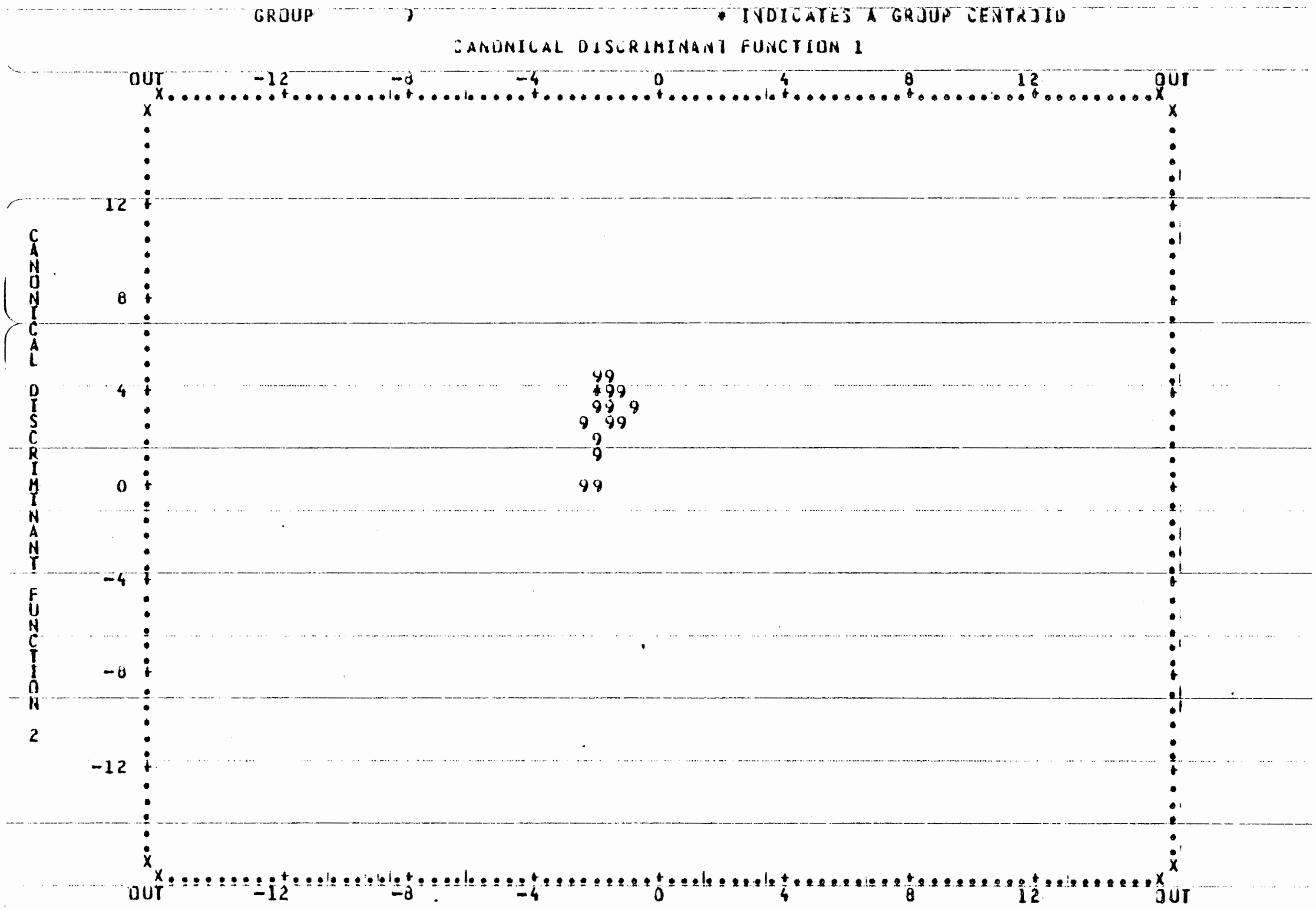


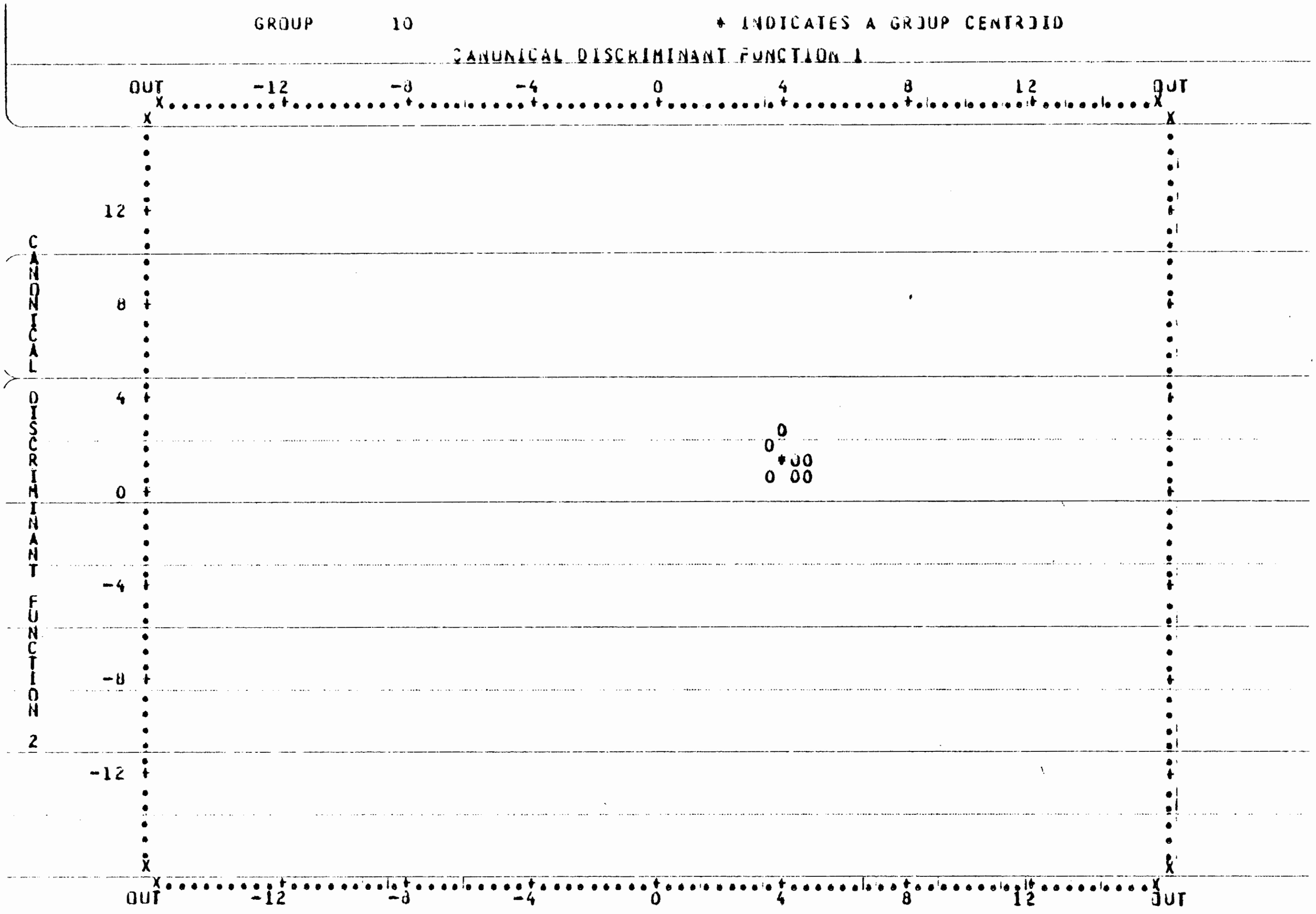
GROUP 7 * INDICATES A GROUP CENTROID



GROUP 8 * INDICATES A GROUP CENTROID




GROUP 9
* INDICATES A GROUP CENTROID
CANONICAL DISCRIMINANT FUNCTION 1
OUT
-12
-8
-4
0
4
8
12
OUT
CANONICAL DISCRIMINANT FUNCTION 2
12
8
4
0
-4
-8
-12
99
*99
99 9
9 99
9
9
99


GROUP 10
* INDICATES A GROUP CENTROID
CANONICAL DISCRIMINANT FUNCTION 1
OUT
-12
-8
-4
0
4
8
12
OUT
CANONICAL DISCRIMINANT FUNCTION 2
12
8
4
0
-4
-8
-12
X
0
*

```
         CASE      MIS            ACTUAL          HIGHEST PROBABILITY     2ND HIGHEST
SUBFILE SEQNUM     VAL    SEL     GROUP           GROUP P(X/G) P(G/X)     GROUP P(G/X)   DISCRIMINANT SCORES

ELPHEXA      1                      1.                1  .4536  .9563         4  .0335     -1.9409    -2.9547       .5742    -1.9555        .2497
                                                                                             .6544   -1.5119    -.8287      .4488
ELPHEXA      2                      1.                1  .6549  .9691         4  .0308     -2.0327    -3.0942       .6501    -1.7069        .1665
                                                                                             .6053   -1.0744    -.0336      .6582
ELPHEXA      3                      1.                1  .9984  .9889         4  .0107     -1.3267    -2.6328       .2363     -.5742       -.6503
                                                                                            -.4711     -.2813   -.4037      .3097
ELPHEXA      4                      1.                1  .7878  .9172         4  .0825     -1.8742    -2.8004      1.0176    -1.5584       -.0336
                                                                                             .3154     -.9389    .3069      .4758
ELPHEXA      5                      1.                1  .9975  .9954         4  .0044     -1.0709    -2.3130       .2608    -1.2105      -1.2877
                                                                                             .4116     -.3962   -.4065     -.3999
ELPHEXA      6                      1.                1  .4707  .9141         4  .0857     -1.9071    -3.3369      1.1847    -1.0414        .1421
                                                                                            -.7122     -.4568   -.1774     1.5795
ELPHEXA      7                      1.                1  .6628  .9175         4  .0823     -1.8347    -3.1220      1.1009    -1.4029        .1511
                                                                                            -.3951     -.7083   -.5044      .7852
ELPHEXA      8                      1.                1  .6880  .9112         4  .0887     -1.6244    -2.9246      1.1199    -1.6943       -.0048
                                                                                            -.0745    -1.1467   -.4060      .1827
ELPHEXA      9                      1.                1  .6757  .9067         4  .0931     -1.8509    -2.9321      1.1638    -1.6643       -.0752
                                                                                            -.0730    -1.2265   -.2244      .2645
ELPHEXA     10                      1.                1  .9944  .9950         4  .0037     -1.0917    -2.7078       .2232     -.6276       -.9765
                                                                                            -.2296      .4799   -.6018      .8060
ELPHEXA     11                      1.                1  .2423  .9185         8  .0791     -1.5272    -3.1236     -1.7465     -.7540       1.4298
                                                                                            -.8488     -.5286   -.1960     -.9259
ELPHEXA     12                      1.                1  .0053  .9446         4  .0502     -2.2893    -3.9773      -.7816    -1.0860       2.7446
                                                                                           -1.7410     -.9600   -.2337     -.2645
ELPHEXA     13                      1. ***            8  .3069  .7534         1  .2464     -1.6477    -2.9248     -2.5195     -.3375       1.2479
                                                                                            -.5914     -.3911   -.1179     -.8445
ELPHEXA     14                      1.                1  .1845  .9306         8  .0473     -1.6144    -3.5214     -1.5303     -.4296       1.3567
                                                                                           -1.3427      .2128    .5021     -.9082
ELPHEXA     15                      1.                1  .6032  .9815         2  .0127     -1.5711    -2.0338      -.2394      .5687       -.6727
                                                                                             .9884     1.8889    .4726     1.3355
ELPHEXA     16                      2.                2  .6870  .9356         4  .0605      -.9188     -.0017       .3888     1.9359        .8653
                                                                                            1.6239      .3009    .6492     1.3081
ELPHEXA     17                      2.                2  .3003  .7549         4  .1388      -.3813      .9146      1.5153     2.5993       -.2374
                                                                                            -.2723      .9351   1.2113     -.8716
ELPHEXA     18                      1.                1  .7724  .9730         2  .0184     -1.1630    -1.3350      -.4982      .5672       -.9798
                                                                                            1.1025     1.3848   1.0109     -.3616
ELPHEXA     19                      1.                1  .0565  .9343         2  .0426      -.5807    -1.0942      -.7687     2.0467      -1.9162
                                                                                            -.2711     2.2999   1.3046      .3455
ELPHEXA     20                      1.                1  .6820  .9582         4  .0328     -1.5348    -2.0147       .5752      .1122       -.7630
                                                                                            1.1466     1.1590   1.0551     1.4873
ELPHEXA     21                      1.                1  .7722  .9932         4  .0039      -.7765    -2.0166      -.2928      .7591      -1.5678
                                                                                           -1.0488      .6124    .4405     1.1506
ELPHEXA     22                      1.                1  .9975  .9870         4  .0126     -1.3799    -2.3904       .1826     -.7019       -.7957
                                                                                            -.0278     -.7374    .0295      .6258
ELPHEXA     23                      1.                1  .9989  .9957         4  .0042     -1.0823    -2.5568       .3738    -1.0584      -1.2659
                                                                                             .0038     -.0881   -.4239     -.3228
ELPHEXA     24                      1.                1  .9919  .9952         4  .0033     -1.0591    -1.6250      -.2918     -.5310      -1.6118
                                                                                             .5903     -.6283   -.2421      .5428
ELPHEXA     25                      1.                1  .0134  .7921         8  .1784     -2.0220    -2.7553     -1.3626     -.3126       2.3629
                                                                                            -.3910      .7009    .6540    -2.5771
ELPHEXA     26                      1.                1  .7064  .5922         4  .4045     -2.1584    -2.4668      1.4382    -1.0170        .4773
                                                                                             .8385      .1322    .4589      .2734
ELPHEXA     27                      1.                1  .9680  .9210         4  .0714     -1.5580    -1.7598       .4931     -.6612       -.2883
                                                                                            1.0790      .3380    .1636    -1.0275
ELPHEXA     28                      1.                1  .4872  .6410         4  .3576     -2.1186    -2.4375      1.5300    -1.3888        .3814
                                                                                             .9840      .3232    .6212    -1.2171
ELPHEXA     29                      1.                1  .6684  .7377         2  .1436      -.9536    -1.8075       .6335      .2333       -.0081
                                                                                            1.2711      .6318  -1.8118     -.1307
```

```
         CASE       MIS          ACTUAL          HIGHEST PROBABILITY      2ND HIGHEST
SUBFILE SEQNUM      VAL    SEL    GROUP          GROUP P(X/G) P(G/X)     GROUP P(G/X)   DISCRIMINANT SCORES
ELPHEXA     30                      1.                1  .9577  .9658         4  .0257       -1.7666    -2.2021      .0111     -.2703      .1148
                                                                                          1.1702      .6648     -.0351      .6334
ELPHEXA     31                      2.                2  .5824  .9952         4  .0045        -.1455      .3821      .3463     2.6818      .5942
                                                                                          1.5755      .2071    -1.8239      .2010
ELPHEXA     32                      2.                2  .4060  .8052         4  .1944        -.6970     -.6029     1.6474     1.4290     1.7211
                                                                                          1.6930     -.5588    -2.1747      .9019
ELPHEXA     33                      2.                2  .4805  .9558         4  .0430        -.6037      .0219     1.2007     1.7565     1.3710
                                                                                          1.7057     -.7803    -2.4334      .6139
ELPHEXA     34                      1.                1  .1696  .7267         8  .2620       -1.7554    -2.1284    -1.6192     -.0405     1.3367
                                                                                          -.0957      .3165      .4684    -2.2050
ELPHEXA     35                      2.                2  .4421  .7488         4  .2507        -.7382     -.6146     1.7156     1.4756     1.6117
                                                                                          1.6953     -.6828    -1.8924     1.0291
ELPHEXA     36                      2.                2  .0390  .8319         9  .1437       -2.0047     2.0313      .6622      .0694     1.0578
                                                                                          1.0403     -.5606     -.3899     -.3539
ELPHEXA     37                      1.                1  .9765  .9734         4  .0186       -1.3232    -1.7267      .3931      .0496    -1.1158
                                                                                           .4988     1.2788      .1064     -.6137
ELPHEXA     38                      1.                1  .9943  .9955         4  .0044       -1.2020    -2.4836      .4582     -.9785    -1.5323
                                                                                           .3267     -.1321      .6899     -.2987
ELPHEXA     39                      1.                1  .9689  .9951         4  .0047       -1.2108    -2.7247      .3726     -.4416    -1.2448
                                                                                          -.1910      .1680      .1873     1.3673
ELPHEXA     40                      1.                1  .9991  .9881         4  .0115       -1.3222    -2.4110      .1912     -.8795     -.7473
                                                                                          -.1008     -.6652     -.3073      .0242
ELPHEXA     41                      1.                1  .6699  .9054         4  .0945       -1.8587    -2.9343     1.1768    -1.6555     -.0960
                                                                                          -.0726    -1.2501     -.1706      .2888
ELPHEXA     42                      1.                1  .9973  .9959         4  .0038       -1.1016    -2.7306      .2960     -.6774    -1.0596
                                                                                          -.2669      .3952     -.5025      .6067
ELPHEXA     43                      1.                1  .9560  .9805         2  .0121       -1.5112    -1.7090     -.2263      .0766     -.8577
                                                                                          1.3605      .8857      .0655      .6542
ELPHEXA     44                      1.                1  .8199  .9727         4  .0228       -1.4484    -2.1932      .6091     -.1139     -.6276
                                                                                           .9179     1.8864      .7812      .1173
ELPHEXA     45                      1.                1  .9017  .9898         4  .0085       -1.5522    -2.2850      .2264     -.5881     -.5249
                                                                                          1.5228     1.3798      .3754     -.4037
ELPHEXA     46                      1.                1  .9420  .9704         4  .0255       -1.4036    -2.3068      .7025     -.1673     -.6146
                                                                                           .5630     1.5522      .2112      .1056
ELPHEXA     47                      1.                1  .6092  .9860         4  .0076       -1.2209    -1.5069      .4348      .0053    -1.8384
                                                                                          1.4436     1.5725     1.2311     -.2693
ELPHEXA     48                      1.                1  .9901  .9985         4  .0012        -.8639    -2.0311      .0761     -.5386    -2.2143
                                                                                           .2776      .1399     -.1382      .3061
ELPHEXA     49                      1.                1  .6018  .9866         4  .0104       -1.2488    -2.3931      .7900      .0049    -1.1215
                                                                                           .8305     2.2033      .5451      .9811
ELPHEXA     50                      2.                2  .7352  .9419         4  .0576        -.3141      .2800     1.1173     2.3928     1.0640
                                                                                          1.1493     -.7524    -1.3922      .2155
ELPHEXA     51                      1.                1  .9095  .9875         4  .0120       -1.2559    -1.9664      .0494    -1.4014     -.8328
                                                                                           .6076    -1.3029     -.4823     -.8987
ELPHEXA     52                      1.                1  .9863  .9862         4  .0132       -1.4134    -2.3722      .1614     -.5755     -.8094
                                                                                           .0277     -.7662      .2276     1.0602
ELPHEXA     53                      1.                1  .4854  .9167         4  .0832       -1.8236    -2.6489     1.1146    -2.1097     -.2085
                                                                                           .5135    -1.3693      .0926    -1.0355
ELPHEXA     54                      1.                1  .9768  .9582         4  .0188       -1.2976    -1.4768      .2309     -.1124    -1.0942
                                                                                           .9095     1.0190      .0233     -.7115
ELPHEXA     55                      1.                1  .9856  .9223         4  .0742       -1.6632    -2.2387      .7563     -.1861     -.3537
                                                                                           .3229      .8170      .5780     -.3147
ELPHEXA     56                      1.                1  .7916  .9873         4  .0091       -1.6214    -2.2270      .1220     -.2736     -.4881
                                                                                          1.6733     1.3851      .7261      .6999
ELPHEXA     57                      1.                1  .9435  .9853         4  .0104       -1.5466    -2.1047      .1092     -.5406     -.4852
                                                                                          1.7001      .8623      .0672      .4013
ELPHEXA     58                      1.                1  .9326  .9709         4  .0258       -1.6441    -2.1600      .1469     -.3690     -.1616
                                                                                          1.4095      .6295      .8578      .0342

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       CASE           MIS          ACTUAL          HIGHEST PROBABILITY      2ND HIGHEST
SUBFILE SEQNUM        VAL   SEL    GROUP           GROUP P(X/G) P(G/X)     GROUP P(G/X)   DISCRIMINANT SCORES
ELPHEXA      59                     1.                1  .4215  .9708         2  .0070    -1.3223    -2.2520     -.0688      .5335    -1.1277
                                                                                            .8373     2.2651    -.0495     1.6766
ELPHEXA      60                     1.                1  .8256  .9914         2  .0058    -1.3098    -1.8304     -.0798      .0491    -1.3781
                                                                                           1.5342     1.4442     .1568      .8321
ELPHEXA      61                     1.                1  .8260  .9889         4  .0072    -1.0737    -1.6358      .4844     -.2993    -1.6800
                                                                                            .9989     1.5240     .0307    -1.1073
ELPHEXA      62                     1.                1  .2820  .9227         2  .0726     -.9077     -.1606    -1.1881     -.7142    -1.8639
                                                                                            .7016      .1605   -2.1799     -.1238
ELPHEXA      63                     1.                1  .9224  .9988         4  .0010     -.9457    -2.3845      .1623     -.0896    -2.1512
                                                                                           -.1355     1.0156     .4549      .7993
ELPHEXA      64                     1.                1  .9995  .9957         4  .0027    -1.1182    -2.0187     -.1140     -.2470    -1.6184
                                                                                            .0894      .1898     .2682      .4412
ELPHEXA      65                     1.                1  .9995  .9680         4  .0309    -1.1713    -2.0991      .4972     -.7005     -.8732
                                                                                           -.3638     -.4525    -.0744     -.0288
ELPHEXA      66                     1.                1  .1422  .9369         4  .0595     -.4180    -2.1698      .9429     -.7815     -.9105
                                                                                           -.1929     -.6972   -2.5507    -2.1606
ELPHEXA      67                     1.                1  .9410  .8232         4  .1669    -1.4674    -1.9287     1.0290     -.1024     -.4016
                                                                                            .0298     1.1251     .5257     -.6741
ELPHEXA      68                     4. ***            1  .2776  .9839         4  .0154     -.8693    -2.2562      .8414    -1.2499    -2.1046
                                                                                          -1.3391    -1.9359     .9463     -.7160
ELPHEXA      69                     4. ***            1  .6550  .9910         4  .0063    -2.1004    -1.1554     -.2013    -2.3549     -.7212
                                                                                            .4295     -.3323    -.6442     1.0740
ELPHEXA      70                     4. ***            1  .1309  .9887         4  .0072    -1.4827    -1.3702      .5778    -2.9260    -1.8355
                                                                                          -1.6724    -1.2699    -.7996     -.5723
ELPHEXA      71                     4. ***            1  .5167  .9911         4  .0068    -2.0817     -.9557     -.1963    -2.6557     -.8548
                                                                                            .7496     -.7455    -.6033      .4455
ELPHEXA      72                     4. ***            1  .0961  .9059         4  .0907    -2.6391    -1.5802     1.4324    -2.9753     -.0597
                                                                                           1.1777     1.5827    -.0231     -.7213
ELPHEXA      73                     4. ***            1  .8308  .9305         4  .0162    -1.9351    -1.1353      .3309    -2.2216     -.9139
                                                                                           -.3474      .1142    -.5181      .3832
ELPHEXA      74                     4. ***            2  .9632  .9347         4  .0452    -1.7411     1.3145      .6169      .3913      .9744
                                                                                           1.0555      .2814     .5273      .6131
ELPHEXA      75                     2.                2  .8104  .9832         4  .0163    -1.2358     1.2317     1.4861      .3132     1.0386
                                                                                           1.3839     -.1699   -2.4483      .5692
ELPHEXA      76                     2.                2  .9817  .9279         4  .0680    -1.8602     1.2216     1.2149     -.1701     1.0274
                                                                                            .9459      .0845    -.6365      .7264
ELPHEXA      77                     2.                2  .8557  .9753         4  .0218    -1.5132      .6877      .8090      .8969      .7912
                                                                                            .2372     1.4955    -.1677     2.0018
ELPHEXA      78                     1.                1  .7053  .9956         4  .0042     -.9886    -2.1414      .2908    -1.7236    -1.3837
                                                                                            .6409     -.7451    -.7277    -1.7536
ELPHEXA      79                     4. ***            1  .6138  .7750         2  .1635    -2.1238     -.0841      .2666    -1.4162     -.7749
                                                                                            .4882     1.2012    -.1950     -.5040
ELPHEXA      80                     4. ***            2  .8592  .7386         4  .2597    -1.9428      .6897     1.5787     -.6174     1.4087
                                                                                           1.2163      .6072    -.1304      .4385
ELPHEXA      81                     4.                4  .0177  .6280         2  .3608    -1.8077     1.2200     1.7209    -1.8873      .9380
                                                                                           1.9995     -.6459    -.4036    -2.7382
ELPHEXA      82                     5.                5  .6873 1.0000         7  .0000     3.3734    -2.6366    -2.3067    -3.5104     1.8391
                                                                                           -.1111      .1720     .7090    -1.3957
ELPHEXA      83                     1.                1  .6965  .9006         4  .0993    -1.4648    -2.6057      .9939    -1.3942     -.2626
                                                                                           -.4434     -.7741     .5544    -1.5373
ELPHEXA      84                     4.                4  .4884  .5395         2  .4481    -1.9226     1.0349      .8514     -.7379      .6246
                                                                                            .4852    -1.7328     .3460      .2643
ELPHEXA      85                     1.                1  .9603  .9961         4  .0037    -1.0707    -2.2520      .2769    -1.4066    -1.3668
                                                                                            .6406     -.2063    -.0409    -1.2750
ELPHEXA      86                     1.                1  .9603  .9885         4  .0113    -1.0093    -2.2006      .8098     -.9706    -1.6629
                                                                                           -.0155      .0944     .7011     -.9475
ELPHEXA      87                     4. ***            2  .7429  .7108         4  .2722    -1.8435      .5528      .7863     -.2387     1.1254
                                                                                           -.4940     -.8957    -.8140     1.4086
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          CASE         MIS           ACTUAL          HIGHEST  PROBABILITY     2ND HIGHEST
SUBFILE  SEQNUM   VAL    SEL       GROUP          GROUP  P(X/G)  P(G/X)    GROUP  P(G/X)   DISCRIMINANT SCORES
ELPHEXA     88                      1.                1   .9679   .9984       4   .0016      -.8290   -2.4522     .4231   -1.3731   -1.7840
                                                                                             .5270     .2034   -.5460    -.6832
ELPHEXA     89                      2.                2   .9903   .9760       9   .0094     -1.4051    1.3424     .4540     .9042     .3003
                                                                                             .4113    1.4106   -.1045     .3884
ELPHEXA     90                      1.                1   .9915   .9986       4   .0012      -.8231   -2.0419     .0715    -.6527   -2.1694
                                                                                             .2331     .2014   -.3825    -.0760
ELPHEXA     91                      1.                1   .5935   .9956       2   .0022      -.5754    -.9016   -1.2148     .0909   -2.5254
                                                                                             .9270    -.0125    .1163     .1189
ELPHEXA     92                      1.                1   .9870   .9980       4   .0018      -.9404   -2.4062     .0885   -1.0109   -1.8592
                                                                                             .6806     .0817    .0938     .5507
ELPHEXA     93                      1.                1   .8348   .9895       2   .0077     -1.2673   -1.5981    -.1868    -.2002   -1.3753
                                                                                            1.9017    1.1736   -.0064     .4255
ELPHEXA     94                      8.                8   .2348   .9999       2   .0000     -1.2658    -.0533   -3.7396     .8484    1.1124
                                                                                            -.3662    1.0203  -2.1244   -2.1619
ELPHEXA     95                      8.                8   .3650  1.0000       2   .0000     -1.2858    -.0336   -3.7782     .9483    1.1315
                                                                                            -.3190    1.0301  -2.0280   -1.8090
ELPHEXA     96                      1.                1   .5983   .8589       8   .1304     -1.3072   -2.5295   -2.0502    -.4106     .4261
                                                                                            -.3329    -.0869    .4339   -1.0966
ELPHEXA     97                      1.                1   .8621   .9932       2   .0026      -.8002   -1.2557   -1.1689     .4605   -1.9281
                                                                                            -.0391    -.5227   -.0234     .2370
ELPHEXA     98                      2.                2   .6766   .5334       9   .3329     -1.2677    1.7750     .2795     .3737    -.2303
                                                                                            -.0803   -1.2910    .3378     .6357
ELPHEXA     99                      4. ***            2   .1152   .5001       4   .4728     -1.0093     .9245    3.2231     .3344    1.4543
                                                                                            -.8151    1.2293  -1.7846   -1.7978
ELPHEXA    100                      3.                3   .0413   .5026       4   .4429      -.6596     .2677    2.4846    -.0869     .1534
                                                                                           -2.1232   -2.3526  -1.8721    1.7827
ELPHEXA    101                      3.                3   .1005   .5974       4   .3510      -.0377    -.3233    1.2143    1.4278   -1.1555
                                                                                           -1.4487   -2.0890   1.2179    1.3697
ELPHEXA    102                      3.                3   .1436   .9545       4   .0316      -.8323    1.6037    1.6191    -.3978    -.7390
                                                                                           -2.2110   -2.7961    .9331    -.8179
ELPHEXA    103                      2. ***            6   .0157   .6685      10   .2835      4.6847     .6835    -.0450    -.4722    1.4252
                                                                                            2.9106     .3582  -1.0121     .8839
ELPHEXA    104                      7. ***            5   .2270   .9993       7   .0004      4.4676   -1.2840    -.6724   -2.4691    -.9503
                                                                                            1.4802     .3440  -1.3590     .6966
ELPHEXA    105                      1.                1   .1340   .8837       2   .0815      -.6726    -.1134    -.7070    -.7289   -1.9360
                                                                                            -.1221     .7543  -2.4955   -1.2909
ELPHEXA    106                      1.                1   .8695   .9976       4   .0015      -.8876   -1.3431    -.8858    -.3672   -1.7642
                                                                                             .9816    -.7966    .7631    -.5240
ELPHEXA    107                      1.                1   .8317   .9675       4   .0292      -.3733   -2.2189    1.0193    -.2765   -1.5151
                                                                                             .2103    -.2889  -1.5719    -.1603
ELPHEXA    108                      1.                1   .6717   .9998       4   .0002      -.5924   -2.1132    -.4956   -1.2003   -2.7330
                                                                                             .1793   -1.2275   -.2580     .5463
ELPHEXA    109                      3.                3   .1593   .9851       4   .0131      -.8999     .9070    1.6999     .6125    -.3833
                                                                                           -3.4624   -1.8719    .5751    1.5973
ELPHEXA    110                      1.                1   .6192   .9987       4   .0013      -.3484   -3.6349     .1340     .5157   -1.5977
                                                                                            1.0282    -.6149    .3633     .8624
ELPHEXA    111                      4.                4   .3702   .9329       3   .0524     -1.5571     .9450    2.7567    -.8894     .2052
                                                                                           -1.0314    -.9575   1.4226   -1.4418
ELPHEXA    112                      1.                1   .6887   .9962       8   .0019     -1.0405   -1.6386   -1.4248    -.1106   -1.3425
                                                                                            1.1631    -.9902    .0533    1.3041
ELPHEXA    113                      6.                6   .9985  1.0000      10   .0000      6.2283    -.1563     .4237    2.2569    -.8396
                                                                                            -.0678     .3333    .1016     .4311
ELPHEXA    114                      6.                6   .9235  1.0000      10   .0000      6.4715     .2985     .8319    1.8156   -1.1244
                                                                                            -.1615     .1407   -.0053   -1.3676
ELPHEXA    115                      1.                1   .7433   .9974       2   .0013      -.6232   -1.3670   -1.0301     .5123   -2.4647
                                                                                             .1682     .0093    .2076     .6852
ELPHEXA    116                      7. ***            5   .0043   .6843       6   .2258      4.9734    -.5941   -2.0394   -1.1326   -1.2114
                                                                                             .1283     .7134  -2.8387     .0027

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          CASE        MIS           ACTUAL          HIGHEST PROBABILITY     2ND HIGHEST
SUBFILE SEQNUM        VAL    SEL     GROUP          GROUP P(X/G) P(G/X)     GROUP P(G/X)   DISCRIMINANT SCORES
ELPHEXA    117                         6.               6  .9486 1.0000        10  .0000     6.4380      .5609      .6623     1.7099    -1.0840
                                                                                             .2783     -.1050     -.0500    -1.2641
ELPHEXA    118                         1.               1  .8401  .9971         2  .0015     -.5409    -1.3699    -1.0921      .3392    -2.3209
                                                                                             .1139      .1846     -.3145      .1294
ELPHEXA    119                         1.               1  .4134  .9999         4  .0001     -.8384    -2.3828     -.8552    -1.1206    -2.6075
                                                                                             .5608    -1.4692     -.1410     1.4973
ELPHEXA    120                         7.               7  .4129 1.0000         5  .0000     3.3343     2.2486    -1.9926    -3.9739     -.6381
                                                                                            -.5002     1.2869    -2.9883     -.5841
ELPHEXA    121                         7.               7  .6585 1.0000         5  .0000     3.5541     2.8966     -.9828    -3.8689    -1.4560
                                                                                           -1.0920      .5701    -2.0217    -1.1191
ELPHEXA    122                         7.               7  .8062 1.0000         5  .0000     3.4786     2.6394    -2.6603    -3.5361     -.7641
                                                                                            -.1626      .3075    -2.4304      .1062
ELPHEXA    123                         7.               7  .4867 1.0000         5  .0000     3.7081     2.6685    -1.4780    -3.1015    -1.3683
                                                                                           -1.6774      .9443    -1.5128     -.7611
ELPHEXA    124                         1.               1  .4140  .9785         2  .0168     -.1554    -1.1591     -.9141      .7240    -1.9432
                                                                                             .6263     -.5272    -1.6075     -.8612
ELPHEXA    125                         8.               8  .2147  .9958         1  .0042     -.7313    -2.4911    -3.0509      .3679     1.4053
                                                                                             .1327    -1.3053    -2.2090     -.9749
ELPHEXA    126                         3. ***           5  .2775  .9947         3  .0041     3.0740     -.0427      .0765    -3.4256     -.4558
                                                                                           -1.6656     1.1588      .3657     1.0921
ELPHEXA    127                         3. ***           7  .1571  .8929         3  .0616     3.1407     2.3394      .5376    -2.2768     1.0492
                                                                                            -.5111     -.9889     1.0242      .2583
ELPHEXA    128                         3. ***           5  .1640  .9932         3  .0051     3.0573     -.2461      .2687    -3.5218     -.5819
                                                                                           -1.8803     1.5877      .7816      .0908
ELPHEXA    129                         6.               6  .7992 1.0000        10  .0000     6.5175      .5284      .7289     1.5518    -1.1220
                                                                                             .1992     -.1288     -.1871    -1.8248
ELPHEXA    130                         8. ***           1  .0194  .9694         2  .0189      .0643     -.7131    -1.7181      .5964    -2.5603
                                                                                            1.4653     -.5384    -2.4198    -1.2830
ELPHEXA    131                         1.               1  .9260  .9552         4  .0323     -.8474    -2.1864     1.1732     -.4668    -1.6258
                                                                                            -.9152      .4954      .3948     -.1102
ELPHEXA    132                         5.               5  .2490  .9999         7  .0001     2.5838     -.0696    -3.8268    -3.0639     1.9654
                                                                                           -1.1457     -.4158      .9989     -.5726
ELPHEXA    133                         6.               6  .9845 1.0000        10  .0000     6.4738      .2405      .8053     2.0158    -1.0323
                                                                                            -.3864     -.0355     -.3916     -.4741
ELPHEXA    134                         3.               3  .0991  .8117         1  .1359     -.6216      .3883      .2141     -.5132    -2.1126
                                                                                           -1.3098     -.0976    -1.9292    -2.1349
ELPHEXA    135                         6.               6  .9520 1.0000        10  .0000     6.3891      .2782      .2298     1.5159     -.7792
                                                                                             .3655     -.1218     -.6618    -1.2068
ELPHEXA    136                         8.               8  .9794  .9998         1  .0002    -1.0470    -1.8671    -3.8600      .9299      .1881
                                                                                            -.8745     -.3634     -.6464     -.6763
ELPHEXA    137                         4. ***           2  .2932  .5019         4  .2839    -1.3147     1.8522     2.0955      .6406      .1525
                                                                                            -.4239      .7702     1.5491    -1.1428
ELPHEXA    138                         6.               6  .2351 1.0000         5  .0000     5.9218    -1.6533    -1.0552      .8751    -2.2040
                                                                                            -.3723      .7619    -1.0214      .2996
ELPHEXA    139                         1.               1  .8767  .9520         4  .0376    -1.1978    -1.9697      .7395    -1.1255    -1.2907
                                                                                            -.1500    -1.1602      .3681    -1.1778
ELPHEXA    140                         3.               3  .6666  .5575         4  .2932    -1.1295     1.4341     2.1949     -.5164     -.2073
                                                                                           -1.0644     -.3853     -.0365     -.9846
ELPHEXA    141                         1.               1  .4482  .9508         8  .0375    -1.1703    -2.7281    -1.4611     -.0150      .2931
                                                                                           -1.4600      .6987      .6114    -1.3155
ELPHEXA    142                         5.               5  .1174 1.0000         7  .0000     4.3307    -1.5866    -3.4124    -1.5945     1.2183
                                                                                            -.2314     -.1733    -1.0582    -1.7411
ELPHEXA    143                         6.               6  .0109  .9988         5  .0012     5.4776    -1.1580    -2.0192     1.3987     2.4389
                                                                                            -.3859     -.7022    -2.0066     -.2514
ELPHEXA    144                         2.               2  .8110  .7563         4  .2389     -.7744      .2001     1.0108     1.7927      .4144
                                                                                            1.1566      .1962     1.0788      .0341
ELPHEXA    145                         3.               3  .0474  .5796        10  .4188     3.6339     2.0475     1.0355     -.7901      .4912
                                                                                           -2.5436      .8120     1.5312     1.3309
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        CASE        MIS           ACTUAL           HIGHEST PROBABILITY      2ND HIGHEST
SUBFILE SEQNUM      VAL   SEL      GROUP           GROUP P(X/G) P(G/X)     GROUP P(G/X)  DISCRIMINANT SCORES
ELPHEXA     146                    1. ***           2  .6549  .6484          4  .2700      -.4761      .1333      .9985     1.3245    -1.1013
                                                                                          .6825    -.4199      .7327      .7156
ELPHEXA     147                    1.               1  .3548  .9737          4  .0239     -2.0129     -.5430     -.3147    -2.2339     -.8360
                                                                                          .2077   -1.2064      .0818   -1.2018
ELPHEXA     148                    5.               5  .7228 1.0000          7  .0000      3.5028    -1.7650    -3.2536    -2.1493     1.4302
                                                                                         -.5737     .3699      .2328     -.3443
ELPHEXA     149                    5.               5  .2666 1.0000          7  .0000      3.7214    -1.6188    -3.6907    -2.1143     1.2293
                                                                                         -.6824     .1090      .6598   -1.7038
ELPHEXA     150                    3.               3  .1008  .8187         10  .0883      3.7445     2.1091      .5782    -1.3761      .6290
                                                                                        -1.8351    -.1995      .6115    1.0609
ELPHEXA     151                    5.               5  .1331 1.0000          7  .0000      2.7802     -.2864    -3.4257    -2.4607     2.1456
                                                                                        -2.4562     .4309      .3608      .1967
ELPHEXA     152                    5.               5  .7041 1.0000          8  .0000      3.3844    -2.4398    -2.7767    -2.2580     1.7880
                                                                                         -.9174     .5215      .2597      .8795
ELPHEXA     153                    2. ***           1  .8997  .9533          2  .0419     -1.3506    -1.3141     -.6662      .4413    -1.0012
                                                                                          .9450    1.1857     -.7362      .1026
ELPHEXA     154                    1.               1  .6098  .9944          3  .0031      -.4966    -1.3535     -.4459      .7028    -2.7481
                                                                                         -.5982     .3510      .5926      .1644
ELPHEXA     155                    1.               1  .9223  .9977          2  .0013      -.7349    -1.3907     -.4450     -.2348    -2.4543
                                                                                          .2986     .0408     -.6498     -.0295
ELPHEXA     156                    3. ***           5  .0251  .7542          7  .1524      3.7163      .9120     -.3167    -2.8892    -1.7131
                                                                                        -1.7510    1.1799     1.0389     -.3716
ELPHEXA     157                    1.               1  .6063  .9983          4  .0016      -.9979    -3.0466      .4903     -.2307    -1.5777
                                                                                         -.3566    1.2049      .0454     1.9739
ELPHEXA     158                    2.               2  .7680  .9118          4  .0875      -.2473      .0044     1.8405     1.7563      .6241
                                                                                         1.3803     .4537    -1.8195     -.5471
ELPHEXA     159                    4. ***           1  .3462  .6936          4  .2566     -1.8896     -.7461     1.2629    -1.9385    -1.0229
                                                                                        -1.6410    -.1164      .2962     -.8336
ELPHEXA     160                    5.               5  .9353 1.0000          7  .0000      3.5976    -1.2279     -.9531    -2.9438     -.6229
                                                                                          .8282    -.1356      .7008      .5334
ELPHEXA     161                    5.               5  .4287 1.0000          1  .0000      3.4451    -2.1029     -.5232    -2.6616     -.1045
                                                                                          .3102     .2286      .7941     2.7224
ELPHEXA     162                    7.               7  .0942 1.0000          5  .0000      3.5082     2.1000    -1.3688    -3.6081     -.7886
                                                                                        -1.8284    1.2451    -3.5762     -.1152
ELPHEXA     163                    1.               1  .9482  .9988          4  .0006      -.6881    -1.7642     -.6652     -.0504    -2.1511
                                                                                          .5225    -.0641      .4008      .6029
ELPHEXA     164                    4. ***           1  .6806  .6593          2  .2079     -2.3558     -.2014      .2349    -1.1824     -.2536
                                                                                         -.0721     .9222     -.1887     -.4235
ELPHEXA     165                    6.               6  .9788 1.0000         10  .0000      5.2607     -.2514      .6452     1.4399     -.4533
                                                                                          .4799    -.7638     -.7795      .7441
ELPHEXA     166                    1.               1  .9249  .9840          4  .0156     -1.0446    -2.5840      .9599     -.4327    -1.5761
                                                                                         -.9004    -.0778      .1308      .8286
ELPHEXA     167                    7.               7  .8908 1.0000          5  .0003      3.4952     3.9891    -1.0141    -2.9425      .7382
                                                                                          .7475    -.8713    -2.5073      .6830
ELPHEXA     168                    1.               1  .3506  .9727          8  .0266     -1.2856    -2.6124    -1.8346     -.7064      .2301
                                                                                         -.5025    -.2672      .4278    -2.1852
ELPHEXA     169                    4. ***           1  .3032  .7023          4  .2477     -1.8624     -.7518     1.2557    -2.0103     -.9887
                                                                                        -1.6680    -.0713      .1307    -1.0720
ELPHEXA     170                    3.               3  .1153  .9028          1  .0796      -.8614      .7044     -.9979      .4148    -2.8234
                                                                                        -1.9745     .9203      .5216     -.5093
ELPHEXA     171                    1.               1  .1289  .9744          2  .0224       .1064    -1.1973     -.8463      .7207    -2.3455
                                                                                          .6477    -.6528    -2.4847      .2351
ELPHEXA     172                    1.               1  .9752  .9988          4  .0010      -.8385    -1.9652      .0569     -.7702    -2.2328
                                                                                          .5008     .3996      .0379     -.6735
ELPHEXA     173                    5.               5  .0142 1.0000          8  .0000      3.6128     -.6921    -4.1215    -1.3046     1.7048
                                                                                          .7816     .8261     1.9026    -2.1153
ELPHEXA     174                    4. ***           1  .4082  .9551          4  .0426     -2.1718     -.7675      .2925    -2.6266     -.7474
                                                                                          .0329    -.8280      .1672    -1.1194

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             CASE      MIS        ACTUAL        HIGHEST PROBABILITY   2ND HIGHEST
SUBFILE    SEQNUM      VAL  SEL   GROUP         GROUP P(X/G) P(G/X)   GROUP P(G/X)    DISCRIMINANT SCORES
ELPHEXA     175          1.          1  .9936   .9956     4  .0043   -1.1585   -2.2251     .2762   -1.1496   -1.4530
                                                                     .7434    -.3283     .4788    -.4098
ELPHEXA     176          1.          1  .9849   .9987     4  .0010    -.8943   -2.1532     .0503    -.3594   -2.1345
                                                                     .2250     .7623     .2362     .3258
ELPHEXA     177          1. ***      8  .2598   .9971     1  .0027   -1.3046   -1.0344   -3.2563    -.1872    1.0368
                                                                    -.3272    -.0348   -2.7133    -.1780
ELPHEXA     178          4.          4  .5119   .6964     2  .2958   -1.9804     .3773    1.1717    -.8545    1.2003
                                                                     .2758   -1.5437    -.0347    1.5250
ELPHEXA     179          1.          1  .3306   .7502     8  .2461   -1.4305   -2.5816   -1.6285     .2066     .7782
                                                                   -1.5513     .0785     .8569    -.8310
ELPHEXA     180          1.          1  .9235   .9974     4  .0016    -.9484   -1.5478    -.8409     .0024   -1.7225
                                                                     .6770    -.4908     .9994     .3141
ELPHEXA     181          1.          1  .9665   .9986     4  .0010    -.9124   -2.1202    -.0274    -.2227   -2.0740
                                                                     .2981     .8129     .2994     .8192
ELPHEXA     182          1.          1  .9998   .9914     4  .0071   -1.3218   -1.8886    -.2832    -.1887   -1.0774
                                                                    -.0666    -.3497     .1771     .3766
ELPHEXA     183          1.          1  .9585   .9995     4  .0004   -1.0005   -2.0082    -.4135    -.9850   -2.0992
                                                                    1.2323    -.1026    -.0530    -.2668
ELPHEXA     184          5.          5  .7154  1.0000     8  .0000    3.2843   -2.4424   -3.2821   -2.7889    1.9552
                                                                     .0053     .3454     .1296     .0081
ELPHEXA     185          1.          1  .7451   .9987     2  .0005    -.6208   -1.3330    -.9394     .2295   -2.6168
                                                                     .3447     .1295     .6024    -.5143
ELPHEXA     186          1.          1  .9255   .9992     2  .0005    -.9397   -1.5909    -.8317    -.3476   -2.3632
                                                                     .9186     .0370    -.2517     .0730
ELPHEXA     187          3.          3  .6874   .6473     2  .1929   -1.1181    1.7455     .9652     .3873    -.5931
                                                                    -.9417   -1.0161     .6434    -.5244
ELPHEXA     188          3. ***      4  .0412   .6111     9  .1500   -1.5026    1.8916    1.6859   -1.2583     .0344
                                                                     .1230   -2.4334     .1775   -1.9472
ELPHEXA     189          6.          6  .9839  1.0000    10  .0000    6.6426     .4963     .1014    2.4839   -1.0136
                                                                    -.1583    -.3057     .2098    -.2609
ELPHEXA     190          7.          7  .9781  1.0000     5  .0000    3.7802    3.4870    -.5329   -2.8415     .8133
                                                                    -.2436    -.8184   -2.0238     .0306
ELPHEXA     191          6.          6  .7477  1.0000    10  .0000    6.5791     .6066    -.3010    1.6725    -.9981
                                                                     .7581   -1.1710    -.2973   -1.5221
ELPHEXA     192          1.          1  .9387   .9982     4  .0017    -.9817   -2.3627     .4896   -1.1777   -2.0650
                                                                     .9009     .1308     .7530    -.2627
ELPHEXA     193          8.          8  .4103   .5787     1  .4211   -1.5266   -2.8591   -2.5215    -.3250     .8127
                                                                    -.2358    -.2999    -.4361     .1270
ELPHEXA     194          4. ***      2  .2604   .6412     4  .2816   -1.5341    1.2754     .7978   -1.3985     .2599
                                                                    1.0257   -1.7920    -.8432    -.6214
ELPHEXA     195          3.          3  .0045   .6851    10  .2016    2.8030    3.0014    2.0495   -3.4618    1.0879
                                                                   -2.5149     .8880     .6641     .5250
ELPHEXA     196          5.          5  .6878   .9999     7  .0001    4.0429   -1.1281    -.5128   -2.8724   -1.1020
                                                                     .3986     .5521     .1095     .6219
ELPHEXA     197          5.          5  .2537   .9999    10  .0001    3.6393   -1.2149    -.1203   -3.5998    -.1777
                                                                    2.1067    1.2996     .2137   -1.1593
ELPHEXA     198          1.          1  .2608   .9999     4  .0001   -2.6030   -1.5644    -.7541   -2.2543   -1.9357
                                                                    -.7616    1.8961    -.2247    -.8415
ELPHEXA     199          1.          1  .9740   .9951     4  .0047   -1.2559   -2.4127     .3125    -.6349   -1.4487
                                                                     .4988    -.0792     .9859     .9205
ELPHEXA     200          1.          1  .3973   .9382     2  .0322   -1.3844    -.2679   -1.0146    -.5620   -1.8710
                                                                    -.9141     .5113    -.9020    1.4873
ELPHEXA     201          1.          1  .6664   .9911     2  .0055    -.9386   -1.7339    -.5802     .4470   -1.5907
                                                                    -.8106     .1311   -1.3758    1.4257
ELPHEXA     202          1.          1  .5371   .9214     3  .0369   -1.7445    -.8836     .4149   -1.0788   -1.2284
                                                                   -1.7216    1.1142    -.5459     .9278
ELPHEXA     203          1.          1  .0764   .9358     3  .0505   -1.7359   -1.1634    -.1179   -1.3149   -1.2645
                                                                   -2.6316    -.8496    -.7945    2.0722
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         CASE         MIS            ACTUAL           HIGHEST PROBABILITY      2ND HIGHEST
SUBFILE SEQNUM        VAL    SEL      GROUP           GROUP P(X/G) P(G/X)     GROUP P(G/X)  DISCRIMINANT SCORES

ELPHEXA     204                         3. ***            5  .0097  .9999          3  .0001        2.3900    -1.2169    -1.8557    -2.6226      2.8268
                                                                                                -3.9082    1.0836     .4679      .5935
ELPHEXA     205                         4.                4  .0001  .4792          1  .4568       -2.2227    -1.6446      .2797     -.4896      1.8403
                                                                                                -3.3925    3.0236     .7580   -1.8526
ELPHEXA     206                         4. ***            2  .8154  .6804          4  .3177       -2.0018      .6853     1.6414     -.5131      1.2872
                                                                                                 1.2429     .4638     .2540      .7625
ELPHEXA     207                         4. ***            2  .8857  .9121          4  .0853       -2.1366     1.1365     1.1303      .2503      1.5581
                                                                                                  .4728    -.2049    -.3971     1.4577
ELPHEXA     208                         2.                2  .8913  .7563          4  .2118       -1.6292     1.3150     2.2144      .4575       .6090
                                                                                                 -.4481     .9017     .1691      .5877
ELPHEXA     209                         2.                2  .8714  .9863          9  .0071        -.8104     2.1437      .6944     1.2196       .4856
                                                                                                  .8326    -.2440   -1.9520     -.2836
ELPHEXA     210                         2.                2  .7717  .9892          4  .0105       -1.1750     1.1307     1.8796      .3136      1.2902
                                                                                                 1.2793     .6587   -2.6596      .0220
ELPHEXA     211                         4. ***            2  .7580  .6333          4  .3609       -1.6259      .6127     2.2313     -.3382       .6729
                                                                                                  .6887    1.5683     .3665      .5204
ELPHEXA     212                         4. ***            3  .5893  .5765          4  .3259       -1.2838      .8543     2.3972      .2593      -.1856
                                                                                                -1.8162     .7105     .9017      .1716
ELPHEXA     213                         4.                4  .8384  .9062          2  .0559       -1.7563      .3081     2.2397     -.2181       .7901
                                                                                                -1.2613    -.1632    1.0591      .7918
ELPHEXA     214                         4.                4  .6242  .5061          2  .3065       -1.6461      .8702     1.7672      .2661       .5456
                                                                                                -1.4910    -.2414     .3285     1.2509
ELPHEXA     215                         1. ***            8  .2470  .6302          1  .3697       -1.4226    -3.3242    -2.3820     -.0056       .9700
                                                                                                -1.0246     .4381    -.6784      .3693
ELPHEXA     216                         1.                1  .9685  .9486          2  .0337       -1.3007    -1.4070      .0564      .1066      -.9013
                                                                                                 1.0433    1.2044    -.0680      .1096
ELPHEXA     217                         4.                4  .9254  .8830          2  .0657       -1.4378      .5037     2.3728     -.3760       .1679
                                                                                                 -.7644    -.5023     .3898     -.1655
ELPHEXA     218                         1.                1  .9996  .9766          4  .0025       -1.0898    -1.9916     -.2147     -.2212     -1.4888
                                                                                                  .1238     .3277     .0431      .5715
ELPHEXA     219                         5.                5  .0840 1.0000          8  .0000        3.7110    -1.2159    -4.2986    -2.0667      1.4256
                                                                                                  .9040   -1.0204    2.2770     -.2058
ELPHEXA     220                         5.                5  .0691 1.0000          8  .0000        3.2478     -.8838    -4.3315    -1.7806      2.3193
                                                                                                 -.2636   -1.8417     .6411      .0092
ELPHEXA     221                         1.                1  .6154  .8851          8  .1132       -1.2763    -2.6333    -1.9723     -.4068       .4411
                                                                                                 -.6612    -.3252    -.0627     -.9091
ELPHEXA     222                         1. ***            8  .1394  .9999          1  .0001       -1.2167    -1.4981    -3.8541      .5964      1.0164
                                                                                                 -.8597   -1.7799     .8720   -2.8977
ELPHEXA     223                         1.                1  .5455  .7286          8  .2708       -1.2980    -2.8176    -2.0183     -.0530       .6129
                                                                                                 -.9503     .1235    -.1086     -.0846
ELPHEXA     224                         1.                1  .8581  .9776          2  .0124       -1.7053     -.4800     -.7410    -1.1756     -1.2097
                                                                                                 -.4669    -.0652    -.0880      .7308
ELPHEXA     225                         1.                1  .8215  .9672          2  .0229       -1.6498     -.4433     -.8918    -1.1748     -1.0028
                                                                                                 -.4305     .1594    -.5017      .7988
ELPHEXA     226                         3. ***            7  .1459  .9061         10  .0652        4.2880     1.9852      .2269    -1.1122      1.0913
                                                                                                 -.7634    -.0547   -1.6682      .7487
ELPHEXA     227                         3. ***            7  .0578  .8025          3  .1061        3.9106     2.9053      .8625    -1.8776       .1830
                                                                                                -1.1706    -.6075    1.3974     -.7096
ELPHEXA     228                         3.                3  .6779  .9873          4  .0113        -.6289     1.0578     1.7924      .0217      -.9904
                                                                                                -2.7481   -1.3924     .7302      .0803
ELPHEXA     229                         3.                3  .0641  .7039          2  .2464        -.3466     1.0509     -.8486     1.9379      1.6244
                                                                                                -2.4228    -.7273    -.9286   -1.1520
ELPHEXA     230                         1.                1  .6338  .9457          4  .0492       -1.9448     -.7679      .8059    -1.9347     -1.4319
                                                                                                 -.2965     .1433    1.1184      .4117
ELPHEXA     231                         2. ***            1  .3135  .7435          4  .1888       -2.1141     -.5546     1.1085    -1.4587      -.6038
                                                                                                  .1031    2.1215     .8387     -.5457
ELPHEXA     232                         2.                2  .8999  .9272          4  .0449       -1.9319     1.4482      .4267      .4352      1.5493
                                                                                                  .8988    -.2197     .3489      .5092
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         CASE         MIS                ACTUAL              HIGHEST  PROBABILITY        2ND  HIGHEST
SUBFILE  SEQNUM       VAL     SEL        GROUP               GROUP  P(X/G)  P(G/X)       GROUP  P(G/X)    DISCRIMINANT  SCORES

ELPHEXA     233                          1.                      1   .9729   .9956           4   .0019        -.9343      -1.5123       -.4924       -.0792     -1.8849
                                                                                                           -.2891       -.1774       -.8454       -.2052
ELPHEXA     234                          4.                      4   .4825   .8483           3   .0976       -1.6278        .5231       2.6496        .0921       .6002
                                                                                                         -1.8079        -.2886       1.1257       1.3438
ELPHEXA     235                          3.                      3   .6873   .9128           2   .0436       -1.0178       1.7979       1.4018        .7487      -.8142
                                                                                                         -1.6189        -.6256       1.1343       -.4320
ELPHEXA     236                          5.                      5   .8226  1.0000           1   .0000        3.3046      -2.8053      -2.3565      -3.0154      1.9683
                                                                                                           -.3429        .5589        .9392       -.0942
ELPHEXA     237                          5.                      5   .9104  1.0000           7   .0000        3.5611      -1.6811       -.6431      -3.3521      -.1629
                                                                                                           .9461        -.3611        .3371       1.2226
ELPHEXA     238                          4.                      4   .7809   .6220           2   .3704       -1.1835       -.4726       1.5546        .6497       .8848
                                                                                                          2.0665        -.0945        .6280        .4979
ELPHEXA     239                          8.  ***                 1   .0963   .8879           8   .1102       -1.6996      -2.2266      -1.9552       -.4906       .9154
                                                                                                          1.0386         .6129        .7025      -2.5398
ELPHEXA     240                          4.  ***                 1   .2248   .6331           2   .2188       -1.5287       -.7247       1.0594      -1.5278      -.4258
                                                                                                           .7889        1.1646      -2.0848      -1.3057
ELPHEXA     241                          4.  ***                 1   .4426   .9282           4   .0434       -2.3806       -.5509        .2616      -2.2101      -.4585
                                                                                                          1.5415         .4659        .1209       -.2949
ELPHEXA     242                          4.  ***                 1   .2161   .6128           2   .3343       -1.6873       -.7084        .4187      -1.5638      -.1171
                                                                                                          1.6304         .8534      -2.3120       -.2404
ELPHEXA     243                          9.  ***                 8   .0182   .9708           9   .0272       -2.1341       1.5968      -3.8298       -.4594      1.3498
                                                                                                          -.3243         .8129      -2.0051      -1.5361
ELPHEXA     244                          2.                      2   .8631   .9446           3   .0298        -.5260       1.2037       2.0291       1.1966       .2714
                                                                                                          -.1476        1.4232      -1.6851       -.2299
ELPHEXA     245                          5.                      5   .5063   .9997           7   .0003        3.0210       -.3610       -.8604      -3.8593      -.4123
                                                                                                          -.1198        1.5889       -.0489       1.5955
ELPHEXA     246                          5.                      5   .1310   .9887           6   .0093        4.4175       -.4124       -.9601      -1.9114     -1.7666
                                                                                                          -.2958         .9060       1.1961       -.7039
ELPHEXA     247                          1.                      1   .3623   .8411           4   .0817       -2.2282       -.3358        .4996      -1.8995      -.4302
                                                                                                          1.2170        1.3870        .5148       -.4705
ELPHEXA     248                          9.                      9   .1449   .8929           3   .0739       -1.2771       2.8144       -.5378       -.1414     -1.8726
                                                                                                          -.7288        2.0216      -1.2994      -1.3007
ELPHEXA     249                          5.  ***                 7   .2368   .5532           5   .4348        3.2231        .8418      -2.4298      -4.1084      -.8552
                                                                                                          1.3897        -.1815       -.0945       -.1323
ELPHEXA     250                          4.  ***                 1   .6591   .7773           2   .1561       -2.1699       -.0815        .2985      -1.3161      -.8527
                                                                                                           .5206        1.1056        .0962       -.1808
ELPHEXA     251                          5.                      5   .0031   .9989           6   .0007        4.0865        .0310      -3.6382        .0035      3.1771
                                                                                                           .2103       -1.1648       1.1102       1.1808
ELPHEXA     252                          9.                      9   .5376  1.0000           2   .0000       -1.9050       4.3926      -1.5966        .9163       .1228
                                                                                                          1.4132         .0230       1.4184       1.7735
ELPHEXA     253                          4.  ***                 2   .3701   .7592           4   .2302       -2.2884        .4253       1.4747        .2665      2.0377
                                                                                                           .4914         .6746        .3586       2.3519
ELPHEXA     254                          2.  ***                 1   .5932   .8765           4   .0657       -1.5426      -1.3124        .4282      -1.2886      -.1539
                                                                                                          -.4797         .3595      -2.1957        .5000
ELPHEXA     255                          2.  ***                 3   .0768   .6529           4   .2754       -2.1852       1.7493       2.8817      -1.5112       .3953
                                                                                                         -2.1809         .4781        .6389        .7835
ELPHEXA     256                          2.                      2   .6500   .9365           4   .0632        -.6253        .0879       1.2215       1.6188      1.2658
                                                                                                          1.9570        -.6252      -1.9364       -.0667
ELPHEXA     257                          2.                      2   .5924   .9556           4   .0348        -.3364        .4936        .2763       1.7743      -.2300
                                                                                                          1.0923         .5988        .7813       -.6448
ELPHEXA     258                          2.                      2   .9590   .9307           4   .0359       -1.5334       1.1933        .7574        .3520       .4663
                                                                                                          1.2260         .8545        .5779        .7540
ELPHEXA     259                          3.                      3   .2675   .6814           2   .3131         .1066       2.0353        .1668       1.9703      -.8756
                                                                                                         -1.1351        -.2857      -2.2359        .0021
ELPHEXA     260                          3.  ***                 7   .1792   .9196           6   .0708        4.7377       2.7217       -.7010       -.3861       .1492
                                                                                                          -.3838        -.0814      -1.1099        .6778
ELPHEXA     261                          3.  ***                10   .0237   .6154           3   .2490        4.8282       2.4257       1.1666       -.3082      -.3624
                                                                                                         -2.3888         .6799      -1.3378        .1888
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       CASE          MIS            ACTUAL            HIGHEST PROBABILITY      2ND HIGHEST
SUBFILE SEQNUM       VAL     SEL     GROUP            GROUP P(X/G) P(G/X)     GROUP P(G/X)  DISCRIMINANT SCORES
ELPHEXA     262                        3.                 3   .0138  .9652        7  .0238      2.8123      3.5139      1.0083     -2.2832      1.2620
                                                                                            -3.2500       .3849      1.0671       .5859
ELPHEXA     263                        2.                 2   .0758  .4986        9  .2535     -1.2293      3.5070       .5947      1.3397       .5435
                                                                                            -1.6856      1.8065     -2.0064      -.1793
ELPHEXA     264                        4.  ***            2   .7629  .9911        4  .0074     -1.1146      1.4510      1.2357       .6511       .7492
                                                                                              .7822       .5300     -2.7009      -.7490
ELPHEXA     265                        3.                 3   .2717  .9739        2  .0185      -.3828      1.2021      2.8891      1.4242      -.6258
                                                                                            -2.8390       .8031     -1.5786      -.4573
ELPHEXA     266                        4.  ***            2   .9319  .9502        4  .0492     -1.5127      1.1948      1.5112       .4385      1.3953
                                                                                             1.0779      -.3615     -1.7867       .0516
ELPHEXA     267                        2.                 2   .0296  .9681        8  .0117     -1.1637      1.0009      -.5313      2.1828      3.1500
                                                                                            -1.6391      1.0371     -1.2777     -1.2460
ELPHEXA     268                        1.                 1   .9978  .9883        4  .0113     -1.4255     -2.2817       .1032      -.6613      -.8238
                                                                                              .3185      -.5182       .6124       .5883
ELPHEXA     269                        4.  ***            2   .1894  .6956        1  .2566     -1.4895      -.7940       .6750      -.2094      -.3883
                                                                                             -.4532      1.9243     -2.7918       .7644
ELPHEXA     270                        3.                 3   .0661  .9435        2  .0303     -1.3212       .6463       .7340     -1.6485     -1.5614
                                                                                            -2.2227      1.8461     -2.2556      -.4339
ELPHEXA     271                        3.                 3   .1537  .9919        2  .0079       .2099      1.9361      1.8459      1.8578     -1.3104
                                                                                            -2.5487      1.0883     -1.9315     -1.4629
ELPHEXA     272                        4.  ***            2   .4404  .8750        4  .1086     -1.6265       .4002       .8192      -.0109       .7980
                                                                                             -.5022      -.4100     -1.2369      2.7032
ELPHEXA     273                        2.                 2   .8591  .9377        3  .0511      -.7628      1.7184      1.6145      1.9753       .2812
                                                                                             -.6236       .7235     -1.3203       .2667
ELPHEXA     274                        1.                 1   .0140  .9722        4  .0122      -.9147     -2.9202      -.4504       .9479       .0996
                                                                                            -3.4754      1.7682       .7720      -.5083
ELPHEXA     275                        2.  ***            4   .6622  .5127        2  .3387      -.6340      -.4338      1.0035       .4096      -.6343
                                                                                             1.3739     -1.2324       .1145       .7205
ELPHEXA     276                        2.                 2   .8509  .9629        4  .0345     -1.0799       .9221      2.0323       .7625      1.0536
                                                                                              .1582      1.3238     -2.1984      -.0448
ELPHEXA     277                        4.  ***            1   .8357  .9881        4  .0097     -1.6391     -2.2578       .2241      -.3322      -.6084
                                                                                             1.6255      1.2609       .8882       .4584
ELPHEXA     278                        4.  ***            2   .7179  .5594        9  .3951     -1.4154      1.5805      -.1719       .1641      -.0175
                                                                                              .5164     -1.1518       .3612       .4404
ELPHEXA     279                        2.                 2   .7138  .9414        4  .0579      -.4029      -.2713      1.4364      1.5970       .8442
                                                                                             1.7151       .3301     -2.0798       .0511
ELPHEXA     280                        1.                 1   .8106  .9982        4  .0016      -.9751     -2.8050       .3738      -.4123     -1.5848
                                                                                              .0402       .9161      -.0064      1.7994
ELPHEXA     281                        2.  ***            1   .2305  .9537        2  .0319      -.7908     -2.3307       .4063      -.2276      -.2233
                                                                                             1.6224      1.2003     -2.6564      -.7254
ELPHEXA     282                        4.  ***            1   .8379  .9878        4  .0086     -1.5839     -2.2288       .0948      -.3936      -.4236
                                                                                             1.5479      1.4639       .4888       .4422
ELPHEXA     283                        1.                 1   .9042  .9854        4  .0093     -1.5374     -2.3100       .0958      -.3123      -.3157
                                                                                             1.3530      1.3225      -.1437       .7892
ELPHEXA     284                        1.                 1   .9438  .9962        4  .0029     -1.1178     -2.3150      -.0513       .1031     -1.4712
                                                                                             -.5384       .3581      -.2053      1.4144
ELPHEXA     285                        3.                 3   .1024  .9746        2  .0218      -.6319      3.0533       .7261      1.4953      -.5430
                                                                                            -2.9412      1.0923     -2.1604      1.0821
ELPHEXA     286                        2.                 2   .8588  .7099        4  .2468     -1.5214       .3945      1.0984      -.2573      -.0773
                                                                                              .1747       .2956       .2138      1.6702
ELPHEXA     287                        2.                 2   .3746  .9543        9  .0447     -1.0260      2.2736      -.4168      1.7972      1.2748
                                                                                             1.2911     -1.1793     -1.5716       .7500
ELPHEXA     288                        2.                 2   .9879  .9486        9  .0371     -1.4228      1.5633       .4303       .7407       .1596
                                                                                              .7932       .9746       .1359       .2345
ELPHEXA     289                        2.                 2   .7836  .6721        4  .2545     -1.5224       .5078      1.3453       .1294       .4880
                                                                                             -.9636       .1625      -.3945      1.8303
ELPHEXA     290                        3.  ***            2   .5389  .9375        3  .0395     -1.3952      1.2166      -.1240       .6508       .2270
                                                                                             -.3645     -1.1471      -.5945      2.0883

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      CASE          MIS          ACTUAL         HIGHEST PROBABILITY     2ND HIGHEST
SUBFILE SEQNUM      VAL   SEL     GROUP         GROUP P(X/G) P(G/X)     GROUP P(G/X)   DISCRIMINANT SCORES
ELPHEXA      291                   2.               2  .8555  .9788         9  .0194      -.8159     1.9705     -.1611     1.6090      .7371
                                                                                         1.2762     -.0754    -1.2618      .0145
ELPHEXA      292                   1.               1  .8920  .9764         4  .0171     -1.3742    -1.6343      .3647      .0511    -1.2006
                                                                                          .8173     1.4407      .7501     -.8049
ELPHEXA      293                   2.               2  .6129  .9959         4  .0014     -1.1403     1.7987      .2740     1.4249     1.4702
                                                                                          .6629     -.3860    -2.6517      .4787
ELPHEXA      294                   1.               1  .2250  .9737         2  .0214     -2.0118    -1.0088     -.6524    -1.3492     -.7147
                                                                                         -.4800      .1070    -1.5322     2.5065
ELPHEXA      295                   4. ***           2  .8571  .7778         4  .2166     -2.0488     1.0260     1.7011      .6308     1.3341
                                                                                         -.3448      .7356      .4182      .9877
ELPHEXA      296                   2.               2  .9691  .8570         4  .1344     -1.7748     1.3576     1.6767      .0942      .7638
                                                                                          .5494      .6936      .2804      .2985
ELPHEXA      297                   3.               3  .3301  .9858         2  .0135       .0613     2.3191     1.0783     2.6026     -.9696
                                                                                        -2.4147      .0168     -.6874     -.6250
ELPHEXA      298                   2. ***           1  .3626  .8049         2  .1654      -.6613    -1.8557      .4969      .8452     -.7519
                                                                                          .6601     1.6744    -2.1704     -.0339
ELPHEXA      299                   3.               3  .0067  .7555         1  .1103     -1.2689      .9420      .0509      .1604    -2.3352
                                                                                        -1.1651     2.8016      .5814    -2.4032
ELPHEXA      300                   3.               3  .6413  .8880         2  .1085      -.7925     1.4183      .6438     1.5830     -.8237
                                                                                        -2.1583     1.1219     -.3141      .8447
ELPHEXA      301                   1.               1  .5357  .9446         8  .0547     -1.3313    -2.8090    -1.8256     -.3422      .3229
                                                                                         -.8007      .0946      .5544    -1.3495
ELPHEXA      302                   3.               3  .3345  .9164         2  .0823       .1739     2.1031      .6487     2.4438    -1.1143
                                                                                        -1.7640      .0732    -1.5582      .4781
ELPHEXA      303                   3.               3  .7690  .9788         2  .0198      -.6196     1.8151     1.0873     1.4867    -1.1505
                                                                                        -2.4338      .5915     -.3427      .4005
ELPHEXA      304                   4. ***           2  .9839  .9374         3  .0251     -1.4926     1.6474      .8183     1.1756      .5147
                                                                                         -.3597      .6080      .0141      .4954
ELPHEXA      305                   3.               3  .0704  .9740         1  .0170      -.2611     -.0699      .7360      .2615    -2.3797
                                                                                        -2.4911     1.9204    -2.0614    -1.1010
ELPHEXA      306                   3.               3  .4612  .5146         4  .4445     -1.4362     1.0350     2.4378     -.1207      .1105
                                                                                        -2.0671     -.6020      .4175     -.8640
ELPHEXA      307                   3.               3  .5378  .9897         2  .0067      -.6507     1.5356     2.0100     1.2352    -1.2483
                                                                                        -2.4802      .9416     1.1271      .0066
ELPHEXA      308                   3.               3  .8399  .6220         2  .3324      -.9142     1.4844      .9190      .8011     -.7697
                                                                                         -.9871      .1683      .4620      .8360
ELPHEXA      309                   3.               3  .5436  .9918         2  .0047      -.6323     1.5090     2.0694     1.1173    -1.2899
                                                                                        -2.5414      .9093     1.0515     -.4157
ELPHEXA      310                   3. ***           2  .8194  .6311         3  .3550      -.2863     1.5095     1.2018     1.2619     -.7669
                                                                                         -.5609     -.0927    -1.3634      .5981
ELPHEXA      311                   2.               2  .3051  .9451         4  .0520      -.9623      .4675      .2712     1.7082      .6467
                                                                                         2.4440     -.5138     1.1382     1.3648
ELPHEXA      312                   2. ***           3  .2206  .4767         2  .4729     -1.2447     1.8211     1.7655     1.6323      .1028
                                                                                        -1.4982     1.7053     1.0476     -.4043
ELPHEXA      313                   9. ***           8  .6842 1.0000         1  .0000     -2.0471      .2487    -3.6638      .8575     1.2643
                                                                                        -1.4848      .3920      .2070    -1.1464
ELPHEXA      314                   2. ***           3  .0873  .5632         9  .2186     -2.0229     3.1466     1.7410      .4099      .5730
                                                                                        -2.1886     1.7883      .1649      .3030
ELPHEXA      315                   2.               2  .3010  .5586         3  .4138     -1.2256     1.7773     1.6841     1.8427      .2666
                                                                                        -1.7059     1.6058      .5315      .5474
ELPHEXA      316                   5.               5  .0608  .3556         6  .2559      4.2647     1.0224      .6147    -1.4646      .2120
                                                                                          .3330     -.8600      .8813     -.9238
ELPHEXA      317                   9.               9  .6867 1.0000         2  .0000     -1.7565     4.6455      .2194      .0428     -.6992
                                                                                          .5459      .4580     1.8302    -1.5395
ELPHEXA      318                   2. ***           8  .2281  .9494         2  .0471     -1.1368     -.1816    -1.6451     2.3205     2.2338
                                                                                          .7776     -.2744     1.3288     -.3116
ELPHEXA      319                   2.               2  .7508  .9455         1  .0336     -1.4764      .6449     -.6448      .2957     -.5176
                                                                                          .3753     -.0389    -1.9734      .2236
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           CASE       MIS           ACTUAL           HIGHEST PROBABILITY     2ND HIGHEST
SUBFILE   SEQNUM      VAL    SEL    GROUP            GROUP P(X/G) P(G/X)     GROUP P(G/X)   DISCRIMINANT SCORES
ELPHEXA     320                     2. ***           3   .0224   .4965       9   .4925        -1.5042      4.0893      1.9097       .2589      -.6623
                                                                                            -2.1142     1.8469       .0379     -1.6645
ELPHEXA     321                     9. ***           8   .2035   .9369       1   .0106        -2.2403       .0090     -3.1922      -.7787      1.0922
                                                                                              .6592      .2302       .2733     -1.4138
ELPHEXA     322                     1.               1   .1199   .5790       8   .4119        -1.6796     -2.1028     -1.7390      -.0739      1.5125
                                                                                             -.0804      .5111       .0707     -2.2657
ELPHEXA     323                     2. ***           9   .3711   .8156       2   .1325        -2.2378      3.1696      1.3181       .1250       .5435
                                                                                            -1.1872     1.3715       .7514       .2281
ELPHEXA     324                     3.               3   .1805   .9375       9   .0531        -1.6946      2.3332       .5253      -.7395      -.4272
                                                                                            -2.7897    -1.2475      -.3039      1.7459
ELPHEXA     325                     9.               9   .3075   .8625       2   .1299        -1.3026      3.6804       .8665       .1827      -.1963
                                                                                              .2625     1.2476     -1.5348     -1.5973
ELPHEXA     326                     2. ***           9   .3774   .5581       2   .4301        -2.0655      3.2020       .5330      -.0311      1.3835
                                                                                              .4338     -.3737     -1.7898      -.1395
ELPHEXA     327                     1.               1   .4577   .9646       8   .0335        -1.0838     -2.5991     -1.5029      -.2847       .3386
                                                                                            -1.4274      .2205      -.1327     -1.6104
ELPHEXA     328                     1.               1   .8540   .9790       2   .0142        -1.0832     -1.5408       .2244       .0089     -1.4273
                                                                                             1.1841     1.7645      -.0601       .0422
ELPHEXA     329                     1.               1   .8445   .9760       4   .0167        -1.4106     -1.8391       .0888       .3718     -1.1139
                                                                                              .4982     1.8007       .8302      -.1219
ELPHEXA     330                     4. ***           1   .6121   .8518       4   .0914        -2.2660      -.9102       .7384     -1.3873      -.3514
                                                                                              .1703     1.7643       .2185       .5862
ELPHEXA     331                     8.               8   .1068   .7001       1   .2864        -2.1667      -.8070     -2.2032      -.7476      1.3881
                                                                                             -.4843     1.3250       .5053     -1.4491
ELPHEXA     332                     2. ***           1   .9780   .9623       4   .0205        -1.3606     -1.4480       .2235       .1012     -1.1289
                                                                                             1.0014      .9577       .3813       .0193
ELPHEXA     333                     5. ***           7   .0078   .6972       5   .2922         2.1674      1.4796       .1970     -4.8341       .1426
                                                                                             -.3191     2.6817      -.5828       .3112
ELPHEXA     334                     1.               1   .2173   .9732       8   .0184        -1.6124     -3.0539     -1.1344      -.1394      1.4572
                                                                                             -.2480     1.6852       .4018     -1.2167
ELPHEXA     335                     1.               1   .3367   .9679       4   .0235        -1.2675      -.8558       .2269      -.8964     -1.4813
                                                                                             1.9266     -.2186       .2784     -2.1809
ELPHEXA     336                     1.               1   .9948   .9699       4   .0295        -1.2815     -2.2438       .6034      -.4311     -1.0052
                                                                                             -.4120     -.0702       .8466       .2372
ELPHEXA     337                     4. ***           1   .4344   .9218       4   .0409        -2.3586      -.5339       .1947     -2.2020      -.3693
                                                                                             1.5607      .5618      -.0470      -.2389
ELPHEXA     338                     1.               1   .9835   .9858       4   .0124        -1.3904     -2.3412       .0527      -.5311      -.6751
                                                                                              .0715     -.6252       .0183      1.2568
ELPHEXA     339                     1.               1   .9982   .9959       4   .0039        -1.1001     -2.7563       .3672      -.7586     -1.1298
                                                                                             -.3163      .3278      -.4711       .3028
ELPHEXA     340                    10.              10   .3636  1.0000       3   .0000         3.7700      1.8427      3.4361     -1.4663      2.3610
                                                                                             -.1712     3.6111      -.5814     -2.1286
ELPHEXA     341                     4.               4   .5351   .9547       2   .0352        -1.0717      -.9865      3.2076       .3945      2.0077
                                                                                             1.4001     -.3325     -1.1525     -1.2778
ELPHEXA     342                     4.               4   .4920   .9353       2   .0645        -1.0466     -1.1738      3.1299       .6459      2.2578
                                                                                             1.0776      .2126     -1.4939      -.7848
ELPHEXA     343                     2. ***           1   .2211   .9645       2   .0187         -.5124     -2.3097      1.0038       .0452     -1.0047
                                                                                             1.4165     2.3668     -1.6050      -.8506
ELPHEXA     344                     1.               1   .3834   .9124       2   .0799         -.2496     -1.3237      -.0484       .6703     -1.5187
                                                                                             1.6961     1.1402     -1.4190      -.9470
ELPHEXA     345                     1.               1   .1705   .9223       2   .0551         -.3849     -1.7917       .6410       .3608     -1.3426
                                                                                             1.0935     1.9056     -2.3756     -1.0061
ELPHEXA     346                     1.               1   .9992   .9952       4   .0046        -1.1082     -2.2918       .2329     -1.0717     -1.2965
                                                                                              .4737     -.4211      -.2014       .0796
ELPHEXA     347                     3. ***           1   .8849   .9508       4   .0366         -.8320     -2.2523      1.1573      -.3164     -1.5316
                                                                                            -1.1625      .3270      -.0628       .6112
ELPHEXA     348                    10.              10   .7428   .9996       6   .0004         4.2050       .3346      1.9032      -.1631       .8658
                                                                                             -.1643     2.4811      1.4619      1.3006
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            CASE       MIS          ACTUAL            HIGHEST PROBABILITY      2ND HIGHEST
SUBFILE   SEQNUM       VAL   SEL     GROUP            GROUP P(X/G) P(G/X)     GROUP P(G/X)   DISCRIMINANT SCORES

ELPHEXA      349                        3.  ***        10  .9823 1.0000         6  .0000         3.8003     1.0467      2.1926      -.1857      1.7521
                                                                                                  .7025    2.8544     1.6658      -.8905
ELPHEXA      350                       10.             10  .3284  .9975         6  .0025         4.6955     1.4760       .5956       .4211      1.3784
                                                                                                 2.4665    2.2053     -.8169     -1.3075
ELPHEXA      351                       10.             10  .8546 1.0000         6  .0000         4.0444     1.3931      1.9829       .2268       .8245
                                                                                                  .7821    3.6723     2.0577     -1.2551
ELPHEXA      352                       10.             10  .7288 1.0000         6  .0000         3.9137     1.2858      1.5834       .3418      1.6207
                                                                                                  .9317    2.4146     2.6482      -.5184
ELPHEXA      353                       10.             10  .9693 1.0000         6  .0000         3.7592      .8110      2.2998       .0299      1.7604
                                                                                                  .3216    3.1409     1.7512      -.5971
ELPHEXA      354                       10.             10  .6519 1.0000         6  .0000         4.7049      .7765      2.6520       .0578      1.3630
                                                                                                 1.0893    3.8678     -.2895     -2.1966
ELPHEXA      355                       10.             10  .8407 1.0000         3  .0000         3.9154     2.7993      1.4788       .1276      2.0112
                                                                                                 -.1348    2.8840     -.9165      -.4055
ELPHEXA      356                        4.              4  .9588  .7310         2  .2647         -.9848     -.6588      2.0557       .9602       .9033
                                                                                                  .9263     .8633      .3901       .0301
ELPHEXA      357                        1.              1  .5849  .9695         2  .0270         -.8618     -.9451      -.6721       .8897     -1.9081
                                                                                                  .9567    1.4023      .5182      -.2416
ELPHEXA      358                        4.              4  .9632  .7513         2  .2453        -1.3465     -.6978      1.5801       .7988      1.4797
                                                                                                 1.1475     -.5384     -.0994       .4765
ELPHEXA      359                        4.  ***         2  .8612  .5106         4  .4834        -1.0991     -.5431      1.4929       .6483      1.0935
                                                                                                 1.7695     -.1218     -.2643       .7278
ELPHEXA      360                       10.             10  .1272  .7846         3  .2120         3.9143     1.6259       .7919     -1.0806       .2409
                                                                                                -2.1203    1.8235      .9872      1.3157
ELPHEXA      361                       10.             10  .2952  .9958         3  .0035         4.4458     1.4966      1.6187     -1.3048       .3949
                                                                                                -1.6592    1.7954    -1.6012      -.0047
ELPHEXA      362                        3.              3  .1388  .6052        10  .3881         3.5440     1.7317      1.2562     -1.6612       .6892
                                                                                                -2.1142     .0916      .3918       .8797
ELPHEXA      363                        3.              3  .7607  .8808         2  .0602        -1.1708     1.4457      2.0282       .4455      -.5946
                                                                                                -1.8785     .4406      .5705      -.6252
ELPHEXA      364                        3.              3  .7429  .9351         2  .0424         -.9827     1.4511      1.4296       .9847      -.5160
                                                                                                -2.0887     .5288      .9687      -.6046
ELPHEXA      365                        1.              1  .8922  .9985         4  .0010         -.8161    -2.4373       .0375      -.0673     -1.8639
                                                                                                 -.4080    1.0709     -.5527      1.1365
ELPHEXA      366                        4.              4  .7597  .9311         2  .0680        -1.1355     -.1978      2.4540      1.1689       .8458
                                                                                                  .7446     .2804     1.9130      -.5050
ELPHEXA      367                        4.              4  .5286  .9142         2  .0855        -2.4829      .2322      1.9827     -1.0316      2.5038
                                                                                                  .7395     -.5939      .3476      -.2148
ELPHEXA      368                        3.              3  .0192  .7228        10  .2661         3.4336     1.0756      1.6171     -1.6681      1.1718
                                                                                                -2.2896      .7674      .3458      2.4921
ELPHEXA      369                        4.              4  .6572  .9823         2  .0172        -1.8548     -.9116      2.4413      -.3442      2.0743
                                                                                                 1.8115    -1.1914      .3061      -.2626
ELPHEXA      370                        6.              6  .9395 1.0000        10  .0000         6.1531     -.5816      1.0459       .7849      -.2810
                                                                                                 1.0999     -.7463      .0441       .1274
ELPHEXA      371                        4.              4  .4428  .9913         2  .0081        -1.9378     -.8541      2.5385      -.3852      1.8312
                                                                                                 2.0831    -1.1967     1.2099      -.6512
ELPHEXA      372                        6.  ***        10  .1133  .8713         6  .1287         4.9614    -1.2369      2.2250       .3812       .7359
                                                                                                  .9809    1.7911     2.0361       .7467
ELPHEXA      373                        4.              4  .7158  .9919         2  .0078        -1.7103     -.7925      2.9007      -.2494      1.8714
                                                                                                 1.3479     -.4975      .8722     -1.2601
ELPHEXA      374                        4.              4  .7071  .9737         2  .0257        -1.9133    -1.3170      2.4660       .2813      2.2855
                                                                                                 1.1725     -.4285      .3688      1.0594
ELPHEXA      375                        1.              1  .0465  .6517         8  .3339        -1.8000    -3.4573     -1.6891      -.2567      1.9680
                                                                                                -1.7666     -.5172     -.0469      -.3833
ELPHEXA      376                        4.              4  .7033  .9594         2  .0300        -1.8508    -1.1859      2.4387       .0659      2.2907
                                                                                                 1.2233     -.7546     -.2249       .9409
ELPHEXA      377                        4.              4  .6693  .9836         2  .0158        -1.9080    -1.0401      2.4532      -.1393      2.0937
                                                                                                 1.7602     -.6375      .8364      -.1727
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         CASE        MIS            ACTUAL          HIGHEST PROBABILITY      2ND HIGHEST
SUBFILE SEQNUM       VAL    SEL      GROUP          GROUP P(X/G) P(G/X)      GROUP P(G/X)   DISCRIMINANT SCORES
ELPHEXA     378                        4.               4  .5536  .9625          2  .0369      -1.8790     -1.3884      2.8494       .3775      2.3991
                                                                                                .9037      -.5700      -.2007      1.5987
ELPHEXA     379                        4.               4  .7392  .9742          2  .0251      -1.9033     -1.2332      2.4093       .1351      2.2896
                                                                                               1.4388      -.1539       .6351       .3835
ELPHEXA     380                        4.               4  .4372  .9925          2  .0066       -.8988     -2.4099      2.7581      1.6530      1.8755
                                                                                               1.2860      -.3476       .5996       .4243
ELPHEXA     381                        4.               4  .2467  .9986          2  .0010       -.7789     -1.9089      3.3302      1.2162      1.2408
                                                                                               1.4661      -.6665      1.6720     -1.6387
ELPHEXA     382                        4.               4  .1094  .9995          2  .0004       -.4343     -1.8980      4.2770      1.7474      1.0508
                                                                                               -.2649       .1553      1.4178     -1.8707
ELPHEXA     383                        4.               4  .2191  .9979          2  .0020      -1.3648      -.5060      3.8419      -.1338      1.4780
                                                                                                .2049       .1021      1.1157     -2.7106
ELPHEXA     384                        4.               4  .1880  .9261          2  .0682       -.6226      -.5270      3.0235      1.0613       .5839
                                                                                               -.3592      2.1001       .7585     -2.0722
ELPHEXA     385                        4.               4  .9125  .9910          2  .0089      -1.5436     -1.1046      3.4073       .5045      1.9789
                                                                                               -.2308      -.0006       .1116       .1792
ELPHEXA     386                        2.               2  .0198  .9230          4  .0747      -2.2456      1.8162      2.0388     -1.6295      2.2466
                                                                                                .1426       .0337     -3.1723      -.7425
ELPHEXA     387                        8.               8  .0997  .9999          1  .0001       -.5985     -1.8727     -3.1623      2.0157      1.0429
                                                                                               -.4574      1.6645     -2.7772     -1.8046
ELPHEXA     388                        8.               8  .8797 1.0000          1  .0000      -1.2226     -1.3310     -4.1124      2.0458       .6487
                                                                                                .0974      1.1603      1.1533     -1.1149
ELPHEXA     389                        8.               8  .9996 1.0000          1  .0000      -1.1157     -1.2633     -4.1870      1.9302       .8085
                                                                                               -.1118       .5370      -.0874      -.6688
ELPHEXA     390                        8.               8  .9906 1.0000          1  .0000      -1.1312     -1.4336     -4.2779      2.3142      1.0318
                                                                                               -.3782      1.0385      -.1961       .2766
ELPHEXA     391                        4.               4  .3789  .7984          1  .2000      -1.7543     -2.4211      2.4442      -.8799       .2438
                                                                                               -.7481      1.2044       .2317     -1.5100
ELPHEXA     392                        4.               4  .4056  .8076          1  .1910      -1.7824     -2.4291      2.4908      -.8481       .1690
                                                                                               -.7466      1.1196       .4248     -1.4230
ELPHEXA     393                        4.               4  .5195  .9941          2  .0050       -.8779     -2.2095      2.7596      1.3498      1.7476
                                                                                               1.6060      -.7542       .6256      -.2109
ELPHEXA     394                        4.               4  .2008  .9392          2  .0579       -.6448     -2.1864      2.5096      2.4348      1.1226
                                                                                                .9000       .1110       .1960      1.7356
ELPHEXA     395                        4.               4  .1688  .9770          2  .0141       -.7449      -.2634      3.5345      1.2758       .6160
                                                                                              -1.1879      1.1058      1.1659     -2.2227
ELPHEXA     396                        4.               4  .1725  .9987          2  .0011       -.3809     -1.7411      3.2207      1.7425      1.1303
                                                                                                .5613      -.6672      1.6990     -2.1875
ELPHEXA     397                        8.               8  .1102  .9937          1  .0056      -1.3113     -2.0617     -2.4110      1.6805      1.0507
                                                                                               -.6960      1.8455     -1.1100      2.3364
ELPHEXA     398                        8.               8  .5726 1.0000          1  .0000      -1.4015     -1.8410     -3.7472      1.3945      1.5109
                                                                                               1.2128       .6211      1.4160      1.0680
ELPHEXA     399                        8.               8  .9997 1.0000          1  .0000      -1.1483     -1.0017     -4.3125      1.9201       .7557
                                                                                                .3556       .1797       .1837      -.2624
ELPHEXA     400                        8.               8  .9776 1.0000          1  .0000      -1.1777      -.9416     -4.2584      1.7802       .6193
                                                                                                .6004       .8011       .7401      -.9608
ELPHEXA     401                        8.               8  .9201  .9998          1  .0002      -1.2741     -1.4477     -3.4878      1.3170       .7221
                                                                                               -.0855      1.0039      -.2772     -1.5767
ELPHEXA     402                        8.               8  .8996 1.0000          1  .0000      -1.2212     -1.0674     -4.2727      1.9741       .6647
                                                                                                .5485       .8644      1.2035      -.9010
ELPHEXA     403                        8.               8  .8045 1.0000          1  .0000      -1.1546     -1.1074     -4.2165      1.7193       .6739
                                                                                                .4333       .9224       .8412     -1.7825
ELPHEXA     404                        8.               8  .8987 1.0000          1  .0000       -.9573     -1.3122     -4.5585      1.2335      -.0966
                                                                                                .0392      -.9921       .9921      -.8414
ELPHEXA     405                        8.               8  .9268 1.0000          1  .0000       -.9556     -1.3000     -4.6028      1.2471      -.0404
                                                                                                .0552      -.9325       .8977      -.7764
ELPHEXA     406                        8.               8  .7738 1.0000          1  .0000       -.9395     -1.0673     -4.6886      1.0518      -.0851
                                                                                                .4392     -1.2606       .9026     -1.0104

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          CASE       MIS          ACTUAL          HIGHEST PROBABILITY     2ND HIGHEST
SUBFILE SEQNUM  VAL    SEL     GROUP          GROUP P(X/G) P(G/X)    GROUP P(G/X)  DISCRIMINANT SCORES
ELPHEXA    407                    8.              8  .9335 1.0000        1  .0000     -1.0071      -1.3229      -4.6829       1.6619        .0523
                                                                                   -.0711   -1.1317        .8000        .8627
ELPHEXA    408                    8.              8  .9848 1.0000        1  .0000      -.9715      -1.5123      -4.5751       1.5042        .0629
                                                                                   -.2902    -.5475        .8586      -.3092
ELPHEXA    409                    8.              8  .9955 1.0000        1  .0000      -.9047      -1.8214      -4.5331       1.6830        .2966
                                                                                   -.9815    -.2663      -.0195        .0964
ELPHEXA    410                    8.              8  .9878 1.0000        1  .0000      -.9665      -1.2964      -4.5305       1.6197        .0859
                                                                                   -.5659    -.7894        .4967        .2635
ELPHEXA    411                    8.              8  .6024 1.0000        1  .0000      -.8562      -1.0998      -4.6682        .7868       -.0232
                                                                                    .3285   -1.1642        .4207     -1.9112
ELPHEXA    412                    8.              8  .9970  .9999        1  .0001     -1.1076      -1.8188      -3.9428       1.2019        .2098
                                                                                   -.7461    -.3699      -.3226        .2749
ELPHEXA    413                    4.              4  .0192  .9917        3  .0076      -.0428      -1.3747       3.9062       -.2296        .3240
                                                                                 -1.9995   -2.5976      -1.8882     -1.3437
ELPHEXA    414                    4.              4  .1992  .9933        2  .0059      -.4713      -1.4737       3.8080        .6639       1.3292
                                                                                 -1.3872   -1.0966      -2.1697        .0070
ELPHEXA    415                    8.              8  .9924 1.0000        1  .0000      -.9483      -1.5912      -4.5606       1.5991        .1342
                                                                                   -.5669    -.7346        .3720        .2123
ELPHEXA    416                    8.              8  .9973 1.0000        1  .0000      -.8985      -1.5817      -4.6302       1.5289        .2536
                                                                                   -.5784    -.5972        .0378        .0060
ELPHEXA    417                    8.              8  .9689 1.0000        1  .0000      -.9923      -1.5588      -4.5864       1.7554        .1167
                                                                                   -.4983    -.7709        .6180        .7494
ELPHEXA    418                    8.              8  .9579 1.0000        1  .0000      -.9747      -1.3368      -4.6714       1.5550        .0727
                                                                                   -.1166   -1.0977        .6147        .4977
ELPHEXA    419                    4.              4  .4119  .9987        3  .0009      -.9894       -.9729       4.0360       -.1381        .7435
                                                                                 -1.5806   -1.1090        .7534     -1.4678
ELPHEXA    420                    8.              8  .9675 1.0000        1  .0000      -.9855      -1.5543      -4.6330       1.7856        .1704
                                                                                   -.4751    -.7159        .5512        .8712
ELPHEXA    421                    8.              8  .9627 1.0000        1  .0000     -1.2396      -1.3480      -4.2381       2.4095        .8216
                                                                                   -.0383    1.0539        .8259        .3717
ELPHEXA    422                    4.              4  .2370  .9526        2  .0374      -.8033       -.8809       3.6181        .4743       2.0185
                                                                                    .4501    -.4686      -2.2714     -1.2930
ELPHEXA    423                    4.              4  .1948  .9973        3  .0014      -.3620      -1.1701       4.3616        .5187        .8498
                                                                                 -1.5277    -.9779      -1.1940     -1.4507
ELPHEXA    424                    8.              8  .9642 1.0000        1  .0000     -1.0166      -1.4822      -4.6215       1.6859        .0650
                                                                                   -.2065    -.5652       1.0775        .3224
ELPHEXA    425                    4.              4  .9404  .9979        2  .0015     -1.3096      -1.2523       3.0528       -.2824       1.2042
                                                                                   -.4390   -1.6324        .3364       -.0955
ELPHEXA    426                    8.              8  .9388 1.0000        1  .0000      -.9868      -1.7701      -4.6077       2.0029        .2906
                                                                                   -.8359    -.3081        .4244       1.2055
ELPHEXA    427                    8.              8  .9932 1.0000        1  .0000      -.9403      -1.5711      -4.6242       1.6444        .2062
                                                                                   -.5337    -.6614        .2886        .3920
ELPHEXA    428                    8.              8  .7983 1.0000        1  .0000      -.9791      -1.6135      -4.6502       1.9744        .2671
                                                                                   -.7044    -.8859        .1404       1.7268
ELPHEXA    429                    8.              8  .9910 1.0000        1  .0000      -.9597      -1.4956      -4.6321       1.5314        .1321
                                                                                   -.2657    -.4753        .7565       -.1931
ELPHEXA    430                    8.              8  .9787 1.0000        1  .0000      -.9437      -1.3522      -4.6545       1.4461        .0864
                                                                                   -.1641   -1.0708        .4403        .1241
ELPHEXA    431                    8.              8  .9931 1.0000        1  .0000      -.9414      -1.4993      -4.6376       1.4838        .1557
                                                                                   -.2834    -.4444        .6450       -.3509
ELPHEXA    432                    8.              8  .3282 1.0000        1  .0000      -.4492      -2.5015      -4.3137       3.6416        .3802
                                                                                    .8100     .4457       1.3712        .3350
ELPHEXA    433                    8.              8  .9935 1.0000        1  .0000      -.9245      -1.8071      -4.5566       1.7660        .3008
                                                                                   -.9427    -.2710        .0842        .3860
ELPHEXA    434                    8.              8  .9058 1.0000        1  .0000     -1.0316      -1.4581      -4.6313       1.7986        .0404
                                                                                   -.1592    -.6043       1.3010        .7058
ELPHEXA    435                    4.              4  .7366  .9892        2  .0064     -1.6291      -1.4505       2.0285       -.5622       1.6441
                                                                                    .9695   -1.9093        .2498        .6298
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         CASE         MIS           ACTUAL           HIGHEST PROBABILITY       2ND HIGHEST
 SUBFILE SEQNUM       VAL    SEL     GROUP           GROUP P(X/G) P(G/X)      GROUP P(G/X)  DISCRIMINANT SCORES

 ELPHEXA     436                      8.                8  .9766 1.0000         1  .0000     -1.0116    -1.7136    -4.5574     1.8429      .1525
                                                                                            -.6007     -.1863      .9569      .4366
 ELPHEXA     437                      4.                4  .0632  .9959         3  .0024      -.2212    -1.6168     3.4268     -.1412      .5974
                                                                                          -1.5883    -2.0797    -2.0557     -.3156
 ELPHEXA     438                      4.                4  .5718  .9984         2  .0012     -1.4444     -.9260     3.0572     -.7804     1.0331
                                                                                            -.0672    -2.6198     -.1065     -.7930
 ELPHEXA     439                      4.                4  .0750  .9951         3  .0044      -.6897    -1.1830     3.6130     -.8643      .1657
                                                                                          -2.0514    -2.7876      .1933    -1.3003
 ELPHEXA     440                      8.                8  .9727 1.0000         1  .0000      -.9492    -1.3706    -4.5978     1.4011      .0237
                                                                                            -.1956    -1.1340      .5052     -.0519
 ELPHEXA     441                      8.                8  .9745 1.0000         1  .0000      -.9841    -1.5664    -4.6000     1.7461      .1385
                                                                                            -.4988     -.7462      .5618      .7241
 ELPHEXA     442                      4.                4  .3701  .9987         3  .0010     -1.0343    -1.0667     4.1504      .0475      .6467
                                                                                          -1.8450    -1.4887      .7263     -.6840
 ELPHEXA     443                      4.                4  .8313  .9989         2  .0007     -1.1783    -1.2180     3.5741     -.0378      .9888
                                                                                          -1.1688    -1.2228      .6581     -.4071
 ELPHEXA     444                      4.                4  .6576  .9990         2  .0005     -1.2592    -1.4354     3.6720      .3333      .9572
                                                                                          -1.4854     -.9969     1.0434      .4135
 ELPHEXA     445                      1.                1  .9923  .9553         4  .0206     -1.2473    -1.5783      .3057     -.1400    -1.0367
                                                                                             .5743      .8303     -.6008     -.6195
 ELPHEXA     446                      5.                5  .5145 1.0000         7  .0000      2.9046    -2.1398      .2864    -4.4356      .9980
                                                                                             .6451    -1.4791     -.0483      .1425
 ELPHEXA     447                      1.                1  .9943  .9961         4  .0038     -1.1232    -2.4874      .4014    -1.1470    -1.3972
                                                                                             .2730      .0333      .1913     -.0415
 ELPHEXA     448                      1.                1  .4282  .9761         4  .0238     -1.0343    -3.9971     1.0049     -.5966     -.4698
                                                                                            1.0409    -1.5115      .4770     -.4978
 ELPHEXA     449                      1.                1  .6346  .9069         4  .0929     -1.8799    -3.1405     1.2089    -1.3292     -.0222
                                                                                            -.3914     -.9047     -.0572      .9868
 ELPHEXA     450                      1. ***            5  .6451 1.0000         1  .0000      2.8760    -2.3424      .2978    -4.1235     1.1053
                                                                                             .3256    -1.0959     -.0210      .8017
 ELPHEXA     451                      5.                5  .3752  .9999         7  .0001      4.0533    -1.7528     -.5325    -2.7870      .5982
                                                                                             .7939     -.6294    -2.1320      .6901
 ELPHEXA     452                      1.                1  .5047  .9482         4  .0457     -2.0789    -1.1346      .2871    -2.2945     -.3772
                                                                                            -.8970     -.5696    -1.2494      .0311
 ELPHEXA     453                      4. ***            1  .9917  .9661         4  .0331     -1.2472    -2.3409      .6596     -.4136     -.9649
                                                                                            -.7295     -.2825      .3178      .4803
 ELPHEXA     454                      5.                5  .6574 1.0000         1  .0000      2.8158    -2.2784      .3573    -4.1904      .9229
                                                                                             .5958    -1.0325      .7262      .3425
 ELPHEXA     455                      5.                5  .7603 1.0000         1  .0000      3.5010    -2.1393     -.4684    -2.8837     -.1044
                                                                                             .2084      .2531      .4941     1.9511
 ELPHEXA     456                      1.                1  .7460  .9988         4  .0012      -.2941    -3.6848      .2283      .2557    -1.6391
                                                                                             .9018     -.6312      .0954     -.0532
 ELPHEXA     457                      1.                1  .5367  .9992         4  .0008      -.8657    -2.7643      .0146    -1.6112    -1.9901
                                                                                            -.4129    -1.9449     -.4563      .4005
 ELPHEXA     458                      5.                5  .8255 1.0000         7  .0000      3.5698    -1.7836     -.5500    -3.2997     -.1852
                                                                                             .6336     -.6453     -.0191     1.5670
 ELPHEXA     459                      2. ***            4  .9772  .9638         2  .0333      -.9969     -.9890     2.5827      .0060     1.0220
                                                                                            1.2159      .0458      .1535     -.8453
 ELPHEXA     460                      5.                5  .3004 1.0000         1  .0000      2.8111    -2.0698     -.1892    -2.8097      .9333
                                                                                            -.1411     -.6303      .3365     3.0783
 ELPHEXA     461                      1.                1  .8730  .9977         4  .0022      -.9109    -3.0901      .8968    -1.7630    -1.4498
                                                                                             .4834      .4144     -.3396     -.6170
 ELPHEXA     462                      5. ***            1  .7705  .9279         4  .0713     -1.7588    -2.0629      .6217    -1.4419     -.4873
                                                                                             .3621    -1.8050     -.3214      .0505
 ELPHEXA     463                      5.                5  .9806 1.0000         7  .0000      3.3300    -1.8224     -.6077    -3.1933      .2917
                                                                                             .3398     -.7043      .3761     1.0218
 ELPHEXA     464                      1.                1  .9250  .9506         4  .0300     -1.3079    -2.2753      .9281     -.7527     -.8314
                                                                                             .4056      .9260     -.4369    -1.3673
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         CASE          MIS            ACTUAL          HIGHEST  PROBABILITY      2ND  HIGHEST
SUBFILE  SEQNUM        VAL    SEL      GROUP          GROUP  P(X/G)  P(G/X)     GROUP  P(G/X)   DISCRIMINANT  SCORES

ELPHEXA     465                          5.               5   .7324 1.0000         1   .0000      2.8081    -2.4751      .3339    -3.9021      1.0858
                                                                                                   .2751     -.5861      .6096      .9369
ELPHEXA     466                          1.               1   .5269   .9060        4   .0939     -1.8048    -2.7246     1.1236    -1.9961      -.1361
                                                                                                   .2456    -1.5573     -.3710     -.5484
ELPHEXA     467                          1.               1   .6852   .9097        4   .0901     -1.8331    -2.9271     1.1343    -1.6844      -.0279
                                                                                                  -.0740    -1.1730     -.3463      .2096
ELPHEXA     468                          5.               5   .7003 1.0000         1   .0000      2.7884    -2.4807      .3666    -3.8797      1.0333
                                                                                                   .2762     -.6456      .7450      .9979
ELPHEXA     469                          1.               1   .9759   .9993        4   .0006     -1.0356    -2.6823     -.0662    -1.1919     -1.5284
                                                                                                   .9783      .0917     -.5526      .6614
ELPHEXA     470                          5.               5   .4443 1.0000         1   .0000      2.5678    -1.8593      .7309    -3.8023      1.4544
                                                                                                  1.3848      .3321     1.1015     -.5551
ELPHEXA     471                          5.               5   .2176   .9982       10   .0018      3.4805    -1.7623     -.0054    -2.7159      -.0727
                                                                                                  1.4190     2.4739     1.1310      .3989
ELPHEXA     472                          5.               5   .6915 1.0000         1   .0000      2.7836    -2.4820      .3745    -3.8743      1.0206
                                                                                                   .2764     -.6600      .7778     1.0127
ELPHEXA     473                          5.               5   .0157   .9852       10   .0148      3.1831     -.8412     -.6499    -1.1024      4.4681
                                                                                                   .3118      .7601     1.8634     -.4411
ELPHEXA     474                          5.               5   .0870 1.0000         1   .0000      2.4067    -3.1208    -1.6007    -3.9250      3.6375
                                                                                                  -.7526    -1.1470      .6845     -.8480
ELPHEXA     475                          5.               5   .2658 1.0000         7   .0000      2.6966    -2.1149     -.1479    -4.7282       .9868
                                                                                                  1.6461    -1.8754      .4914      .0465
ELPHEXA     476                          1.               1   .9370   .9983        4   .0015      -.8466    -2.4833      .5257    -1.4327     -1.9048
                                                                                                   .4792      .0787     -.3843     -.9283
ELPHEXA     477                          9.               9   .5253   .9036        2   .0515      -.9065     3.4467     -.2518      .3120      -.5466
                                                                                                  -.5802     -.4702    -2.0402     -.0948
ELPHEXA     478                          9.               9   .9862   .9976        2   .0022     -1.8717     3.8820     -.2007      .5426      -.0661
                                                                                                  -.0869     1.0695      .6667      .2833
ELPHEXA     479                          9.               9   .6669   .9993        2   .0004     -1.7348     4.1765      .3548      .3149      -.5202
                                                                                                  -.2508     1.2248     1.4804    -1.4547
ELPHEXA     480                          9.               9   .9070   .9986        2   .0009     -1.7598     4.1487      .2659      .6619      -.3925
                                                                                                  -.4121     1.0711     1.2210     -.0400
ELPHEXA     481                          9.               9   .5571   .9547        2   .0452     -1.2943     3.8721     -.5065      .5958       .2999
                                                                                                  1.0202      .5775    -1.9969     -.1525
ELPHEXA     482                          9.               9   .9996   .9996        2   .0004     -2.0013     4.0588     -.7345      .0661       .0163
                                                                                                   .9947      .2399      .4775      .2060
ELPHEXA     483                          9.               9   .9938   .9999        2   .0001     -2.0288     4.2914     -.7824     -.0428      -.1096
                                                                                                  1.4042     -.1860      .7621      .2466
ELPHEXA     484                          9.               9   .9949   .9994        2   .0005     -1.9914     3.8795     -.6330     -.0099       .0081
                                                                                                   .8098      .7947      .6843     -.6880
ELPHEXA     485                          9.               9   .9393 1.0000         2   .0000     -2.0180     4.3296     -.7110     -.3297      -.2337
                                                                                                  1.5837     -.0350     1.0953     -.9504
ELPHEXA     486                          9.               9   .9543 1.0000         2   .0000     -2.0195     4.3488     -.7638     -.2682      -.1820
                                                                                                  1.6209      .0143     1.0748     -.7285
ELPHEXA     487                          9.               9   .9959   .9999        2   .0001     -1.9635     4.2640     -.7610     -.2563      -.0665
                                                                                                  1.3138     -.1157      .3874     -.4815
ELPHEXA     488                          9.               9   .9854   .9895        2   .0103     -2.1513     3.5650      .0402     -.2928       .0920
                                                                                                   .3520      .9018     -.3446     -.0562
ELPHEXA     489                          9.               9   .7006   .8743        2   .1222     -2.1639     3.1338      .0984      .1629       .3149
                                                                                                  -.3629     1.5959     -.5343      .6801
ELPHEXA     490                          9.               9   .9489   .9889        2   .0108     -2.1827     3.4777     -.6700      .5297       .7849
                                                                                                  -.3797      .8064     -.0596      .2462
ELPHEXA     491                          9.               9   .9914   .9999        2   .0001     -2.0133     4.1161     -.6971     -.1175      -.0960
                                                                                                  1.2237      .3923      .9267     -.6363
ELPHEXA     492                          9.               9   .9983   .9988        2   .0012     -2.0314     3.8355     -.6631      .3175       .0617
                                                                                                   .6366      .5627      .5469      .6353
ELPHEXA     493                          9.               9   .7265   .9850        3   .0090     -1.6014     3.3922     -.5827      .2767      -.5043
                                                                                                 -1.1362     -.4613     -.2025     1.8045
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          CASE       MIS            ACTUAL         HIGHEST PROBABILITY      2ND HIGHEST
SUBFILE  SEQNUM      VAL    SEL      GROUP         GROUP P(X/G) P(G/X)      GROUP P(G/X)   DISCRIMINANT SCORES
ELPHEXA    494                         9.              9  .9971  .9952          2  .0046      -1.9729     3.5600     -.5205      .2337      .1229
                                                                                               .1276      .9395      .1321     -.0946
ELPHEXA    495                         9.              9  .9845  .9998          2  .0002      -1.9709     4.1111     -.7194     -.2172     -.0316
                                                                                              1.1892      .4732      .6530     -.9623
ELPHEXA    496                         9.              9  .9496  .9962          2  .0038      -1.9905     3.7904     -.7596      .4805      .2624
                                                                                               .4136      .5085     -.1071     1.4339
ELPHEXA    497                         9.              9  .9965  .9999          2  .0001      -1.9773     4.2641     -.7494     -.2286     -.0918
                                                                                              1.3221     -.1462      .4755     -.3932
ELPHEXA    498                         9.              9  .9988  .9988          2  .0012      -2.0201     3.8345     -.6701      .2919      .0800
                                                                                               .6281      .5853      .4757      .5522
ELPHEXA    499                         9.              9  .9887  .9999          2  .0001      -2.0187     4.3193     -.8699      .0221     -.0113
                                                                                              1.4510     -.0864      .6525      .5025
ELPHEXA    500                         9.              9  .9961  .9986          2  .0014      -2.0073     3.8547     -.7379      .3279      .1609
                                                                                               .6587      .6693      .3620      .7026
ELPHEXA    501                         9.              9  .9964  .9994          2  .0006      -2.0036     3.9030     -.6889      .0863      .0523
                                                                                               .8616      .8321      .7254     -.3402
ELPHEXA    502                         9.              9  .9591 1.0000          2  .0000      -2.0394     4.3730     -.8152     -.1546     -.1498
                                                                                              1.6786      .0367     1.1636     -.3239
ELPHEXA    503                         9.              9  .7340  .9524          2  .0463      -1.9681     3.3063     -.5821      .7052      .3996
                                                                                              -.4221     1.2351     -.4370     1.3409
ELPHEXA    504                         9.              9  .9787  .9999          2  .0001      -1.9265     4.2284     -.6921     -.4388     -.0993
                                                                                              1.2244     -.1312      .2069    -1.1253
ELPHEXA    505                         9.              9  .9481 1.0000          2  .0000      -1.9418     4.5031     -.8696     -.4433     -.0825
                                                                                              1.7066     -.4136      .3460     -.6777
ELPHEXA    506                         9.              9  .9954  .9998          2  .0002      -1.8004     4.2993     -.2697     -.2724     -.2200
                                                                                               .5670      .3678      .5032     -.9842
ELPHEXA    507                         9.              9  .9912  .9939          2  .0060      -1.9407     3.5795     -.6031      .2288      .2380
                                                                                               .1453     1.0651     -.1053     -.0754
ELPHEXA    508                         9.              9  .9978  .9990          2  .0010      -1.9774     3.9886     -.7453      .1860      .1139
                                                                                               .7341      .0785     -.0200      .8227
ELPHEXA    509                         9.              9  .9978  .9987          2  .0013      -2.0217     3.8424     -.6908      .3193      .0992
                                                                                               .6440      .6032      .4741      .6532
ELPHEXA    510                         9.              9  .9999  .9987          2  .0013      -1.9877     3.7995     -.5990      .1209      .0402
                                                                                               .5428      .5610      .3246     -.0541
ELPHEXA    511                         9.              9  .9993  .9995          2  .0005      -1.9699     4.0718     -.7978      .0427      .1113
                                                                                              1.0005      .3456      .2555      .1545
ELPHEXA    512                         9.              9  .9627  .9950          2  .0050      -2.0173     3.6323     -.6868      .5426      .2466
                                                                                               .2907     1.0398      .3011     1.0168
ELPHEXA    513                         9.              9  .9935  .9987          2  .0013      -2.0315     3.8558     -.7206      .3739      .1195
                                                                                               .6753      .6186      .5151      .8699
ELPHEXA    514                         9.              9  .7650  .9930          2  .0036      -1.7232     3.9000      .3518      .7032     -.2958
                                                                                              -.8576     1.4727      .9039     -.3241
ELPHEXA    515                         9.              9  .9993  .9998          2  .0002      -1.8523     4.3237     -.2942      .1053     -.2467
                                                                                               .6438      .3192      .7967     -.3755
ELPHEXA    516                         9.              9  .9997  .9996          2  .0004      -1.9669     4.0136     -.6362     -.1406     -.0486
                                                                                               .8887      .1922      .3288     -.5320
ELPHEXA    517                         9.              9  .7319 1.0000          2  .0000      -2.1511     4.4258     -.8687      .2287     -.2064
                                                                                              1.8444     -.0669     1.7943      .9890
ELPHEXA    518                         9.              9  .4846  .9999          2  .0001      -2.4301     2.9001    -2.2853    -1.2832    -1.6123
                                                                                              1.4730      .3309      .5789      .3927
ELPHEXA    519                         9.              9  .3245  .9996          2  .0003      -2.2924     2.5998    -2.1452    -1.6127    -1.4644
                                                                                               .8665      .8291     -.3414    -1.1628
ELPHEXA    520                         9.              9  .5139  .9980          2  .0014      -2.2282     2.4419    -1.6391     -.9476    -1.6140
                                                                                              -.1404     1.5649      .2370     -.4518
ELPHEXA    521                         6.              6  .0025  .9734          3  .0247       2.1254     -.8888     1.0652     3.6218    -2.5560
                                                                                              -.8540    -1.7557      .0847    -1.4842
ELPHEXA    522                         6.              6  .0002  .9383          3  .0407       2.0518      .0090      .4112     3.8794    -2.3745
                                                                                              -.9090    -3.0680     -.7118    -1.6570

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          CASE         MIS            ACTUAL            HIGHEST PROBABILITY        2ND HIGHEST
SUBFILE SEQNUM         VAL   SEL       GROUP           GROUP P(X/G)  P(G/X)      GROUP P(G/X)   DISCRIMINANT SCORES
ELPHEXA    523                        6.                6  .0043   .6330        2  .2042       1.5556    -.6435    1.5112    3.5660   -1.7495
                                                                                              .3697  -1.2845   -1.0216     -.5281
ELPHEXA    524                        4.                4  .0226   .9928        3  .0067       -.0762   -1.3842    3.9616    -.1917     .2351
                                                                                           -1.9977  -2.5984   -1.6587   -1.2402
ELPHEXA    525                        6.                6  .5030  1.0000        5  .0000       5.9188    -.6621    -.3452    1.4294     .0772
                                                                                            1.5463    -.6708    -.8634    1.9749
ELPHEXA    526                        8.                8  .2992   .9973        2  .0026       -.7400    1.1361   -2.9245    2.2394    2.2092
                                                                                             -.6246    -.5300   -1.3699     .3297
ELPHEXA    527                        8.                6  .2687   .9999        2  .0001       -.8615     .0350   -2.6874    3.6831    2.2473
                                                                                             -.1055     .4496    1.2081     .3165
ELPHEXA    528                        4.                4  .2876   .9992        3  .0006      -1.1017   -1.1182    4.1458     .1336     .6058
                                                                                           -1.6286    -.7332    1.6891   -1.1950
ELPHEXA    529                        8.                8  .0999   .9999        2  .0001        .1830    -.4663   -2.6082    3.4747    1.9785
                                                                                             -.8845   -1.1168   -2.3650     .2515
ELPHEXA    530                        8.                8  .0737   .7263        2  .2702      -1.0344    1.2734   -2.1313    1.8888    2.9336
                                                                                              .5657     .0741   -1.0895    -.6717
ELPHEXA    531                        4.                4  .7881   .9971        2  .0028      -1.4040    -.8736    3.9510     .4600    1.6022
                                                                                             -.6479    -.0356     .5457    -.7287
ELPHEXA    532                        6.                6  .7678   .9997       10  .0003       5.5295    -.3894     .9013    1.3385    1.0031
                                                                                            1.8094    -.3268    -.1613     .4084
ELPHEXA    533                        8.                8  .1989   .9965        2  .0034       -.6530    1.0914   -2.8727    1.9295    2.2430
                                                                                             -.7608    -.4591   -1.8560    -.7355
ELPHEXA    534                        8.                6  .0815   .9980        2  .0019       -.7932    1.5992   -3.0264    3.1618    2.7112
                                                                                             -.2509    -.0036   -1.1506     .1991
ELPHEXA    535                        6.                6  .2546   .9963       10  .0037       5.4361    -.4611     .2457    1.0131    1.4123
                                                                                            2.7198     .2927    -.2166    -.2969
ELPHEXA    536                        8. ***            9  .0113   .5414        8  .4313      -2.3623    1.8338   -2.5335     .1590    2.6087
                                                                                           -1.5261    -.1566    1.0471    1.0196
ELPHEXA    537                        8.                8  .0583   .8693        2  .1302       -.7074    1.2429   -2.3103    2.6235    2.3299
                                                                                             -.2973    1.0011   -2.0347     .0652
ELPHEXA    538                        6.                6  .1998   .8071       10  .1929       4.8586    -.9097    1.4707     .6632     .4686
                                                                                            1.3103    1.2952    1.8113     .9620
ELPHEXA    539                        6.                6  .8391   .9999       10  .0001       5.5586    -.6787     .5802    1.2639    -.5181
                                                                                             -.4566     .2549    1.6682     .8657
ELPHEXA    540                        8.                8  .7700  1.0000        1  .0000      -1.6918    -.2761   -4.5853     .2757     .6389
                                                                                           -1.2976    -.6030    -.7164     .5795
ELPHEXA    541                        6.                6  .6984   .9922       10  .0078       5.1892    -.0733     .3866    1.1876     .1379
                                                                                            1.4269     .8342    1.7865    -.0543
ELPHEXA    542                        4.                4  .9105   .9927        2  .0072      -1.5712   -1.1125    3.4531     .5357    1.9054
                                                                                             -.2372    -.0840     .3013     .2647
ELPHEXA    543                        6.                6  .2639   .8810       10  .1190       5.8429    -.7008    2.0564     .8851     .6149
                                                                                              .9963    1.3316   -1.3574    -.5259
ELPHEXA    544                        4.                4  .7693   .9759        2  .0225      -1.8753   -1.1118    2.4391    -.0413    2.2032
                                                                                            1.4915    -.7836     .2773     .3713
ELPHEXA    545                        6.                6  .7714   .9981       10  .0019       6.1066     .1240    1.0621    1.3072     .1275
                                                                                            1.1304     .6896    -.9360   -1.2519
ELPHEXA    546                        6.                6  .2213   .9401       10  .0599       3.2618     .0253     .9649    1.3635    -.2558
                                                                                              .9673    1.3118    2.8449    -.8298
ELPHEXA    547                        4.                4  .4796   .9329        2  .0670      -1.0546   -1.2571    3.1833     .7899    2.2590
                                                                                              .8112    -.0562   -1.7736    -.1149
ELPHEXA    548                        6.                6  .9391  1.0000       10  .0000       6.3039     .7786     .0201    2.6158    -.2305
                                                                                            1.0288     .4357    -.2966    -.7065
ELPHEXA    549                        6.                6  .4032   .9993       10  .0007       5.7943    -.2525    -.0500    1.5418     .8101
                                                                                            2.2439     .9428   -1.2638     .1833
ELPHEXA    550                        8.                8  .5445  1.0000        1  .0000       -.4907   -1.6605   -3.8796    2.8543    1.0778
                                                                                             -.3893    1.1169   -2.1600    -.1335
ELPHEXA    551                        6.                6  .6978   .9992       10  .0008       5.4888     .0007    1.0695    1.1924     .7584
                                                                                            1.6132    -.1427   -1.2775    -.0724
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        CASE         MIS          ACTUAL              HIGHEST PROBABILITY       2ND HIGHEST
SUBFILE SEQNUM       VAL   SEL    GROUP               GROUP P(X/G) P(G/X)       GROUP P(G/X)   DISCRIMINANT SCORES
ELPHEXA     552                     6.                    6  .9548 1.0000         10  .0000     6.4969      .1767      .7771     2.1570     -.9180
                                                                                                -.6344     -.1811     -.9018      .2217
ELPHEXA     553                     8.                    8  .9684 1.0000          1  .0000     -.6766    -1.9048    -4.5102     1.7546      .3643
                                                                                              -1.2696     -.4549     -.5303      .5358
ELPHEXA     554                     6.                    6  .2502  .5126         10  .4874     4.8368     -.7111     1.6831      .9698      .9851
                                                                                                 .4594     1.3722     1.6643      .6586
ELPHEXA     555                     6.                    6  .1567  .5755         10  .4239     5.1330     -.0893     1.8517     -.2849      .3491
                                                                                                -.6141      .8901    -1.0253     1.2890
ELPHEXA     556                     4.                    4  .0999  .9737          2  .0259     -.2233    -2.3990     3.0400     1.9757     1.9264
                                                                                               1.6574     -.5411    -1.5086     -.2780
ELPHEXA     557                     6.                    6  .2851  .9999         10  .0001     5.7225     -.5349      .0349     2.0784      .8635
                                                                                               1.6853      .7886    -1.2972     1.7748
ELPHEXA     558                     8.                    8  .8845 1.0000          1  .0000    -1.1931    -1.6555    -4.1820     2.6378     1.0189
                                                                                                -.7134     1.2900      .0877      .9382
ELPHEXA     559                     4.                    4  .2306  .9283          2  .0715    -2.7477     -.2571     2.6543     -.7662     2.6327
                                                                                                 .0595     -.1973     -.2101     1.8769
ELPHEXA     560                     9.                    9  .9669  .9996          2  .0003    -1.7382     4.3788      .1831      .4477     -.4347
                                                                                                -.0363      .7477     1.1955     -.3388
ELPHEXA     561                     9.                    9  .9959  .9997          2  .0003    -2.0389     4.0830     -.7705      .2145      .0156
                                                                                               1.0626      .2227      .6794      .7209
ELPHEXA     562                     9.                    9  .9884  .9999          2  .0001    -2.0807     4.2426     -.6005     -.0877     -.3442
                                                                                               1.3428     -.4359     1.1718      .0166
ELPHEXA     563                     9.                    9  .9925  .9999          2  .0001    -2.0292     4.1279     -.7170     -.0495     -.0917
                                                                                               1.2556      .3895     1.0099     -.3989
ELPHEXA     564                     9.                    9  .9761  .9997          2  .0003    -2.0393     4.0871     -.7389      .3274     -.0661
                                                                                               1.1002      .1216      .9955     1.0874
ELPHEXA     565                     9.                    9  .7877 1.0000          2  .0000    -2.0681     4.5877     -.8118     -.3155     -.3287
                                                                                               2.0553     -.4410     1.4842     -.4807
ELPHEXA     566                     9.                    9  .4694 1.0000          2  .0000    -1.7949     4.3736    -1.2008    -1.0012     -.9669
                                                                                               1.5922    -2.1897     1.0998     -.1920
ELPHEXA     567                     9.                    9  .9989  .9998          2  .0002    -1.8787     4.3162     -.2504      .1352     -.3170
                                                                                                 .6453      .2396      .9779     -.2938
ELPHEXA     568                     9.                    9  .9996  .9999          2  .0001    -1.8394     4.4592     -.2916      .0023     -.3206
                                                                                                 .7324     -.3051      .5131     -.1288
ELPHEXA     569                     9.                    9  .9985  .9998          2  .0002    -1.8091     4.3496     -.3358      .2579     -.2412
                                                                                                 .7147      .3083      .9915      .1559
ELPHEXA     570                     9.                    9  .9968  .9996          3  .0002    -1.5858     3.9060     -.6877     -.3152     -.7399
                                                                                                -.1534    -1.0002      .3007      .4218
ELPHEXA     571                     9.                    9  .6913  .7977          3  .1757    -1.5249     2.9495     -.3797      .1380     -.4022
                                                                                              -1.8120      .5214     -.4808      .2690
ELPHEXA     572                     9.                    9  .9625  .9966          2  .0028    -1.7015     3.8262     -.1204      .1929     -.0579
                                                                                                -.2457     1.1170      .1782     -.9282
ELPHEXA     573                     9.                    9  .9862  .9999          2  .0001    -1.5813     4.1453     -.7824     -.4668     -.7872
                                                                                                 .2501    -1.3359      .3697      .3383
ELPHEXA     574                     9.                    9  .8731  .9979          2  .0011    -1.6853     4.1095      .3130      .3939     -.3663
                                                                                                -.5304     1.1290      .8068     -.9623
ELPHEXA     575                     9.                    9  .8954  .9998          2  .0001    -1.5824     4.0880     -.8082     -.2577     -.6992
                                                                                                 .0287    -1.5177      .0040     1.2618
ELPHEXA     576                     9.                    9  .9211  .9655          3  .0276    -1.5864     3.7926     -.4283      .1290     -.5610
                                                                                              -1.3625      .0487      .0045      .6461
ELPHEXA     577                     9.                    9  .8230 1.0000          2  .0000    -1.7519     4.0893    -1.2086     -.6992     -.7066
                                                                                                 .9621    -1.8932      .3347      .6500
ELPHEXA     578                     1.                    1  .9917  .9986          4  .0010     -.8362    -1.9041     -.1175     -.5885    -2.0549
                                                                                                 .6150      .5728     -.0538      .0131
ELPHEXA     579                     9.                    9  .9953  .9985          3  .0008    -1.5831     3.6969     -.6848     -.0854     -.5932
                                                                                                -.5038     -.5650      .1376      .8075
ELPHEXA     580                     9.                    9  .9942  .9991          3  .0006    -1.5330     3.7058     -.5472     -.4999     -.7651
                                                                                                -.3911     -.4518      .3946     -.8553
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         CASE        MIS          ACTUAL          HIGHEST PROBABILITY       2ND HIGHEST
SUBFILE SEQNUM       VAL   SEL    GROUP           GROUP P(X/G) P(G/X)       GROUP P(G/X)    DISCRIMINANT SCORES
ELPHEXA   581                      9.                9  .9934   .9996          3  .0002      -1.6091    3.8761    -.5834    -.3596    -.8681
                                                                                            -.1961   -1.1345    .4978     .2270
ELPHEXA   582                      9.                9  .9761   .9999          3  .0000      -1.5953    4.1126    -.6781    -.5385    -.9062
                                                                                             .1966   -1.4573    .5116     .0522
ELPHEXA   583                      9.                9  .9957   .9992          3  .0006      -1.5724    3.7049    -.5280    -.4639    -.8036
                                                                                            -.3813    -.4976    .5204    -.7423
ELPHEXA   584                      9.                9  .9969   .9999          3  .0001      -1.6115    3.9643    -.6418    -.4679    -.8746
                                                                                             .0859    -.8754    .8363    -.3204
ELPHEXA   585                      9.                9  .9995   .9994          3  .0004      -1.6142    3.7368    -.5823    -.2835    -.7902
                                                                                            -.2963    -.5030    .7371    -.1116
ELPHEXA   586                      9.                9  .9197   .9589          3  .0329      -1.5519    3.1922    -.4566     .0589    -.4984
                                                                                           -1.3837     .1245   -.2158     .4223
ELPHEXA   587                      9.                9  .9692   .9999          3  .0001      -1.5687    4.0937    -.6474    -.6491    -.9107
                                                                                             .1451   -1.4501    .3714    -.3335
ELPHEXA   588                      9.                9  .9957   .9996          3  .0002      -1.5928    3.8847    -.6217    -.3661    -.8134
                                                                                            -.1895   -1.0744    .3794     .2218
ELPHEXA   589                      9.                9  .9835   .9929          3  .0054      -1.6128    3.4134    -.4442    -.0178    -.7181
                                                                                            -.9758    -.4069    .3004     .5451
ELPHEXA   590                      9.                9  .9838   .9999          2  .0001      -1.9917    4.0965    -.6604    -.2203    -.1117
                                                                                            1.1738     .3866    .8194    -.9983
ELPHEXA   591                      9.                9  .9685   .9999          2  .0000      -1.6230    4.1229    -.6833    -.4519    -.9282
                                                                                             .2324   -1.4908    .6727     .3457
ELPHEXA   592                      9.                9  .9813   .9999          2  .0000      -1.5978    4.1371    -.7451    -.4588    -.8411
                                                                                             .2444   -1.3954    .4886     .3491
ELPHEXA   593                      9.                9  .9194   .9673          3  .0265      -1.6025    3.1880    -.4017     .1472    -.6038
                                                                                           -1.3616     .0003    .1148     .6959
ELPHEXA   594                      9.                9  .8697   .9145          3  .0644      -1.7755    3.0385     .1944    -.3705    -.5809
                                                                                           -1.2724     .5752   -.1649     .1541
ELPHEXA   595                      9.                9  .9882   .9997          2  .0002      -1.6193    3.9366    -.7456    -.1549    -.7148
                                                                                            -.0755    -.9906    .4668     .9862
ELPHEXA   596                      9.                9  .9348   .9983          3  .0015      -1.4429    4.0756    -.1620    -.1717   -1.0323
                                                                                            -.7943   -1.2185    .3477     .3623
ELPHEXA   597                      9.                9  .9533   .9947          3  .0038      -1.5482    3.5722    -.5512    -.1533    -.6305
                                                                                            -.8740    -.8521   -.3510     .7298
ELPHEXA   598                      9.                9  .9407   .9998          3  .0001      -1.5510    4.0487    -.7155    -.4201    -.7715
                                                                                            -.0584   -1.5783   -.0703     .6751
ELPHEXA   599                      9.                9  .9397   .9999          3  .0001      -1.5865    4.0689    -.5623    -.6893   -1.0141
                                                                                             .1087   -1.5579    .5244    -.5054
ELPHEXA   600                      9.                9  .9778   .9999          3  .0001      -1.5649    4.1053    -.6862    -.6184    -.8678
                                                                                             .1666   -1.4069    .3269    -.2134
ELPHEXA   601                      9.                9  .9280   .9999          2  .0001      -1.7050    3.8693   -1.0514    -.4712    -.6201
                                                                                             .6004   -1.5233    .2901    1.0108
ELPHEXA   602                      9.                9  .8868  1.0000          2  .0000      -1.5915    4.3473    -.7587    -.7032    -.9681
                                                                                             .5915   -1.8077    .5925    -.0814
ELPHEXA   603                      9.                9  .9279   .9999          2  .0000      -1.6502    4.1602    -.7569    -.2641    -.8908
                                                                                             .3250   -1.4709    .8511    1.0096
ELPHEXA   604                      9.                9  .9706   .9966          3  .0031      -1.4408    3.9169    -.1122    -.1691    -.9963
                                                                                            -.9355    -.6243    .5717    -.2449
ELPHEXA   605                      9.                9  .5856  1.0000          2  .0000      -1.7258    4.2982   -1.2357    -.9868    -.8004
                                                                                            1.2952   -2.2646    .3137     .0800
ELPHEXA   606                      9.                9  .9931   .9996          3  .0002      -1.5995    3.8668    -.5654    -.4072    -.8768
                                                                                            -.2194   -1.1388    .4510     .0591
ELPHEXA   607                      9.                9  .9743   .9998          3  .0001      -1.6605    3.9107    -.6371    -.1517    -.8649
                                                                                            -.1002   -1.1540    .7720     .9499
ELPHEXA   608                      9.                9  .9509   .9999          3  .0001      -1.5745    4.0764    -.5935    -.6906    -.9707
                                                                                             .1156   -1.5107    .4358    -.4964
ELPHEXA   609                      4. ***            1  .9811   .9585          4  .0310      -1.1841   -2.4008     .7748    -.7222   -1.0186
                                                                                            -.8803    -.3068    .0089    -.6079

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          CASE          MIS           ACTUAL          HIGHEST PROBABILITY      2ND HIGHEST
SUBFILE  SEQNUM         VAL   SEL      GROUP          GROUP P(X/G) P(G/X)      GROUP P(G/X)   DISCRIMINANT SCORES
ELPHEXA     610                        6. ***            2  .0015   .6167          6  .1897      1.2554      -.5754       .5008      2.8247     -1.5243
                                                                                               2.3632   -1.7909     -.6497   -1.1842
ELPHEXA     611                        4.                4  .1865   .9817          1  .0128       .2696     -1.9498      2.6727      2.1630      -.7170
                                                                                               -.0899    -.8126     1.6414     .2052
ELPHEXA     612                        4.                4  .1550   .9946          3  .0024       .2362     -1.4474      3.0016      2.0137      -.5406
                                                                                               -.5782   -1.9115     1.4501    -.6953
ELPHEXA     613                        4.                4  .1233   .9898          2  .0084     -1.1131     -2.5487      2.4143      1.6372      1.8927
                                                                                               1.7536   -1.2517      .5122    1.6375
ELPHEXA     614                        6.                6  .5721 1.0000         10  .0000      5.7186       .0071       .6346      2.3463     -1.1271
                                                                                              -1.0847      .3725     2.1026     .9827
ELPHEXA     615                        4.                4  .0936   .9950          1  .0020       .2006     -1.4832      2.9426      2.1261      -.5150
                                                                                               -.3391   -1.0863     2.3122   -1.1010
ELPHEXA     616                        4. ***            3  .3355   .7566          4  .2135      -.3938       .3674      2.3176      1.9731      -.6020
                                                                                              -2.2329     -.4331      .6478    -.8600
ELPHEXA     617                        8.                8  .9755 1.0000          1  .0000      -.8990     -2.0462     -4.4883      1.8588       .4040
                                                                                              -1.3635      .1322     -.1755     .2828
ELPHEXA     618                        6.                6  .5514 1.0000         10  .0000      3.5551      -.2419       .1521      2.0839      -.8458
                                                                                               -.6954      .3046     1.8506    1.8370
ELPHEXA     619                        4.                4  .3263   .9976          1  .0016      -.5030     -2.6766      2.9545      1.3460      1.0117
                                                                                               -.1794   -1.9669      .2670    1.0336
ELPHEXA     620                        6.                6  .9439 1.0000         10  .0000      5.5014      -.0145      -.3909      1.2281      -.7317
                                                                                                .5504     -.1946     1.5576     .2828
ELPHEXA     621                        4. ***            1  .5188   .9956          4  .0034      -.5876     -3.7229       .0258       .8530     -1.0063
                                                                                                .5275     -.8293      .3690    1.3245
ELPHEXA     622                        4.                4  .1611   .9930          2  .0069      -.1057     -2.1741      3.6201      1.9561      1.4913
                                                                                               1.2495     -.6422     -.9240   -1.1181
ELPHEXA     623                        4.                4  .0474   .9738          3  .0193       .3786     -1.0140      2.6741      2.1923      -.8980
                                                                                               -.7845   -1.5689     1.2951   -2.1370
ELPHEXA     624                        6.                6  .9671 1.0000         10  .0000      6.3196      -.2172       .3291      2.2710      -.5910
                                                                                               -.3508      .3475     -.8496     .7276
ELPHEXA     625                        6.                8  .9338 1.0000          1  .0000      -.9091     -2.1855     -4.4828      1.9449       .4726
                                                                                              -1.4607      .7525      .0949    -.0244
ELPHEXA     626                        6. ***           10  .3639   .8586          6  .1410      4.4527      1.0949       .9159       .6765       .4185
                                                                                               -.2561     1.6045     1.6249    1.5120
ELPHEXA     627                        6.                6  .9660 1.0000         10  .0000      6.6726       .2724       .1230      2.6138      -.8586
                                                                                               -.5531      .1495     -.1045    -.2191
ELPHEXA     628                        4.                4  .0810   .8405          2  .1593     -2.6893      -.4350      2.5216      -.5526      2.9712
                                                                                               -.2649      .4480     -.7797    2.2671
ELPHEXA     629                        4. ***            5  .0000   .4730         10  .3069      3.6693      -.9100       .0374       .2993      3.6798
                                                                                              -3.7632      .3531     1.7806     .8122
ELPHEXA     630                        4.                4  .0190   .9907          3  .0041       .1677     -2.0435      3.0050      2.9924      -.1905
                                                                                              -1.5133     -.7354     1.5296    1.4320
ELPHEXA     631                        6. ***            3  .0167   .9269         10  .0526      4.1019      2.5809       .0606       .1301       .2282
                                                                                              -3.0477      .4279     1.2543    1.4218
ELPHEXA     632                        6.                6  .9072 1.0000         10  .0000      6.0306      -.6193       .2452      1.6776      -.2068
                                                                                                .8062     -.3352     -.3991    1.6543
ELPHEXA     633                        6.                6  .9043 1.0000         10  .0000      6.5582       .8154       .0465      2.3704     -1.2516
                                                                                                .5621     -.5987     1.1845    -.4415
ELPHEXA     634                        7.                7  .0000 1.0000          5  .0000      4.7737      4.7370     -3.4933     -4.0327      2.3799
                                                                                                .8023   -2.9099     1.3270   -3.6454
ELPHEXA     635                        7.                7  .5931 1.0000          9  .0000      3.1252      4.5245     -1.4329     -3.0365       .2401
                                                                                                .4228     -.8042     1.0239    -.1838
ELPHEXA     636                        7.                7  .5138 1.0000          9  .0000      3.1026      4.5097     -1.3718     -3.0366       .1562
                                                                                                .4081     -.8954     1.1920    -.2106
ELPHEXA     637                        6.                6  .9779 1.0000         10  .0000      6.5874       .5028       .1302      2.6138     -1.0972
                                                                                               -.1133     -.4108      .5528     .1639
ELPHEXA     638                        6.                6  .9658 1.0000         10  .0000      6.5991       .5872       .0709      2.4658     -1.0888
                                                                                                .1529     -.1312      .8078    -.5171

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        CASE       MIS         ACTUAL          HIGHEST PROBABILITY    2ND HIGHEST
SUBFILE SEQNUM     VAL   SEL   GROUP           GROUP P(X/G) P(G/X)    GROUP P(G/X)   DISCRIMINANT SCORES
ELPHEXA   639                    6.              6  .1627  .9963       10  .0037       4.9134    -.6918    1.7461     .6635      .3860
                                                                                       -.5712    -.5719    2.6605     .5777
ELPHEXA   640                    4.              4  .0002  .9534        1  .0283        .1336   -1.9377     .2339    2.0127     1.1015
                                                                                      -2.1661   -3.2881    1.8202   -2.3967
ELPHEXA   641                    6.              6  .9617 1.0000       10  .0000       5.4362     .0884     .8706    2.1175    -1.0512
                                                                                       -.4917     .4881     .0764    -.7545
ELPHEXA   642                    6.              6  .9365 1.0000       10  .0000       6.5143     .6838    -.4634    2.0370     -.8985
                                                                                        .9425   -1.1030    -.0050    -.2252
ELPHEXA   643                    6.              6  .9912 1.0000       10  .0000       6.4625     .2583     .7647    2.0925    -1.0025
                                                                                       -.3460    -.0116    -.3477    -.1983
ELPHEXA   644                    4. ***          3  .1179  .5599        4  .4349       -.2590    -.2294    2.3153     .9154    -1.0212
                                                                                      -2.2704   -2.3991     .9040    -.0211
ELPHEXA   645                    6.              6  .9997 1.0000       10  .0000       6.2875     .0662     .3299    1.9448     -.8335
                                                                                        .2714     .0731    -.1330    -.1926
ELPHEXA   646                    4. ***         10  .0004  .8805        5  .0556       4.3587    -.6632    3.5458   -1.7987     2.0365
                                                                                      -1.3957   -1.1104   -1.2834    -.2495
ELPHEXA   647                    6.              6  .7440 1.0000       10  .0000       6.5068     .8592    -.5559    2.0960     -.8969
                                                                                       1.1185   -1.6630    -.2215     .6079
ELPHEXA   648                    6.              6  .9795 1.0000       10  .0000       6.6450     .4784     .1498    2.4246    -1.0599
                                                                                       -.1936    -.3495     .2226    -.4815
ELPHEXA   649                    6.              6  .9831 1.0000       10  .0000       6.6368     .4901     .1239    2.4766    -1.0420
                                                                                       -.1667    -.3358     .2569    -.2953
ELPHEXA   650                    6.              6  .9232 1.0000       10  .0000       6.3715    -.2025     .2432    2.2123     -.4532
                                                                                       -.3537     .5037   -1.2052     .5673
ELPHEXA   651                    4.              4  .0174  .9894        2  .0057       1.0000   -1.4624    3.2982    2.1236     -.4370
                                                                                       -.2961   -2.0241   -1.0538   -2.1267
ELPHEXA   652                    4.              4  .0492  .9994        2  .0004        .4552   -2.3160    4.2418    1.7206      .4794
                                                                                       -.6807   -1.5056    -.8318   -1.5699
ELPHEXA   653                    6.              6  .0072  .9538        2  .0302       1.6939    -.7427     .8628    4.3957    -1.5957
                                                                                        .1771    -.5913    -.0894    -.1026
ELPHEXA   654                    7.              7  .5647  .9998        5  .0002       2.7744    2.8148   -2.8588   -4.1060    -1.0745
                                                                                       -.2112    -.0548     .0435     .3264
ELPHEXA   655                    6.              6  .6911 1.0000       10  .0000       6.6461    1.0146    -.0061    1.9303    -1.2588
                                                                                        .8404    -.8591     .7837   -1.5138
ELPHEXA   656                    4.              4  .5640  .9585        3  .0364       -.5911    -.5180    3.1733    1.0867     -.1054
                                                                                      -1.7701   -1.0423    1.1471    -.0663
ELPHEXA   657                    6.              5  .9468 1.0000       10  .0000       6.5555     .3279     .2463    2.6151    -1.1518
                                                                                       -.2709     .0851     .9567    -.4764
ELPHEXA   658                    6. ***          8  .0006  .9992        6  .0003       1.1598    -.8815   -1.5537    4.9201     1.1367
                                                                                      -1.4029   -1.6409    -.3346   -2.1403
ELPHEXA   659                    8.              8  .9718 1.0000        1  .0000      -1.2421   -1.7907   -3.7985    1.5839     1.1216
                                                                                        .1929     .9745     .5916    -.6276
ELPHEXA   660                    8.              8  .0892  .9961        2  .0037      -1.6140    1.1325   -2.6749    2.5867     2.8527
                                                                                      -1.1959     .9667     .0453    1.0455
ELPHEXA   661                    4. ***          2  .3706  .9506        4  .0334        .1591     .2297     .4781    2.5034     -.3476
                                                                                        .4880   -1.2569   -1.3547    1.0626
ELPHEXA   662                    4.              4  .8365  .9107        2  .0789       -.0935    -.3963    2.7527    1.3183      .2345
                                                                                       -.2532   -1.3282    -.7516    -.0706
ELPHEXA   663                    6.              6  .9751 1.0000       10  .0000       6.6324     .7394     .0090    2.3727    -1.0776
                                                                                        .2608    -.6641     .3569    -.2091
ELPHEXA   664                    6.              6  .0043 1.0000        7  .0000       6.6219    1.9026    -.1523    1.1954    -1.7233
                                                                                       2.3478   -2.4874    1.4392   -2.3793
ELPHEXA   665                    7.              7  .2888  .9998        5  .0002       2.4250    3.0500     .6295   -4.5376     1.4574
                                                                                       -.0951    -.8936    -.1641     .2963
ELPHEXA   666                    6.              6  .9558 1.0000       10  .0000       6.3117     .2569    -.7968    2.1011     -.7120
                                                                                       1.1788    -.7215     .2616     .0633
ELPHEXA   667                    6.              6  .0011  .9553        3  .0283       1.7489    -.8187     .2945    3.8219    -1.6971
                                                                                       -.4178   -2.8900    -.4838     .3566
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        CASE       MIS            ACTUAL          HIGHEST PROBABILITY      2ND HIGHEST
SUBFILE SEQNUM     VAL    SEL      GROUP          GROUP P(X/G) P(G/X)     GROUP P(G/X)  DISCRIMINANT SCORES
ELPHEXA      668                      7.               7 .2320   .9995        5  .0005     2.5507     3.3424     -.1407    -3.9721     1.5004
                                                                                          .2276    -1.1591      .6548     1.2023
ELPHEXA      669                      4.               4 .0466   .9959        1  .0019      .2124    -1.5375     3.0655     1.9375     -.6473
                                                                                         -.4486    -1.2093     2.3230    -1.7977
ELPHEXA      670                      1.               1 .0027   .7287        4  .2712    -2.0317    -3.6346      .2651    -1.0059     2.0950
                                                                                        -2.0122     -.3806      .9473    -2.0884
ELPHEXA      671                      8.               8 .7536   .9995        1  .0005    -1.2444    -2.7817    -3.4875     1.2896      .7412
                                                                                        -1.1669      .8394      .2464      .9756
ELPHEXA      672                      4. ***          10 .0005   .5725        6  .3373     4.4017    -1.8803     3.1912     -.7981     1.4914
                                                                                         -.7019     -.7829     2.3537     -.0811
ELPHEXA      673                      8.               8 .7502 1.0000        1  .0000    -1.9761     -.2286    -4.1127      .9662     1.2660
                                                                                         -.9833     1.6885     -.0107     -.3240
ELPHEXA      674                      4.               4 .5927   .6653        2  .3322     -.3336     -.2503     3.1173     2.1121      .9928
                                                                                         -.0526      .2850     -.9340      .2232
ELPHEXA      675                      6.               6 .9650 1.0000       10  .0000     6.4433      .2617     -.3812     2.6369     -.7576
                                                                                          .2793     -.4138      .1543      .9859
ELPHEXA      676                      8.               8 .1127   .9999        2  .0001      .1328     -.2070    -2.9123     3.4926     1.8868
                                                                                         -.4110    -1.5196    -1.9779      .7429
ELPHEXA      677                      6.               6 .2396 1.0000       10  .0000     6.3661      .8703      .4518     2.4307    -1.9342
                                                                                          .6197    -1.9021     2.3421      .1812
ELPHEXA      678                      6.               6 .9611 1.0000       10  .0000     6.6006      .2900      .1350     2.8111     -.9420
                                                                                         -.4772      .0372      .3289      .4397
ELPHEXA      679                      6.               6 .9752 1.0000       10  .0000     6.5038      .4082      .7026     1.9764     -.9831
                                                                                         -.2472     -.5331     -.8359      .0324
ELPHEXA      680                      6.               6 .8869 1.0000       10  .0000     6.5219      .6300     -.5067     2.2395     -.7844
                                                                                          .7226    -1.2556     -.4322      .6833
ELPHEXA      681                      8.               8 .2080   .9966        2  .0033     -.7563     1.0256    -2.7874     2.3171     2.1179
                                                                                         -.9375     -.8919    -1.5537      .7403
ELPHEXA      682                      7.               7 .6910 1.0000        5  .0000     3.6629     4.8853    -1.2108    -3.1343      .1817
                                                                                         1.2123    -1.9266    -1.5466    -1.2948
ELPHEXA      683                      4. ***           3 .1650   .5196        2  .4309      .6878      .1773     1.6191     2.8571    -1.1960
                                                                                         -.8294      .2441     -.9717      .2748
ELPHEXA      684                      7.               7 .1671 1.0000        9  .0000     3.8578     5.3900    -1.4610    -3.3308      .1349
                                                                                         2.0765    -2.5581    -1.3600    -1.0760
ELPHEXA      685                      7.               7 .3922 1.0000        5  .0000     3.6792     5.1226    -1.3094    -3.3159      .1502
                                                                                         1.6043    -2.2420    -1.5494    -1.4772
ELPHEXA      686                      7.               7 .9586 1.0000        3  .0000     3.6852     4.2251     -.5274    -3.0726      .4688
                                                                                          .3178     -.7803    -2.4039     -.4884
ELPHEXA      687                      7.               7 .9492 1.0000        3  .0000     3.6385     4.4427     -.5168    -3.1887      .2650
                                                                                          .7104    -1.2900    -1.9729     -.4974
ELPHEXA      688                      1.               1 .7311   .9653        2  .0201    -1.9038     -.4531     -.2247    -1.5956    -1.2155
                                                                                         -.1893     -.0876     -.4711     1.1469
ELPHEXA      689                      1.               1 .3346   .5557        8  .4431    -1.5536    -2.7361    -2.0061     -.0387      .9197
                                                                                        -1.1673     -.0654      .2105     -.3757
ELPHEXA      690                      5.               5 .8165 1.0000        7  .0000     2.5643     -.8785    -2.7137    -3.8713     1.9187
                                                                                        -1.0322      .2318      .1907      .4070
ELPHEXA      691                      5.               5 .7602 1.0000        7  .0000     2.6057     -.8973    -2.6960    -4.0114     1.9418
                                                                                        -1.0924      .2724     -.0448     -.0723
ELPHEXA      692                      5.               5 .0691   .9941        7  .0058     2.9374      .1080     -.3774    -3.9682     -.4607
                                                                                         -.0295      .2416      .2623      .7578
ELPHEXA      693                      5.               5 .4501   .9894        7  .0105     3.2350      .0046     -.3639    -4.1328     -.7518
                                                                                         -.4787     1.0642     -.2911      .5318
ELPHEXA      694                      5.               5 .3192 1.0000        7  .0000     2.6303     -.6452    -3.2068    -2.9503     1.8883
                                                                                        -1.5543      .8945     -.2060     1.3641
ELPHEXA      695                      5.               5 .1854 1.0000        7  .0000     2.3913     -.9967    -2.4352    -4.9844     2.6373
                                                                                         -.6554     -.7828     -.0771    -1.4381
ELPHEXA      696                      5.               5 .5117   .9999        7  .0001     2.8787     -.5638     -.3934    -4.5475     -.4250
                                                                                          .6016      .8537      .8086     1.4333
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       CASE          MIS              ACTUAL            HIGHEST PROBABILITY        2ND HIGHEST
SUBFILE SEQNUM      VAL    SEL        GROUP             GROUP P(X/G) P(G/X)        GROUP P(G/X)   DISCRIMINANT SCORES
ELPHEXA    697                          2.                  2  .2084   .7949           4  .1937      -1.9129      .7362      .7242     -.0319     1.0353
                                                                                                   -.2562  -1.5717    -.6469    2.7258
ELPHEXA    698                          2. ***              4  .5214   .4261           2  .2780       -.2154      .1014     1.5961     1.1093    -1.2656
                                                                                                   -.2491    .0959     .3345   -1.1771
ELPHEXA    699                          4.                  4  .2424   .9628           1  .0167       -.7860    -1.7376      .9223     1.3520     1.8764
                                                                                                  -2.0365    .1735    1.4775    -.1479
ELPHEXA    700                          3.                  3  .4138   .5257           4  .4234       -.0210     -.0875     2.8193     1.3590    -1.2213
                                                                                                  -1.3620    .1518     .5195     .0877
ELPHEXA    701                          4. ***              2  .7556   .7836           4  .2179      -1.3374     -.2279     1.0578     1.6941     1.2695
                                                                                                    .9637   -.3693    -.0512    1.7463
ELPHEXA    702                          6.                  6  .8601  1.0000          10  .0000       6.2509     -.6850      .7104     1.8795     -.2347
                                                                                                   -.2431    .0275    -.9825    1.4233
ELPHEXA    703                          4.                  4  .6596   .5724           2  .4196      -1.2143     -.6985     1.6134     1.1578     1.0891
                                                                                                   1.3724    .6738     .5460    1.4096
ELPHEXA    704                          3. ***              2  .6610   .9755           3  .0184       -.4380     1.1796      .2175      .6291     -.1390
                                                                                                    .3859   -.3805   -2.7753     .3263
ELPHEXA    705                          4.                  4  .7860   .6028           2  .3946      -1.3771     -.6435     1.4530     1.0252     1.5775
                                                                                                   1.2683   -.4571     .0100    1.2936
ELPHEXA    706                          6. ***              2  .0016   .6277           6  .2918       1.4710    -1.2878      .9257     4.0059     -.9922
                                                                                                    .0837   -.2774   -2.0432     .9554
ELPHEXA    707                          4.                  4  .7703   .9937           2  .0062      -1.6314    -1.2430     3.4765      .7485     1.9063
                                                                                                   -.2882    .4490     .8793     .3762
ELPHEXA    708                          1. ***              4  .8373   .7767           2  .1811      -1.4998      .5958     2.1558     -.4718      .3153
                                                                                                   -.5534   -.3868     .6399    1.2844
ELPHEXA    709                          2.                  2  .8557   .9724           4  .0243      -1.7345     1.0505      .6001      .8676     1.1879
                                                                                                    .4972    .5078     .0914    2.0458
ELPHEXA    710                          2.                  2  .9491   .9464           4  .0391      -1.5452     1.1900      .7768      .3653      .4351
                                                                                                   1.2267    .8191     .0585     .7904
ELPHEXA    711                          2.                  2  .8931   .8883           4  .0724      -1.2522      .7911      .3075     -.0507      .0444
                                                                                                    .4494   -.3693    -.0371    1.6334
ELPHEXA    712                          4.                  4  .6570   .8189           2  .1776      -1.3615     -.1860     1.5067      .2619     1.1819
                                                                                                   2.1447  -1.1509     .6028    -.7348
ELPHEXA    713                          6.                  6  .4390  1.0000          10  .0000       5.9047    -1.4866      .7429     1.6094      .1866
                                                                                                    .4380    .2049    -.0362    2.3980
ELPHEXA    714                          9. ***              3  .2331   .5771           2  .3715      -2.0285     1.9844     1.2421     -.8409      .0103
                                                                                                  -1.8002   1.6144    -.7687     .9815
ELPHEXA    715                          4.                  4  .6909   .7414           2  .2490      -1.1332     -.5235     1.6555      .3944      .8329
                                                                                                   1.9404   -.1227     .3873    -.4054
ELPHEXA    716                          4. ***              3  .7777   .6296           4  .2691      -1.2128      .9879     2.3558      .0343     -.1578
                                                                                                  -1.7659    .2101     .2495     .0267
ELPHEXA    717                          4.                  4  .6339   .5145           2  .4797      -1.1951     -.7513     1.5779     1.0776     1.0598
                                                                                                   1.4791    .0955     .2036    1.7495
ELPHEXA    718                          4.                  4  .8929   .6768           2  .1063      -1.7329      .3533     1.7584    -1.0194     1.0339
                                                                                                   -.5332  -1.0358    -.3640    -.1930
ELPHEXA    719                          4.                  4  .8528   .7323           2  .2440      -1.6186      .0813     1.8193     -.4600      .6608
                                                                                                   -.5461   -.0809     .0451    1.6109
ELPHEXA    720                          4. ***              2  .3760   .5000           4  .4934      -1.2499     -.8679     1.5575     1.3219     1.1102
                                                                                                   1.4213    .6787     .7250    1.9861
ELPHEXA    721                          4.                  4  .6198   .6336           2  .1923       -.7570    -1.3502     1.3173      .0153      .0515
                                                                                                   1.0340    .1515     .5334    1.8797
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      CASE          MIS           ACTUAL            HIGHEST PROBABILITY      2ND HIGHEST
SUBFILE SEQNUM      VAL    SEL     GROUP            GROUP P(X/G) P(G/X)     GROUP P(G/X)   DISCRIMINANT SCORES
ELPHEXA     697                     2.                2  .2084  .7949         4  .1937      -1.9129      -.7362       .7242      -.0319      1.0353
                                                                                           -.2562    -1.5717    -.6469     2.7258
ELPHEXA     698                     2. ***            4  .5214  .4261         2  .2780      -.2154       .1014      1.5961      1.1093     -1.2656
                                                                                           -.2491      .0959      .3345    -1.1771
ELPHEXA     699                     4.                4  .2424  .9020         1  .0167      -.7860     -1.7376       .9223      1.3520      1.8764
                                                                                          -2.0365      .1735     1.4775     -.1479
ELPHEXA     700                     3.                3  .4138  .5257         4  .4234      -.0210      -.0875      2.8193      1.3590     -1.2213
                                                                                          -1.3620      .1518      .5195      .0877
ELPHEXA     701                     4. ***            2  .7556  .7836         4  .2179     -1.3374      -.2279      1.0578      1.6941      1.2695
                                                                                            .9637     -.3693     -.0512     1.7463
ELPHEXA     702                     6.                6  .8601 1.0000        10  .0000      6.2509      -.6860       .7104      1.8795      -.2347
                                                                                           -.2431      .0275     -.9825     1.4233
ELPHEXA     703                     4.                4  .6596  .5724         2  .4196     -1.2143      -.6985      1.6134      1.1578      1.0891
                                                                                           1.3724      .6738      .5460     1.4096
ELPHEXA     704                     3. ***            2  .6610  .9755         3  .0184      -.4380      1.1796       .2175       .6291      -.1390
                                                                                            .3829     -.3805    -2.7753      .3263
ELPHEXA     705                     4.                4  .7860  .6028         2  .3946     -1.3771      -.6435      1.4530      1.0252      1.5775
                                                                                           1.2683     -.4571      .0100     1.2936
ELPHEXA     706                     6. ***            2  .0016  .6277         6  .2918      1.4710     -1.2878       .9257      4.0059      -.9922
                                                                                            .0837     -.2774    -2.0432      .3554
ELPHEXA     707                     4.                4  .7703  .9937         2  .0062     -1.6314     -1.2430      3.4765       .7485      1.9063
                                                                                           -.2882      .4490      .8793      .3762
ELPHEXA     708                     1. ***            4  .8373  .7767         2  .1811     -1.4998       .5958      2.1558      -.4718       .3153
                                                                                           -.5531     -.3868      .6399     1.2844
ELPHEXA     709                     2.                2  .6557  .9724         4  .0243     -1.7345      1.0505       .6001       .8676      1.1879
                                                                                            .4972      .5078      .0914     2.0458
ELPHEXA     710                     2.                2  .9491  .9464         4  .0391     -1.5452      1.1900       .7760       .3653       .4351
                                                                                           1.2267      .8191      .0585      .7904
ELPHEXA     711                     2.                2  .8931  .8883         4  .0724     -1.2522       .7911       .3075      -.0507       .0444
                                                                                            .4494     -.3693     -.0371     1.6354
ELPHEXA     712                     4.                4  .6570  .8189         2  .1776     -1.3615      -.1860      1.5067       .2619      1.1819
                                                                                           2.1447    -1.1509      .6028     -.7348
ELPHEXA     713                     6.                6  .4390 1.0000        10  .0000      5.9047     -1.4866       .7429      1.6094       .1866
                                                                                            .4386      .2049     -.0362     2.3980
ELPHEXA     714                     9. ***            3  .2331  .5771         2  .3715     -2.0285      1.9844      1.2421      -.8409       .0103
                                                                                          -1.8032     1.6144     -.7687      .9815
ELPHEXA     715                     4.                4  .6909  .7414         2  .2490     -1.1332      -.5235      1.6355       .3944       .8329
                                                                                           1.9404     -.1227      .3873     -.4054
ELPHEXA     716                     4. ***            3  .7777  .6296         4  .2691     -1.2128       .9879      2.3558       .0343      -.1578
                                                                                          -1.7659      .2101      .2495      .0267
ELPHEXA     717                     4.                4  .6339  .5145         2  .4797     -1.1951      -.7513      1.5779      1.0776      1.0598
                                                                                           1.4791      .0955      .2036     1.7495
ELPHEXA     718                     4.                4  .8929  .8768         2  .1063     -1.7329       .3533      1.7584     -1.0194      1.0339
                                                                                           -.5332    -1.0358     -.3640     -.1930
ELPHEXA     719                     4.                4  .8528  .7323         2  .2440     -1.6186       .0813      1.8193      -.4600       .6608
                                                                                           -.5461     -.0609      .0451     1.6109
ELPHEXA     720                     4. ***            2  .3760  .5000         4  .4934     -1.2499      -.8679      1.6575      1.3219      1.1102
                                                                                           1.4213      .5787      .7250     1.9861
ELPHEXA     721                     4.                4  .6198  .6336         2  .1923      -.7570     -1.3502      1.3173       .0153       .0515
                                                                                           1.0340      .1515      .3334     1.8797
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CLASSIFICATION RESULTS -

                         NO. OF    PREDICTED GROUP MEMBERSHIP
    ACTUAL GROUP         CASES           1          2          3          4          5          6          7          8          9
 --------------------   ------    --------   --------   --------   --------   --------   --------   --------   --------   --------

 GROUP       1            163          156          1          0          1          1          0          0          4          0
                                      95.7         .6          0         .6         .6          0          0        2.5          0

 GROUP       2             61            7         43          4          3          0          1          0          1          2
                                      11.5       70.5        6.6        4.9          0        1.6          0        1.6        3.3

 GROUP       3             51            1          3         36          1          4          0          4          0          0
                                       2.0        5.9       70.6        2.0        7.8          0        7.8          0          0

 GROUP       4            134           22         21          5         83          1          0          0          0          0
                                      16.4       15.7        3.7       61.9         .7          0          0          0          0

 GROUP       5             46            1          0          0          0         43          0          2          0          0
                                       2.2          0          0          0       93.5          0        4.3          0          0

 GROUP       6             69            0          2          1          0          0         63          0          1          0
                                         0        2.9        1.4          0          0       91.3          0        1.4          0

 GROUP       7             20            0          0          0          0          2          0         18          0          0
                                         0          0          0          0       10.0          0       90.0          0          0

 GROUP       8             67            2          0          0          0          0          0          0         64          1
                                       3.0          0          0          0          0          0          0       95.5        1.5

 GROUP       9            100            0          0          1          0          0          0          0          3         96
                                         0          0        1.0          0          0          0          0        3.0       96.0

 GROUP      10             10            0          0          0          0          0          0          0          0          0
                                         0          0          0          0          0          0          0          0          0
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                                NO. OF     PREDICTED GROUP MEMBERSHIP
    ACTUAL GROUP                CASES          10
 -------------------------     ------    ---------

 GROUP         1                163             0
                                                0

 GROUP         2                 61             0
                                                0

 GROUP         3                 51             2
                                              3.9

 GROUP         4                134             2
                                              1.5

 GROUP         5                 46             0
                                                0

 GROUP         6                 69             2
                                              2.9

 GROUP         7                 20             0
                                                0

 GROUP         8                 67             0
                                                0

 GROUP         9                100             0
                                                0

 GROUP        10                 10            10
                                            100.0

 PERCENT OF GROUPED CASES CORRECTLY CLASSIFIED -  84.80
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APPENDIX E: Specimen depositories.

Representative collections have been deposited with the following persons / departments: Ann Miller, Department of Geology, Dalhousie; Dr. S. W. Snyder, Department of Geology, East Carolina University, Greenville, N. Carolina, 27834; Dr. G. Vilks/Dr. C. Schafer, Atlantic Geoscience Centre, Bedford Institute of Oceanography, Dartmouth, N.S. B2Y 4A2; Dr. M. A. Buzas, Department of Paleobiology, U. S. N. M. Nat. History, Smithsonian Inst., Wash., D. C. 20560; Dr. C. W. Poag, U. S. G. S., Woods Hole, Mass., 02543; Prof. R. Feyling-Hanssen, Department of Micropaleotology, University of Åarhus, Universitesparken, DR-8000, Åarhus C. Denmark; Department Invert. Palaeo., R. O. M., 100 Queen's Park Blvd., Toronto, Ont., M5S 2C6; Dr. L. Osterman, INSTAAR, University of Colorado, R. B. #1, Boulder, Co., 80302; Miss Ruth Todd, P. O. Box 4687, Vineyard Haven, Mass., 02568; Dr. K. McDougall, U. S. G. S., 345 Middlefield Rd., Menlo Park, Ca., 94025; Dr. D.H. McNeil, Inst. of Sedimentary and Petroleum Geology, Geological Survey of Canada, Calgary, Alberta T2L 2A7; Prof. J.R. Haynes, Dept. of Geology, University College of Wales, Aberysthwyth, Cards., SY23 3DB, U.K.; Prof. J.W. Murray, Dept. of Geology, University of Exeter, Exeter, BX4 4QE, U.K.; and Dept. of Invertebrate Palaeontology, British Museum of Natural History, Cromwell Road, London, SW7 5BD, U.K.


Elphidium excavatum (Terquem) forma tumida Natland
Elphidium (Cellanthus) tumidum Natland PARKER et. al., 1953; TODD and BRÖNNIMANN, 1957; LEHMANN, 1957; PHLEGER, 1960b; SCOTT, 1976; SCOTT et. al., 1976. (II)
Elphidium tumidum Natland, 1938 (P)
Elphidium excavatum (Terquem) forma gunteri Cole
Elphidium oceanense (d'Orbigny) MURRAY, 1971, 1979; BOLTOVSKOY, 1977; APTHORPE, 1980
HANSEN and LYKKE-ANDERSEN, 1976; POAG, 1978. (nomen nudum) (UU)
Elphidium gunteri Cole KNUDSEN, 1971b, 1973b, 1979; ROSSET-MOULINIER, 1976; HANSEN and LYKKE-ANDERSEN, 1976; SNYDER and KATROSH, 1979.
Elphidium gunteri Cole forma typicum Poag, 1978 (BBB)
Elphidium waddense van Voorthuysen HAYNES, 1973
MURRAY, 1971 (VV)
Cribroelphidium (Elphidium) trinitatense Cushmann and Brönnimann, 1948; TODD and BRÖNNIMANN, 1957. (S)
Elphidium gunteri Cole CUSHMAN, 1939; PARKER et. al., 1953; PHLEGER, 1954, 1960a, 1960b; BANDY, 1956; LEHMANN 1957; VAN VOORTHUYSEN, 1957, 1960; LANKFORD, 1959; HAAKE, 1962; RICHTER 1964a; LÉVY, 1966; LÉVY et. al., 1969. (DD)
LÉVY, 1966; HANSEN and LYKKE-ANDERSEN, 1976 (UU)
VAN VOORTHUYSEN, 1957 (TT)
Elphidium littorale Le Calvez and Le Calvez, 1951 (X)
Elphidium guntheri (sic) Cole var. waddensis VAN VOORHUYSEN, 1951 (Y)
Elphidium oceanense (d'Orbigny) CUSHMAN, 1939 (FF)
Polystomella oceanensis Fornasini, 1904, ab d'Orbigny, 1826 Nomen dubium (A)
LEGEND
in synonomy with
uncertain affinity
errors
☆ a name erected by Bartlett, 1965b though never published by him subsequently published by others.
Elphidium gunteri Cole, 1931 (L)
CUSHMAN, 1930; CUSHMAN and COLE, 1930; PHLEGER, 1951; PHLEGER and PARKER, 1951; TODD and BRÖNNIMANN, 1957.
Elphidium gunteri Cole var. galvestonense Kornfeld, 1931 (M)
Elphidium excavatum (Terquem) forma galvestonensis Kornfeld
Elphidium galvestonense Kornfeld forma typicum Poag, 1978 (DDD)
Elphidium galvestonense Kornfeld PARKER et. al., 1953; PHLEGER, 1954, 1960a; LEHMANN, 1957; PARKER and ATHEARN, 1959; TODD and LOW, 1961. (EE)
Elphidium brooklynense Shupack, 1934 (Q)
Elphidium excavatum (Terquem) forma selseyensis (Heron-Allen and Earland) MILLER et. al 1982
Elphidium selseyense (Heron-Allen and Earland) HAYNES, 1973; BANNER and CULVER, 1978. (ZZ)
Cribroelphidium limnosum Cushman and Brönnimann, 1948 PHLEGER and WALTON, 1950; TODD and BRÖNNIMANN, 1957 (T)
Elphidium florentinae Shupack, 1934 (R)
Elphidium (Polystomella) excavatum (Terquem) HERON-ALLEN and EARLAND, 1932; CUSHMAN, 1944; PARKER, 1952a, 1952b. (J)
Polystomella excavata Terquem, 1875, 1876. (E)
(FFF)
Elphidium excavatum (Terquem) forma lidoensis Cushman MILLER et. al., 1982
Elphidium gunteri Cole forma salsum (part) Poag, 1978 (CCC)
Elphidium excavatum (Terquem) forma excavata Terquem MILLER et. al., 1982
Elphidium excavatum (Terquem) forma clavata Cushman MILLER et. al., 1982
Elphidium excavatum (Terquem) forma magna Miller et. al., 1982
(EEE)
Elphidium ex gr. excavatum (Terquem) "superspecies", HAYNES, 1981
Elphidium cf. advenum Sensu, Todd and Low
Elphidium selseyense (Heron-Allen and Earland)
Elphidium excavatum (Terquem)
Elphidium clavatum (Cushman)
Elphidium incertum (Williamson)
Elphidium williamsoni Haynes
Elphidium excavatum (Terquem) forma selseyensis (Heron-Allen and Earland) FEYLING-HANSSEN, 1972
Elphidium excavatum (Terquem) forma lidoensis Cushman FEYLING-HANSSEN, 1972
(WW)
Elphidium excavatum (Terquem) forma clavata Cushman FEYLING-HANSSEN, 1972
Elphidium excavatum (Terquem) forma alba Feyling-Hanssen, 1972
Cribrononion (Elphidium) excavatum (Terquem) LUTZE, 1965, 1968; LÉVY, 1966; HAAKE, 1967; LÉVY et. al., 1969, 1975; MURRAY, 1971. (KK)
Cribroelphidium vadescens Cushman and Brönnimann, 1948 LEHMANN, 1957 (U)
Elphidium clavatum Cushman WILKINSON, 1979 (8 subspecies); RODRIGUES and HOOPER, 1982. (AAA)
Cribroelphidium salsum Cushman and Brönnimann, 1948 (V)
LUTZE, 1965 ((QQ)
HAAKE, 1967; VON DANIELS, 1970
ROSSET-MOULINIER, 1972, 1976; MURRAY, 1979 (SS)
HAAKE, 1967; LÉVY et. al. 1969, 1975 (RR)
Elphidium clavatum Cushman HANSEN, 1965; KNUDSEN, 1971a, 1971b. (NN)
Cribrononion (Elphidium) lidoense ACCORDI and SOCIN, 1951; LÉVY, 1966; CITA and PREMOLI-SILVA, 1967; LÉVY et. al., 1969 (MM)
HANSEN, 1965; KNUDSEN, 1971b (PP)
☆ Elphidium incertum clavatum "complex" Cushman BARTLETT, 1965b, 1966; GREGORY, 1970; WAGNER, 1970; SCHAFER and COLE, 1978. ☆
Elphidium selseyense (sis) (Heron-Allen and Earland) VAN VOORTHUYSEN, 1957, 1960; BRIAND, 1941; RICHTER, 1961, 1964a. (LL)
HAAKE, 1962 (OO)
Elphidium clavatum Cushman LOEBLICH and TAPPAN, 1953; BARTLETT, 1963, 1964; BUZAS, 1965a, 1965b; TODD and LOW, 1961, 1967. (AA)
Elphidium selseyense (Heron-Allen and Earland) CUSHMAN, 1939; PARKER, 1952b. (GG)
Elphidium lidoense Cushman, 1936, 1939 (N)
Polystomella striatopunctata (Fichtel and Moll) var. selseyensis Heron-Allen and Earland, 1909, 1911. (F)
Polystomella arctica Parker and Jones TERQUEM, 1876
BUZAS, 1966 (JJ)
Elphidium incertum Cushman, 1930, 1939, 1944, 1949; PARKER, 1952a, 1952b; TODD and LOW, 1961; BARTLETT, 1965b. (G)
Elphidium incertum var clavatum Cushman, 1930, 1939, 1948; PARKER, 1952a, 1952b; FEYLING-HANSSEN, 1954, 1964. (H)
Elphidium incertum (Williamson)
Polystomella striatopunctata (Fichtell and Moll)
Polystomella umbilicatula var incerta Williamson, 1858
Polystomella umbilicatula Williamson, 1858 TERQUEM, 1875, 1876 (D)
(K)
Elphidium excavatum (Terquem) forma williamsoni Haynes
Elphidium transluscens Natland BANDY, 1953; PARKER et. al. 1953; PHLEGER, 1954, 1964; TODD and BRÖNNIMANN, 1957; TODD and LOW, 1961. (HH)
Elphidium williamsoni Haynes, 1973, ab Williamson, 1858 HANSEN and LYKKE-ANDERSEN, 1976; CULVER and BANNER, 1978; KNUDSEN, 1979; SCOTT and MEDIOLI, 1980; SCOTT et. al., 1980. (YY)
Elphidium umbilicatula (Williamson) LÉVY et. al., 1969; KNUDSEN, 1971b (XX)
Elphidium excavatum CUSHMAN, 1930, 1939, 1949; VAN VOORTHUYSEN, 1957, 1960; TODD and LOW, 1961; RICHTER, 1961, 1964a, 1967; HAAKE, 1962, 1967; FEYLING-HANSSEN, 1964; BRODNIEWICZ, 1965; ADAMS and FRAMPTON, 1965; MURRAY, 1965a, 1968, 1970; SCOTT, 1977; SCOTT et. al. 1977. (I)
Elphidium transluscens Natland VON DANIELS, 1970; HANSEN and LYKKE-ANDERSEN, 1976.
Elphidium transluscens Natland, 1938 (O)
Elphidium articulatum (d'Orbigny) KNUDSEN, 1976; ROSSET-MOULINIER, 1976; APTHORPE, 1980; BOLTOVSKOY et. al., 1980.
Elphidium articulatum (d'Orbigny) LUTZE, 1968; MURRAY, 1971; ROSSET-MOULINIER, 1972; KNUDSEN, 1973a, 1973b. (BB)
Polystomella arcticulata d'Orbigny, 1839b (Nomen dubium) (B)
Elphidium excavatum (Terquem) forma cuvillieri Lévy
Elphidium kugleri (Cushman and Brönnimann) BUZAS et. al., 1977; BUZAS and SEVERIN, 1982
Elphidium (Cribronion) cuvillieri Lévy, 1966; LÉVY et. al., 1969; ROSSET-MOULINIER, 1972, 1976 (Z)
Cribroelphidium kugleri Cushman and Brönnimann, 1948; TODD and BRÖNNIMANN, 1957; LEHMANN, 1957. (W)
Elphidium (Cribroelphidium) poeyanum (d'Orbigny) CUSHMAN, 1930; PARKER et. al., 1953; TODD and BRÖNNIMANN, 1957; TODD and LOW, 1961; LOEBLICH and TAPPAN, 1964. (CC)
Polystomella poeyana d'Orbigny, 1839a (C)