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THE DEVELOPMENT OF AGRICULTURAL ENTOMOLOGY IN NOVA SCOTIA[1]

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This paper traces the history of entomology in Nova Scotia. Prior to the 1880's published works were mainly taxonomic listings by gifted amateurs and scattered recommendations on pest control by writers unskilled in the applied field of entomology. Beginning in the 1880's there followed rapid developments in entomological education, research in pest control, and the building of educational facilities. Modern pest control had its inception, in the early 20th century, in the control of outbreaks of such pests as the brown-tail moth, *Nygmia phaerrohoea* Don., which soon expanded into the control of fruit pests. Fruit insect research has, since then, been the main area of entomological endeavour. Until the 1940's the major research effort lay in testing a large number of combination sprays and in the study of the biology of the insect pests. After 1940 the emphasis shifted to an ecological approach in an attempt to integrate the benefits of chemical treatments and the benefits from natural enemies.

Cet article retrace l'historique de l'entomologie en Nouvelle-Ecosse. Avant les anneés 1880, les travaux publiés regroupaient principalement des listes taxonomiques écrites par les amateurs de talent, ainsi que quelques recommendations concernant le contrôle des insects par des non spécialistes du domaine appliqué de l'entomologie. A partir de 1880, des developpements rapides se sont manifestés dans les domaines de l'éducation entomologique, de la recherche sur le contrôle des insectes et la Construction de maisons d'instruction. Au début de 20^{e} siècle, le contrôle des vagues d'insectes nuisables tel que le papillon de nuit à gueue brune, *Nygmia phaerrhoea* Don., a marqué le commencement des méthodes modernes de contrôle des insects. Ces méthodes se répandirent au contrôle des insects s'attaquent aux fruits. Depuis ce temps, les travaux concernant les insectes s'attaquent aux fruits représentent le domaine principal de la recherche entomologique. Jusqu'aux anneés 1940, l'effort principal de recherche a porté sur un test d'un grand nombre de combinaisons d'aérosols et sur l'étude de la biologie des insects nuisibles. Après 1940, l'approche écologique a été accentuée dans le but d'integrer des traitements chimiques et ceux des ennemis naturels.

Introduction

Insects, from the earliest times to the present day, have exerted a profound influence on humans. The damage they cause, the discomfort of their attacks, and other problems, such as the carrying of disease, have long focused attention upon them. On the positive side their beauty and such useful by-products as silk and honey have quickened attention since the cave walls served as an art surface. The science of entomology, not of extreme age in any part of the world, in Nova Scotia dates back to little over a century.

The object of this account is to trace developments in Nova Scotia. In the interest of clarity a strict adherence to chronology has been avoided as parts of the subject might be too widely separated by descriptions on concurrent events. For example, Paris Green, first used for the Colorado potato beetle, *Leptinotarsa decemlineata* Say, in 1882 continued its historic impact on other pests late into the 20th century. During that interval many other events of importance took place.

To give credits for all historical details has been difficult. On some occasions material derived from a number of sources, in a sense, had become common knowledge. Also, in searching for information, it was not the intent of the writer to evaluate research as such. Quotations or references are, therefore, meant only to reveal some historical detail or trend and most of these are in the nature of eyewitness reporting.

[1] Contribution of the Acadian Entomological Society

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Origins in Europe and North America

The following very abbreviated outline of entomology in Europe and North America before about 1800 is intended to give a perspective to developments in Nova Scotia as part of the continuing growth of the science. The next few paragraphs dealing with the background in Europe are synopsized mainly from a remarkable paper by Lochhead (1919).

The earliest references to insects in the Mediterranean area, not of a scientific nature, are to be found in such sources as the Old Testament and in the sculptured stone images of scarab beetles in Egypt before the year 3600 B.C. The Egyptians, in their search for medicines, doubtless made observations on insects but left no written record of them. The earliest written records on insects in Europe of a scientific nature are those of Aristotle (384 B.C.—322 B.C.). Lochhead says of him, "These [parts of Aristotle's papers] reveal the many sided nature of his activities, for he was not only a collector and classifier, but also a morphologist and inductive philosopher. He studied the life histories of many insects, he made many dissections and resolved the organs into tissues. His classification of insects, although based largely on external features, remained unimproved for more than 2000 years, and his generalizations contained ideas of evolution from the simplest to the highest organisms in nature". Quoting from a Professor Sundervall, for whom no source is indicated, Lochhead (1919) says, "Professor Sundervall estimates that Aristotle indicated and described about 60 species of insects and arachnids and about 24 species of crustaceans and annelids". It was pointed out by Lochhead that, despite large numbers of errors and crudities, Aristotle's valuable work has stood the test of time.

After Aristotle there appears to have been no significant contribution to naturalist thought until Pliny the Elder's (23 A.D.—79 A.D.) voluminous works appeared. Pliny, a naval man and a historian, attempted to compile all previous writings on nature. He combined a great deal of fancy with fact and added nothing new. His classification system was deemed by Lochhead to be inferior to that of Aristotle, although he adopted the latter's system in the case of insects.

For a long time after Pliny the Elder, i.e. during the Dark and then the Middle Ages, the study of nature was discouraged and largely neglected. Fortunately the lore of nature in the practices of farmers and gardeners was passed down as practical knowledge which provided a basis when studies on nature were revived at the time of the renaissance. Entomology had its more modern origin as a science with this background. It was made possible by the invention of the microscope without which the science of entomology was virtually impossible.

Space limits mention of but few of those Europeans who, beginning in the seventeenth century, built the foundations for all later entomology. Among the more interesting as well as more important are Malpighi (1628—1694) and Swammerdam (1637—1680). They merit special mention because of their remarkable contributions to the earlier studies of insect anatomy. Overlapping these two men in time, Valisnieri (1661—1730) is of special interest to applied entomology as the first to appreciate the nature of parasitism. It was he who first observed that parasite larvae originate in a host from eggs laid by an adult insect. Linnaeus (1707—1778) is famous enough to be immortal for his invention of binomial nomenclature, even if he had not made his huge contributions to classification.

It might be thought inevitable, after Valisnieri's observations, to expect a considerable study of insect parasitism in Europe. But it was not until 1840 that the principle of controlling an insect population by parasite introductions was demonstrated. In that year Boisgiraud of Poitiers in France introduced the climbing ground beetle, *Calasoma sycophanta* L., into his home town to rid the poplar trees

there of the gypsy moth, *Porthetria dispar* (L.). He also destroyed a population of earwigs in his own garden by bringing in the beetle, *Ocyphus olens* Muller. It is of interest to note that *C. sycophanta* was one of the natural enemies liberated in Nova Scotia between 1912 and 1915 in the attempt to achieve control of the brown-tail moth *Nygmia phaeorrhoea* Don.

Reference to what may be the earliest recorded instance of the practice of spraying was noted by Macoun (1901). He spoke of a formula, published in 1763, for using tobacco against plant lice, but did not say where. The application was made by means of a syringe with its "nose" pierced with about a thousand holes. The syringe was filled with water and lime, to which was added finely powdered tobacco. This remedy appears to have more merit than those in the following note, typical, no doubt, of many that were recommended to gentlemen farmers in the 18th century. In Weston's *"Tracts on Practical Agriculture and Gardening"*, published in England, (see ref. list, A Country Gentleman 1769), the suggested controls for "white" flies on strawberries and roses are unusual, to say the least. The plants were first to be watered and then brimstone or tobacco dust stewn upon them. The picture of the "electric machine" to apply brimstone, pepper, snuff, tobacco, and quick lime is not at all clear. Also the boring of holes into trees and the filling of them with quicksilver, which was highly touted, appears to have had little to recommend it. The use of electricity, which was particularly favoured, was said to stimulate plant growth as well.

Moving from Europe to North America we find entomology in a decidedly embryonic state at the beginning of the 19th century. This conclusion and much of what follows about early United States and Canadian entomology, except where specific references are given, was synopsized from Webster (1895). Circumstances at the turn of the century provided little opportunity for collectors, or applied entomologists, to have their material identified on this continent. Hampered by lack of experts in taxonomy, entomologists sought assistance in England and France. The net result was that most of the new species discovered in North America were described in foreign publications. By the first of the 19th century there had been only 2 papers written that dealt entirely with American species, and these were published in Europe.

Truly North American entomology began with Thomas Say (1787—1834) who, as the first great taxonomist on this continent, has been called the "Father of American Entomology". Thaddeus William Harris (1795—1855) also made large contributions to taxonomy, but he is best known for his work in applied entomology. His book, "Insects Injurious to Vegetation", did for applied entomology what Say had done for taxonomy. These are but two special examples of men who, as first in their fields, led the way to the present level of entomology on this continent.

Entomology in Canada, influenced by contemporary work in the United States, was developing its own brand of the science by the middle of the last century. It began to come into its own in 1837, when the Rev. William Kirby had his descriptions of 447 species, mainly Coleoptera, included in Sir John Richardson's "Fauna Borealis-Americana". The material was later revised by Bethune and published in the Canadian Entomologist. A beginning was also made in the applied field by Prof. H.Y. Hind of Trinity College, Toronto, Ont. in 1857. His "Essay on Insects and Diseases of Wheat", issued in that year, was the first entomological work published with the financial backing of the Canadian Government.

Entomology, developing through the contributions of a number of private individuals by the mid-century, was facing the need for a strictly entomological outlet. This objective was moved one step closer when the *Canadian Naturalist and Geologist*, in 1862 published a list of 30 entomologists in Canada. It was a nucleus

drawn from this group which organized the Canadian Entomological Society in 1863. The new society prepared to publish its journal, *The Canadian Entomologist*, the first issue of which appeared in 1869. Three years later the Canadian Entomological Society was incorporated as the Entomological Society of Ontario to serve as the parent society to a number of affiliates. This status was maintained until the Entomological Society of Canada was created in 1950.

The Department of Agriculture, as proposed in 1867 was formalized by an act of parliament in 1869. The new department rapidly improved government services in many respects, not the least of which for entomology was the appointment of Dr. James Fletcher as Dominion Entomologist in 1884, unpaid then but made permanent in 1885 (Hewitt 1912).

Fletcher himself explained to the assembled fruit growers in Nova Scotia in 1886, "It was decided that the appointment should be a purely honorary one; in fact it was an experiment to test the value of such investigations, to the country at large. The decision was, I believe, a wise one . . . . " (Fletcher 1886). In retrospect no one will argue the wisdom of having a trained man to look after the entire range of pest problems for the Dominion. Webster (1895) provided an apt simile when he told the Entomological Society of Ontario, "It is like attempting to lower Niagara River by dipping the water out of Lake Erie with a teaspoon. You ought to have Dr. Fletcher, and at least a corps of half a dozen well-trained and experienced entomologists and God speed the day when you may have them".

When by another act of parliament, in 1886, the first five Experimental Farms were established, Fletcher took up office at the Central Experimental Farm in Ottawa as Dominion Entomologist and Botanist. He carried those responsibilities until his death in 1909. Upon the appointment of C. Gordon Hewitt the divisions were separated to handle the greatly expanded number of problems. Three problems were of particular interest to Nova Scotia. These were: the Colorado potato beetle *L. decemlineata*, the brown-tail moth *N. phaeorrhoea*, and the San Jose scale *Aspidiosus perniciosus* Comstock. The latter continued to be a threat only, until it finally gained entry to Nova Scotia in 1912.

Developments Originating Before 1880 in Nova Scotia

Taxonomy and Collections in Nova Scotia

The rather slow beginnings of entomology in this province had their origins in the taxonomic interests of non-government intellectuals. Though fundamental to applied entomology, the science of taxonomy in Nova Scotia has, unfortunately, never been the recipient of federal government support.

Most of the better entomological work in the earlier days was in the collecting and classification of insects. Pickett and Payne (1939) provided a valuable historical summary of taxonomy up to about 1880 in their review paper. They say; "About 1839 a Lieutenant Redmond made a collection of Nova Scotian insects, mostly Diptera, which are housed in the British Museum. In 1864 Thomas Belt collected Lepidoptera in the vicinity of Halifax. In the years 1870-1879, J. Mathew Jones made a collection of Coleoptera, Hymenoptera and Lepidoptera in this province. In 1879, the Rev. C.J.S. Bethune compiled a list of 46 species of Nova Scotia butterflies. It is thought that the latter collection was made in the vicinity of Halifax in the late 1800's. Since 1900 more extensive collections have been made by numerous workers. Additional information on these may be obtained by reference to a paper by Brittain in 1918".

It will not, one hopes, minimize the contributions of the private collectors if the titles, taxonomic groups collected and the geographic areas of collecting are omitted. Unfortunately, the fate of most of these collections is unknown. A brief but

pertinent discussion of personages and the material collected may be found in Ferguson (1954). In addition to those discussed or to be discussed there were such names as E. Chesley Allen, C.E. Gooderham and Margaret Brown. The day of the private collector began to pass during the war years of 1914-1918. Both the *Proceedings of the Nova Scotia Institute of Science* and the *Proceedings of the Nova Scotia Entomological* Society, later the *Proceedings of the Acadian Entomological Society*, served as vehicles for their publications.

The collection started by Prof. H.W. Smith in Truro after 1886 was intended mainly for student use and no serious attempt to build a collection was made until after the Agricultural College was founded in 1905. By 1918 most of the identified reference material, according to Brittain (1918), had been collected after 1915. It continued to grow into a fine, well-referenced collection under the direction of H.G. Payne until its tragic loss by fire in 1946.

An important collection of Nova Scotia species was also built up over many years at the Annapolis Royal Entomological Laboratory. Owing to the interests of G.E. Sanders the collection contained some 3000 specimens by 1919. It was greatly expanded later by F.C. Gilliat and still further by H.T. Stultz. The collection was moved to the new Science Service Laboratory in Kentville in 1951. The current number of specimens in the Kentville collection is unknown but is probably in excess of 10,000.

The largest and best collection today is maintained in the Nova Scotia Museum of Science in Halifax. It was begun shortly after 1899 when Harry Piers, an orthopterist of note, became curator of the museum. Brittain (1918) says that the museum collection at that date consisted of about 2000 specimens with full data, all collected after 1900. It started with the purchase in 1906 and 1909 of the 1049 specimens of Lepidoptera upon which the paper by Perrin and Russell (1911) was based. Two more additions were made, one of Lepidoptera by Lucy C. Eaton and another by A.H.C. Richards. Piers, who had extensive interests, evidently maintained his connections with entomology, publishing several papers after taking office. One of them was on Formicidae (Piers, 1923). There was, however, no other significant contribution to the collection until the period 1934 to 1946 when J.H. McDunnough, Chief of the Division of Systematic Entomology in Ottawa collected Lepidoptera in Nova Scotia. The collection of Lepidoptera was greatly expanded by D.C. Ferguson who had responsibility for the Museum collection between 1946 and 1965. When Ferguson was joined on the staff by McDunnough, who worked in cooperation with Ferguson between 1950 and 1962, Nova Scotia benefited greatly. Their investigations on the fauna of Lepidoptera have given us an extensive knowledge of identities and distribution of this order in Nova Scotia.

The size of the collection in the museum has continued to grow until, as of 1981, it contains in excess of 325,000 specimens, a high proportion of which are Lepidoptera, mostly Nearctic, but other orders are well represented. Barry Wright, who took charge of the Museum collection in 1965, has added his large private collection of Palearctic and Nearctic Coleophoridae. His comprehensive paper on the Coleophoridae of America, north of Mexico, is soon to be published.

Status of Applied Entomology, 1865-1885

When the Provincial Government was reorganized in 1864 it brought all the Agricultural Societies under common control but did little directly for entomology. By initiating the *Nova Scotia Journal of Agriculture* in 1865 as a vehicle for the dissemination of agricultural information to farmers, some interest in insect control was promoted. The *Journal* was a periodical in newspaper form that outlasted the Board of Agriculture, and its successor, the Central Board of Agriculture. It ceased publishing in 1885.

The remedies contained in the *Journal of Agriculture* are, perhaps, more interesting as a record of control concepts than of successful remedies. The quotation below (from Vol. I) may seem amusing today with our greater sophistication. "The turnip crops are liable to various maladies. The turnip fly, *Haltica nemorum*, is its present greatest pest. This insect attacks the infant plant so soon as it expands its cotyledons and sometimes destroys whole fields. Various remedies have been proposed, such as burning the stubble, applications of odorous manure distasteful to the fly, mixing seeds with sulphur, excessively thick sowing in the drill to provide for the insect and have a crop left, steeping the seeds in water to promote rapid germination, sowing hot lime over the young plants, watering every other day five to six times if necessary, catching flies in tarred cloth, fumigation by burning rubbish to windward of the field, drawing freshly painted boards over the field, an application of wormwood, powdered sulphur strewn over the seed bed, snuff, heavy rolling, etc. We believe, however, that the only remedy is to dust the terminal leaves of the young turnip plants with quick lime, a bushel of which is sufficient to dust an acre. Lime and road dust proved good substitutes, the latter probably from the lime it contains. Powdered plaster would answer better. These substances should be applied in the morning when the dew is on the leaves".

The practical value of the suggestions is not great, but they do provide an excellent picture of the untested remedies offered to farmers. The author did, however, make the earliest known references to the use of sulphur as an insecticide to have been published in this province. It has since been shown in various areas of the continent that sulphur has insecticidal properties. Kelsall (1922) claimed it increased the toxicity of lead arsenate. In the literature there are also a number of references to its adverse effects on natural enemies, some by direct poisoning and others through distortion of their sense organs.

Losses from insects in those earlier years must simply have been accepted as unavoidable and natural. Seemingly, government sources were not sufficiently interested to take action until it was forced upon them by the discovery that the Colorado potato beetle, *L. decemlineata* had gained entry into the province. That one catastrophe, in particular, served to precipitate developments in government participation in the techniques of agriculture. Presumably the authorities were already making plans to take part in agricultural education, as many changes followed shortly after the discovery of the potato beetles on the crops.

Heavy outbreaks of the new pest occurred in 1882 just before the Central Board of Agriculture was replaced by the Office of the Secretary for Agriculture (which was set up in 1885). The potato beetle outbreak was a startling development for farmers. It was also the first instance in which government authorities in Nova Scotia took an active part in organizing the control of a pest. *The Journal of Argriculture* has this to say: "Reports have been made in the newspapers and otherwise of the occurrence of the Colorado beetle on the potato crops of Nova Scotia, particularly, in the countries of Cumberland, Pictou, and Kings. It is probable that in some if not all cases some pests other than the great destroyer have been found. We shall feel much obliged if the persons who have the opportunity will kindly send us dead specimens for examination. The beetle can be humanely killed by dropping into alcohol or chloroform and will travel in a pill box."

The Annual Report of the Central Board in 1883 warned, "During the past year the so called Colorado potato beetle, which has been so destructive to the potato crop in other parts of America, has begun to show itself in Nova Scotia. The Board has collected information as to the best means of destroying it which will be diffused among farmers at the proper season . . . . It is believed that vigilance on the part of the potato grower in carrying out these instructions will effectually prevent the spread of this pest to any serious extent in this province". A letter to the editor

of the *Journal of Agriculture* in 1883 says very few potatoes were planted as people were afraid of the bug. Another said the potato beetle was causing consternation.

Pickett and Payne (1939), having quoted from the Report of the Secretary to the Central Board of Agriculture, go on to say with faint, but justified irony, "From the above it would appear that the government officials in those days had the same fond hopes as those cherished by many of their modern counterparts in thinking that the recommended control measures would be carried out precisely".

The Role of Paris Green in Nova Scotia

The counselling distributed to farmers was not available to the writer. No doubt it was much the same as that in Vol. 4 of the *Journal of Agriculture*. In exhorting farmers to use Paris Green or London Purple, the news item first suggested as very effective the jarring of the beetles into a pail, a method used in small gardens for a long time. The instruction to apply Paris Green was an historic development signifying a great step forward in the use of poisons. It might be easy now to underrate the importance of the first really effective stomach poison, which was also the introduction in Nova Scotia of arsenicals as some of the most widely used insecticides.

Paris Green continued in popularity at least into the 1930's, or later, for potatoes as well as in poisoned baits. In 1941 it was still fourth in the volume of poisonous materials produced in the United States. This insecticide is a complex combination of copper metarsenite and copper acetate, which had its first use as a poison in the United States for the potato beetle. London Purple, as registered today, is a different product from the earlier one. The older material was an industrial by-product of variable arsenic content obtained from the manufacture of dyes. Its effects were unpredictable.

Compared to previously available poisons Paris Green was an outstanding insecticide, in spite of the dangers to foliage. James Fletcher, Dominion Entomologist, speaking before the Nova Scotia Fruit Growers in 1886 then considered the potato beetle to be the most severe pest problem faced by farmers in Nova Scotia. He recommended (Fletcher 1886) treatments with Paris Green, and also suggested the same poison for the codling moth *Laspeyresia pomonella* (L.) and the plum curculio, *Conotrachelus nenupar* (Hbst.). Nevertheless he warned that Paris Green should not be used at strengths greater than a tablespoonful to a barrel of water; otherwise, the damage to the tree might be greater than from the unchecked pests. At this small dosage the cankerworm, *Alsophila pometaria* (Harr.), was difficult to control. To make the poison less phytotoxic the addition of flour or plaster of Paris was recommended as a diluent in both the dry and liquid preparations.

Other Poisons Before 1880

Kerosene was considerably less significant in control recommendations, but it was long deemed a useful insecticide. Probably its insecticidal properties were known for some years before an anonymous writer (probably the editor) asked in *The Journal of Agriculture* of 1885 (Vol. 4), and answered his rhetorical question, "How few of us are there who would not give anything, as they say, to know how to keep away the cabbage fly from their seed beds, yet about a tablespoonful of coal oil put into a garden pot of water, sprinkled over the seed bed when the little jumping beetle is noticed as having appeared, will instantly kill the whole brood. Coal oil kills scale insects . . . .". Added is a warning that, although the oil will kill all vermin on the apple tree, it will destroy the tree. This readily available agent continued in use for many years and had some limited application even in the twentieth century. Fletcher, in his talk to the Fruit Growers in 1886, highly recommended it for scale insect control on apple trees along with the suggestion it be emulsified with sour milk or whale oil soap and then diluted.

Another insecticide that was well known for a time, even if less effective, was whale oil. It was first used in Massachussetts, but in Nova Scotia was most commonly used as a soap for wetting other poisons or as an emulsifier. This oil was recommended in 1872 for the garden slug and the rose beetle, but as the second remedy. *The Journal of Agriculture* was not too enthusiastic when it suggested, "All kinds of remedies have been proposed—whale soap, petroleum, etc., but the best thing is to set a boy to crush them by thumb and forefinger". Boys will be boys, but the method does not suggest itself as a favoured form of amusement.

Developments Originating 1880 - 1905

The Beginnings of Agricultural Education

The excitement in 1882 over the introduction of the potato beetle, which had marked the first instance of active participation by government authority in insect control, was followed by a series of moves into extension and education in general. The Central Board of Agriculture was dissolved in 1885 to be replaced by the Officer of the Secretary for Agriculture. The value of instructing farmers had been demonstrated by the potato beetle problem. It seems a reasonable assumption that by then it had been realized that a more informed farm population was an obvious economic advantage to Nova Scotia. Consequently, one of the first acts of the new office was to appoint a Lecturer in Agriculture in 1885, to hold office in the Provincial Normal College in Truro. The objective was to prepare teachers, in particular, to carry information on agricultural methods to rural areas. There were short courses for boys from the farm as well.

Prof. H.W. Smith was the first, and only, such appointee to hold that position. This he did until he was moved to the newly opened Nova Scotia Agricultural College in Truro in 1905. His teaching duties at the Normal College included chemistry, botany, zoology, veterinary medicine, entomology geology, physics, hygiene, and practical agriculture.

Almost immediately upon taking up office Prof. Smith found he was handicapped by lack of land for experimentation. His representations to the government to rectify the situation met with success. In July 1888, a piece of land which now constitutes part of the Nova Scotia Agricultural Farm was purchased.

Interest in the School of Agriculture at the Provincial Normal College, among other factors, was showing the need for an institution for agricultural instruction. Fruit growers were playing a part for, according to Dr. R.S. Longley (1963), their association had been pressing for the establishment of a School of Horticulture for some time before 1886. The government finally agreed with the rationale of investing in education. As a result, the School of Horticulture at Acadia University was opened for classes in 1892 - 1893 with E. E. Flavelle as Director. Three years later he was succeeded by Prof. F.C. Sears. Sears taught there until the school was closed and he was moved to the Nova Scotia Agricultural College in 1905.

The steps already taken in the appointment of Prof. Smith in 1885 and the purchase of land in 1888 were indications that science was coming to agriculture. But these events were only a part of general trends toward improved techniques in farming, education in the sciences, and in improved marketing knowledge in all of Canada. The concept of training young people in order to bring science to farming in Nova Scotia was receiving wide support by the 1890's. At that time the Nova Scotia Fruit Growers' Association was providing some of the more active support.

Plans for an agricultural college assumed concrete form in 1898 when the legislature passed "An Act to Provide for an Agricultural College to be built in Truro". The new facilities, which we know as the Nova Scotia Agricultural College, opened in 1905 with Prof. Melville Cuming as Principal and with Prof.Smith con-

tinuing on as Professor of Biology. Judging by his reports to the Secretary for Agriculture the reorganization had provided Smith with more time to write descriptive material on insect stages and life history. Such information was one of the main entomological needs of the times.

Plans had already been underway to build the College when H.G. Payne, previously mentioned in the section on taxonomy, assumed care of the insect collection and the extension work in entomology. These duties placed him in a logical position to play a major role in combatting an outbreak of the brown-tail moth, *N. phaeorrhoea*, a few years later.

Presumably the staff shared with Prof. Smith his views with respect to the need for an entomologist in the province. He had said as early as 1892 of such an appointment, "There is need of a good entomologist for the province who would devote his time and energy to the fruit growers and farmers of the province. Now if he were employed as Professor of Entomology in the Provincial School [meaning the School of Agriculture at the Normal College] he could visit these local schools and experimental stations and could have experiments conducted and by so doing, show farmers how to combat their numerous insect enemies etc. At the same time he could give instructions in this line to pupils of this local school". His wish was granted some twenty years later in the appointment of Dr. Robert Matheson in 1912.

The Role of the Nova Scotia Fruit Growers' Association

The rather sudden upsurge in agricultural organization across Canada, particularly after 1880, found expression in the activities of the Nova Scotian fruit growers. Because it has been typical of their organization we may safely assume that the group had been pressing for such changes as the setting up of the Office of the Secretary for Agriculture, the appointment of a Lecturer in Agriculture and in the planning for educational facilities in agriculture. Although Prof. H.W. Smith's duties included the teaching of entomology, the main source of practical information on the subject for a fairly long time was through the fruit growers' meetings and in their annual reports.

The Nova Scotia Fruit Growers' Association, first organized as the Fruit Growers' Association and International Show Society in 1863, issued its first published report in 1883. Succeeding annual reports drew much stronger attention to fruit growers' interests and, coincident with a wave of government participation in agriculture, emphasized the need to improve production methods. Certainly the government recommendations to use Paris Green for the potato beetle affected fruit growers who, being general farmers, were becoming more interested in insect control in general.

Without doubt the ravages of insects in orchards had concerned fruit growers long before their annual reports began to publish discussions of control measures. The honor of having had the first paper on orchard insects in Nova Scotia published under his name, however, goes to Mr. T. E. Smith, a nurseryman rather than an entomologist. His address was published in the 1884 report. However odd some of his comments may seem by modern standards, he gave his audience the best then available in his talk entitled, "How to destroy insects in orchards" (Smith 1884). Although his ideas were inaccurate, the information he presented is interesting and his sources somewhat a mystery. Possibly his facts were obtained from English sources such as Weston's Tracts on Practical Agriculture and Gardening published in 1769, mentioned in the introduction.

In discussing the control of the cankerworm, *Alsophila pometaria* Har., then, as now, a most important pest of apples Smith (1884) suggested the following remedies. One was to fasten a band of coarse cloth soaked in printer's ink around

the trunk of the tree. He also recommended Paris Green and London Purple mixed in the proportions of one part to seven hundred parts of water to be applied with a force pump or syringe. These arsenicals, Smith pointed out, would destroy the apple foliage if used at any stronger dosage. Also described briefly are the apple tree caterpillar (not identifiable), the tent caterpillars collectively (presumably *Malacosoma disstria* Hb. and *M. americana* Fab.), the codling moth *L. pomonella,* and the oystershell scale *L. ulmi*. The codling moth could be controlled by encouraging birds, by lighting bonfires to attract and destroy the moths, by picking up wormy apples, and by the banding of the tree trunks with cloth impregnated with printer's ink. Smith says of the oystershell scale: "An excellent wash is made by dissolving 2 lb. of potash in six to eight quarts of water, which may be applied with a mop about the latter part of May or the first of June. Large sums of money have been paid for this simple recipe". The "simple recipe" had no direct influence on the scale population at all. Research some 60 years later showed that it did allow the natural enemies to flourish and thus destroy the scale population. Belief in the use of whitewash, however, persisted for many years.

The impact of James Fletcher, Dominion Entomologist, on Entomology in Nova Scotia

The official appointment of Dr. James Fletcher by the Dominion Government in 1885 marked the beginning of federal involvement in entomology in Canada. It also coincided with the provincial appointment of a Lecturer in Agriculture in Truro. Following Fletcher's assumption of his duties the instructions for pest control began to be based on tested methods. Fletcher also cooperated in following years with provincial authorities by supplying technical papers on agricultural pests for inclusion in the Lecturer's reports to the Secretary for Agriculture. At that time little opportunity was available in Ottawa or in Nova Scotia for field experimentation. Presumably both men made use of tests made in Ontario and in the United States as well as those from such books as W.E. Saunders' "Insects Injurious to Fruit" published by Libby, New York.

The decision to invite a trained entomologist to speak to the assembled fruit growers in 1886 was a good one for the orchardists and, eventually, for entomology. The address he gave (Fletcher 1886) proved to be the beginning of the mutual liaison of farmers' experience with the research of plant pathologists, entomologists and chemists, which is a feature of spray practices in the Annapolis Valley to this day. After 1915, all recommendations for orchard pest control in Nova Scotia came through this liaison from tests in orchards.

The material covered by Fletcher (1886) in his historic address is much too lengthy for more than a brief synopsis. He showed the growers the importance of using measures based on knowledge of the life history and habits of the pests, knowing how to recognize them, being aware of the best spray materials, selecting sprays on the basis of feeding habits, finding ways to make the poisons safe to use, having some idea of the role of parasitism, etc. The information then available on how to render toxic materials safe for foliage was still rather primitive, although the poisons were very effective.

Development of Equipment for Applying Sprays

It is impossible to give a date for the first use of equipment in Nova Scotia for spraying plants. A few early instances of recommendations have been mentioned. Materials applied to plants in dust form must have been made with anything available such as a piece of cloth. There are early recommendations for using a watering can for liquid applications or by allowing poison mixtures to drip from a piece of cloth. Such were the rather primitive means of applying materials like

hellebore, pyrethrum, tobacco concoctions, and the miscellany recommended to small gardeners and the farmers alike. More serious attention began to be paid to methods of applying sprays to apple trees after Fletcher's (1886) first address, but there are earlier records. Some of our older citizens still recall the use of the mop as an applicator.

Frequent mention was made during the nineteenth century of the use of the "syringe" as an instrument for applying insecticides. This seems to have been any kind of pump which, when thrust into a pail of liquid delivered it with a small amount of force through a tube and nozzle. "Spraying", says Macoun in 1901, "is an old custom under a new name. While the word 'spraying' has been in use less than twenty years, the word 'syringe' was used long ago. It was when the liquids began to be used for extensive work that the expression 'to spray' superceded 'to syringe', although the latter is still used to a limited extent".

Some indication of the date of the first employment of wagon-mounted sprayers in the Annapolis Valley is provided in a letter written by Mr. R.W. Starr of Wolfeville and quoted by Macoun in 1901 as follows: "I can scarcely give dates as to when spraying was first adopted in this province, as the practise has grown up from small beginnings, with the fine rose watering pot and garden syringe using solutions of whale oil soap, tobacco, and hellebore to destroy currant and gooseberry worms and thrips on rose bushes. These methods were used by the Hon. C.R. Prescott as early as the 1840's at least . . . . In 1885 Mr. A.S. Harris . . . . got a small force pump and double orifice from New York. With this he sprayed his trees, using Paris Green, one teaspoonful to two quarts of water. This was so successful that the next year everyone who was troubled with the cankerworm provided himself with a pump and arsenites. Since then the spray has been continuous where needed, large pumps fitted to casks or tanks and placed upon wagons being used for this purpose. The first of these was gotten by myself in 1880. I used a brass cylinder lift and force pump with suction and delivery holes. With this I tried nearly every kind of nozzle made . . . ."

While general acceptance of the idea of spraying did not come without a good deal of resistance, the practice did make important strides after the 1880's. Power spraying developed rather slowly. Some idea of the standards of pressure needed were given by Mr. A. McNeill to the Fruit Grower's meeting in 1902. He pointed out (McNeill 1902) that it is difficult to maintain the 100 lb. pressure required and that spraying could never be properly done until the man at the pump handle could be dispensed with in favour of a power machine. "Even a hired man gets tired at the pump handle . . . ." After 1900 power sprayers were becoming more numerous, but in the memory of some older farmers, the barrel with its hand pump was not fully superceded by 1914.

Prof. P. J. Shaw, in his report to the Secretary for Agriculture for (Shaw 1911), gave a good indication of progress. "One of the greatest developments in spraying occurred last year in the change on the part of many growers from the hand pump outfit to the gasoline powered sprayers. One hundred and thirty of these power outfits are said to have been sold in the fruit district last season . . . . Aside from this [value of the engine for farm use] the power sprayer is likely to displace, in large measure, the hand outfit . . . ."

According to Kelsall (1939) spraying was fairly general practice by 1910, at which time there were still quite a few hand pump sprayers. By 1918 almost all growers were using powered sprayers. These remained fundamentally the same, except in the amount of spray delivered per minute, until the advent of air-blast sprayers about 1951.

Dusting with power-operated machines as a means of applying combination pesticides to orchards was widely practised for a time after 1918. When these ap-

plicators were first tested in Nova Scotia dusting already had a background of 50 years use in the United States. The practice never fully supplanted spraying in Nova Scotia. For reasons to be discussed, dusting began to lose popularity after 1924.

Just as the coming of age of the power sprayer with its gun or boom was a leap ahead in technique, the air-blast sprayers which began to take over after 1950 were an equally sensational advance. The first of these to be used in Nova Scotia was an Okanagan Mist Blower purchased in 1949 by Agriculture Canada for entomologists. With it came another British Columbia contribution, viz. the idea of concentrating materials in order to spray a great deal faster. Within a few years most of the growers had equipped their sprayers with air-blast attachments. These in turn were replaced in a few years by commercial models designed specifically for air-blast spraying.

The Beginnings of Insecticide-Fungicide Combinations

Paris Green, which had proven so effective for orchard pests beginning after 1880, was so dangerous to foliage that better combinations incorporating the "sovereign" remedy were being recommended soon after by Fletcher (1886). Some suggested additives helped but quite often the dosage of Paris Green had to be kept so low it was likely to be ineffective against certain leaf-eating insects. Consequently, it is not surprising that the use of Bordeaux mixture for apple trees received early support.

The full story of copper and sulphur based fungicides, mixed with various insecticides, would fill volumes. Each, however, played too large a part in the growth of control measures for fruit and vegetable pests to be dismissed without at least a brief resumé. Sulphur, according to Macoun (1901), had been recommended in England in 1821 against mildew on peaches. He also noted that W. E. Saunders had suggested to American experimenters the idea of testing liquid applications of it against apple scab, *Venturia inequalis* Wint. He recommended the boiling of quicklime and sulphur together. This material later became known in Nova Scotia under the name of lime-sulphur. It found popular use a little later than did Bordeaux mixture.

The fungicidal properties of copper sulphate which had been made safe by the addition of lime were discovered in France in 1886. The mixture was not well received in the United States until it was shown in Iowa in 1889 that it removed much of the danger of burning by arsenicals when used on potatoes. A few more years passed before copper fungicides were discussed at the Fruit Growers' meeting in 1892. One of the growers stated that copper sulphate precipitated with strong ammonia did not prevent Paris Green from burning apple foliage severely. Nevertheless a low lime bordeaux mixture suggested in 1893 continued in general use after that. The proportions were: copper sulphate, 4 lb; lime 4 lb; Paris Green, 4 oz; and water 50 gal. For the following few years most of the explanations of spraying dealt with means of preparing the mixture. In 1898, Prof. Sears reiterated with more effect that the adding of Paris Green to Bordeaux rendered the arsenic safer to use (Sears 1898). Some idea of the acceptance of spraying by that time is contained in his statement that most of the first class growers were now spraying. Judging by some contemporary remarks it *was* the "first class" growers and not the majority who were applying sprays regularly. Spraying with hand pumps was still such sheer labour that it was too unpleasant to accept readily. That limitation, and doubts of its value, held up more general acceptance of the practice. In addition, fear was expressed about the dangers of selling poison-treated fruit to the public. With the more general use of powered sprayers in the 1900's the aversion to spraying abated, particularly after it was understood what the Bordeaux - Paris

Green mixture was doing. The introduction of lead arsenate as a poison in 1895 also helped to reduce foliage and fruit damage.

The Bordeaux - Paris Green mixture, which had considerable popularity, was not an unmixed blessing. It did give good control of biting insects such as the codling moth and the cankerworm, along with fair control of apple scab. On the negative side it damaged the foliage and caused severe "russetting" of the fruit surface if used in the bloom period. Then, when lime-sulphur with lead arsenate was substituted in that period the finish of the fruit improved greatly. Unfortunately the combination reduced the crop. Some of the increased injury from either combination was a result of the heavier applications made possible by power spraying, although the reasons were not at first apparent.

Brittain's (1916) work, and then the studies made by staff of the Canada Agricultural Laboratory at the Dominion Entomological Laboratory at Annapolis Royal under G.E. Sanders, began to give the development of spray programs a scientific basis in orchard tests in Nova Scotia after 1915. Brittain's orchard studies in 1915 and 1916 saw the beginnings of an enormous amount of investigation on spray materials by government staff. These first plots by Brittain compared a number of lime-sulphur, soluble sulphur and copper-lime mixtures, each in combination with lead and calcium arsenate. The development of spray programs started by Brittain and taken over largely by federal employees after 1915 is the subject of much of the later parts of this outline. The various components will be discussed in the appropriate sections.

Developments Originating 1905 - 1915

Even before the Nova Scotia Agricultural College had opened its doors to students in 1905 there had been the start of an insect collection and Prof. Smith had taught entomology, among his many subjects. Smith (1892) had early expressed his belief (see p. 000) in the need for a full-time entomologist. The outbreak of the brown-tail moth, *N. phaeorrhoea,* in 1907 and the constant worry over the San José scale, *A. perniciosus,* were probably the final pressures toward the appointment of Dr. Robert Matheson in 1912.

The Outbreak of the Brown-tail Moth

Probably no one insect did more to precipitate a sudden expansion in entomological facilities than the outbreak of the brown-tail moth in 1907. A close rival as a sensation was the introduction soon after of the greatly feared San José Scale. Neither insect actually lived up to the virulence expected of it.

The rapid expansion of staff and facilities induced by the brown-tail moth outbreak no doubt simply speeded up an inevitable process of growth. At least, like the Colorado potato beetle before it, the brown-tail moth infestations had long-lasting influences. The difference this time lay in the rapid response by the Office of the Secretary for Agriculture which immediately placed crews of men in the field.

The suggested date of the introduction of the moth is 1905, but the nests were first discovered by Mr. Perry Foot in his orchard in Lakeville, Kings Co. in 1907. As stated above government response was speedy. Under the direction of Prof. Smith, and headed in the field by H.G. Payne and G.H. Vroom, the survey groups showed that the infestations extended from Yarmouth County to Kings County. In the next few years the outbreak expanded even more widely and a concerted attempt at eradication was made. There was winter scouting with the destruction of nests; fruit growers were encouraged to spray; and government-operated sprayers were placed in the field with crews under the direction of Payne and Vroom. Seemingly the actual ravages of the brown-tail moth were never as serious as expected.

Nevertheless, because of it, the Federal Government took steps important to the future of entomology in Nova Scotia in 1910. The outbreak was declared a national problem and a crew of five men, under the direction of Mr. G.E. Sanders was appointed to cooperate with the provincial men. In addition to scouting, these appointees were charged with making a study of the brown-tail moth with a view to its eradication.

The discovery that the population was maintained at a low density in Europe by natural means had induced experts in the United States to introduce about thirty different species of parasites and predators into northern New England. Under an international agreement and with the authority of L. S. McLaine in Ottawa, some parasites and predators were introduced into New Brunswick and Nova Scotia between 1912 and 1915. These were the climbing around beetle *C. sycophanta,* and tachinid *Comsilura concinnata* Mg., the braconid *Apanteles laecteicolor* Vier., and the fungus *Entomophthora aulicae* (Reich.).

The period of high densities was short. Reports indicate that by 1916 the brown-tail moth was again becoming of minor importance. Gilliat (1920), in a review of the outbreak considered that four factors, viz. the inspections with the destruction of winter nests, climatic conditions, spraying, and the introduction of natural enemies had all contributed to the reduction. None of these factors can be weighed at this late date.

The Office of the Provincial Entomologist

The appointment of Dr. Matheson in 1912 as Provincial Entomologist made him the first in Canada to hold such an office. He and his successors also served as Professors of Zoology at the Nova Scotia Agricultural College in Truro.

During Matheson's one-year tenure of office the San José scale finally arrived in Nova Scotia. The outbreak was discovered by Mr. G.E. Sanders on a planting of young apple trees in Aylesford, Kings County. Although the pest never became the disaster expected of it, the initial fear upon its discovery generated an intensive eradication campaign, including the fumigation of nursery stock. The insect had already made the Department of Agriculture in Ottawa more conscious than ever of the need for trained entomologists and for consistent efforts to combat insect pests. The passage of the San José Act in Ottawa in 1899 had been a measure of the virulence of this pest elsewhere in Canada. The prohibitions were lifted in 1901. New legislation (see Hewitt 1911) incorporating a broader application of inspection and prohibitions was embodied in the "Act to Prevent the Introduction or Spreading of Insect Pests or Diseases Destructive to Vegetation" in 1910. Nova Scotia followed suit in 1911 with its "Injurious Insect Pest Act".

Dr. Cuming (1912) Principal of the Agricultural College said in his report, "We regret to state that during 1912 the presence of an even more insidious pest than the Brown-tail moth has been discovered viz., the San José scale. As soon as the discovery was made scouts were put into the field and every effort made to discover the boundaries of the pest and to destroy infested trees".

Some of the men in the following list of "scouts" are of interest as they later became prominent in entomology in this province. They were: H.R. Brown, S.H. Payne, F.C. Gilliat, C.A. Crocker, Guy Denson, A. Kelsall, Allan Dustan and C. Shipton. Under Matheson's leadership and in cooperation with G.E. Sanders' crew a vigorous campaign of inspection, quarantine measures, the arranging of fumigation of nursery stock, and the burning of infested trees was initiated. Before the campaign was completed Dr. Matheson resigned.

His resignation in 1913 brought a very dynamic and energetic personality, Dr. W.H. Brittain, to Nova Scotia as Provincial Entomologist and Professor of Zoology. His first big job was to carry on the San José scale eradication campaign. Severe as

this scale was, it was less catastrophic than had been feared. The first outbreak was cleared up with an appreciable effort, as have several small localized outbreaks since then.

The majority of Brittain's efforts were divided between his teaching duties, his research on morphology, taxonomic work, and investigations on the biology of pests. He also compiled a great deal of information into bulletins for farmers' use. Last, but not least, he carried on extensive plot work in orchards with the objective of finding safe and effective insecticide-fungicide combinations for insect and disease control.

The Experimental Station and the Entomology Laboratories

For some years prior to 1910 the Nova Scotia Fruit Growers' Association, along with various other groups and interested persons, had been pressing to have a fruit research station established in the Annapolis Valley. The wishes of these people came to fruition in that year. The Provincial Legislature purchased the Sharp farm on the outskirts of Kentville and turned it over to the Federal Government as a base for the station. Mr. J.W. Crowe was appointed temporary superintendent. He turned the job over a year later to Dr. W. Saxby Blair, who developed a fine research station. Although entomology was included in the terms of reference, no facilities were provided at the station for many years. A few years later a small laboratory was erected on the Acadia University campus by the Nova Scotia Government for the use of the Provincial Entomologist. The first entomology at the station came when the provincial extension service acquired rooms there about 1935.

The brown-tail moth eradication campaign was at its height when the Federal Government erected a small laboratory in Bridgetown in 1911. The objectives of its crew were the careful study of the brown-tail moth, investigations on means of controlling its abundance, and the study of other insects on field and orchard crops. This building was abandoned in 1915 when the staff was moved to larger quarters in Annapolis Royal. Research in entomology, thereafter, was directed mainly at the comparison of a great many combinations of insecticides and fungicides and, particularly, at exploring all possible sources for new poisons. A sustained effort was also put into the study of the life histories of many pests. In 1915, also, the Provincial Government erected a log cabin at Smith's Cove in Annapolis County. The Annapolis Royal Laboratory was closed in 1951 and the staff and facilities moved to new quarters in the Science Service Building in Kentville. The latter was incorporated, in part, into the new main building of the Canada Agriculture Research Center opened in 1981.

The Anomaly of the Apple Maggot as a Pest

The purpose of the Provincial Laboratory at Smith's Cove was to provide facilities for a study of the apple maggot, *Rhagoletis pomonella* Walsh. Brittain and Good (1917) did much of their work on the apple maggot there. The interesting anomaly of this pest is that it has attracted and received far more attention than have many pests which in some way damage the tree, foliage, or fruit to a greater extent. It has rarely been the cause of appreciable damage to fruit in commercial orchards, but has resulted in growers being unable to ship infested fruit to certain markets. For the latter reason it has been the cause of some economic losses to growers.

The hypothesis that the apple maggot is a native insect that transferred from the hawthorn (*Crataegus* spp.) to apple suggests that it was here before the apple tree was introduced. The first official identification of the apple maggot adult was made by Matheson (Brittain 1913) who collected specimens in Digby County. That date is, of course, no indication of how long the maggot has been attacking apples in

Nova Scotia. The introduction of apple trees in the early 1600's (Hutten 1981) suggests the earliest, though unlikely, time of transfer to apples as a new host. Hutten's account of apple trees coming in with the New England Loyalists and Planters suggested about 1760 as the earliest reasonable date, if such a transfer did take place. It is not known when apple maggot damage was first recognized as important. Although it seems probable that it was long ago, it is interesting that there is no reference to apple maggot in the *Annual Report of the Nova Scotia Fruit Growers' Association* until after 1900.

If, as assumed, the apple maggot has attacked apples for a long time, its failure to become abundant in commercial orchards was due to the use of arsenicals. These were fairly generally employed before the beginning of the 20th century and very extensively after that. By the 1920's and after, when all commercial spraying included arsenic, the maggot was scarce in most commercial orchards though often abundant outside of the main growing areas.

Attitudes changed greatly after 1925 when Dr. Arthur Gibson, Dominion Entomologist, explained the probability of a British embargo on apples from any area if live maggots were to be found in shipped fruit (Leonard 1933). The following account of the steps taken to avert a disaster in Nova Scotia is based on communication with Mr. Alex Buchanan, Chief Inspector of the Apple Maggot Control Board for thirty-one years, and on the paper by Leonard (1933). The apple maggot achieved lasting notoriety in 1926 when a survey showed the pest to be present, at least in small numbers, throughout the Annapolis Valley. As the English tolerance was zero it was a startling find. Leonard stated, "That same year, 1926, the Provincial Government passed an order-in-council prohibiting the export of apples infested with apple maggot. Under this authority Federal Fruit Inspectors were authorized to hold up infested fruit. There were, however, small provisions for enforcement at first. A comprehensive survey in 1930, with the finding that infestations were extensive, led to the setting up of a largely non-government board called the Advisory Apple Maggot Control Board. Inspectors were appointed to facilitate enforcement of legislation. A further change was made in 1932 when a board of growers called the Nova Scotia Apple Maggot Control Board succeeded the Advisory Board.

It is difficult to give a summary of the control of this unique pest, not normally excessively destructive in sprayed orchards, without minimizing the problems entailed in guaranteeing freedom from it in exported apples. Nevertheless that standard was achieved by an intensive effort. Before the outbreak of World War II about 50 inspectors averaged over 5000 visits per year, many within towns where neglected apple trees were a special problem.

The British market, lost due to the war and never fully recovered, caused a number of changes in the approach to the apple maggot problem. The most obvious ones were the increase in the numbers of neglected trees and a more indifferent attitude on the part of farmers. In the period 1950-1960 the numbers of yearly visits dropped to about 1500 and in the 1970's to around 400. Of late years there have been, at most, 10 to 15 inspectors who respond only when an application for inspection is made.

The arsenicals, which have at all times given reliable control, have not been used greatly since 1970 for several reasons. Prominent among them were the difficulties of enforcement, the numbers of wild and neglected trees, an abundance of hawthorn bushes, and changes in the spray program to suit the control of other pests. At the present time sticky traps are used to indicate levels of fly abundance which, in turn, tell the grower if an application of an organophosphate is required.

The Entomological Society of Nova Scotia and the Acadian Entomological Society

The Acadian Entomological Society, as presently constituted, began in 1915 as the Entomological Society of Nova Scotia, changing to the Acadian Entomological Society in 1921. Unfortunately, there is no known file of correspondence in which to find plans for its inception. Whatever the plans, the prerequisites for organizing had been building for a number of years. There had been an increase in the number of entomologists because of the brown-tail moth and San José scale; the Federal Government had begun to take an indirect part, as in the appointment of Sanders' crew; there was a body of interested taxonomists and collectors; and there was increased spraying of orchards with consequent pressure from growers for information.

The organization under its first name, and later under its second, published its proceedings each year from 1915 until the society became defunct in 1924. The closest we can come to a statement of objectives is contained in the remarks of the Honorary President, Dr. A.H. McKay, in 1915. He used an old concept which is still applicable, viz. "The great war of the future will be between man and the insects. Man is greater; but the insects propagate more rapidly. Were the insects not divided against themselves in six years the human race would be starved into extinction . . . . It is knowledge gives us power. The greatest forces in the world are often invisibly small; so long as we do not know them, and how and when they act, we are helpless as inert matter" (McKay 1915).

Characteristically, Dr. Brittain was the main force behind the new society. He made more contributions to the proceedings than any other individual (Table I) and most of them were above average in quality.

Table I Sources of papers published by the Entomological Society of Nova Scotia and the Acadian Entomological Society.

Year	No. papers submitted all sources	No. papers submitted by non-resident entomologists	No. papers submitted by Brittain
Proceedings of the Nova Scotia Entomological Society			
1915	14	0	2
1916	13	0	5
1917	16	3	3
1918	13	1	4
1919	8	1	3
1920	10	3	2
Proceedings of the Acadian Entomological Society			
1921	8	6	2
1922	13	5	3
1923	6	3	1
1924	9	3	1
	110	25	26

Total Pages = 893
Total Pages in Brittain's Papers = 294

Unfortunately, the membership remained small (e.g. in 1921 there were 16 members from Nova Scotia, 11 from New Brunswick and 2 from outside the Mari-

times) which is obviously the reason the society was unable to find sufficient numbers of high quality papers. The failure of the Acadian Entomological Society to survive did not mean there had been any slackening in progress in the entomological sciences.

Coincident with the outbreak of war in 1939, events only remotely related to those just outlined had the effect of reviving the Acadian Entomological Society. The bringing back to life of the 15-year-dead society was not a miracle of resurrection. When a meeting was arranged in Orono, Maine, in 1939 between A.D. Pickett, C.W. Maxwell and Maynard Harrison (the latter two from Fredericton) and F. Lathrop, reorganization was not a part of the plan. The meeting was simply to discuss controls for an outbreak of the blueberry maggot, *Rhagoletis mendax* Curran, in Yarmouth County, Nova Scotia, and other blueberry problems. In the light of the present strength of the Acadian Entomological Society there can be little doubt that there was a latent need for a reorganization of the Society.

When Dr.Lathrop drew attention to similarities in the environments of Maine and the Maritime provinces the discussion led to an invitation to have a larger group meet in Orono during the following year. The suggestion was enthusiastically received and acted upon. In January of 1940, Pickett, Maxwell, Dr. J. McBain Cameron, Provincial Entomologist of Nova Scotia, and Mrs. Jean Adams, along with a delegation of forest entomologists from Fredericton, met in Orono with entomologists from Maine. That informal exchange of ideas was such a success a decision was made to meet again in Fredericton in 1941. The meeting in Fredericton set a repetitive pattern because of its stimulating value; from the first it was evident that much good was to come of these gatherings. The group, thinking of themselves as the Maritime and Maine Entomologists, but without a formalized name, continued to be a valuable unifying medium for entomology in the Atlantic Provinces and Maine.

The concept of forming an officially organized society met with some doubts for a time. For example, a letter written by W.A. Reeks, who was not averse to the idea, expressed doubts that a branch of the Ontario Entomological Society would be formed. The idea stayed very much alive, however, and grew stronger. The first positive step to make the organization official took place on 29 March 1950 when the constitution presented for discussion was adopted. The society was, thereafter, to be the Acadian Entomological Society. It was to affiliate with the Ontario Entomological Society but not be a branch of it. At that time the Ontario society was still the Canadian parent society. Upon the reorganization in 1950 which made the Ontario Entomological Society an affiliate of the new national Entomological Society of Canada, the Acadian Entomological Society affiliated. The by-laws of the latter were altered in 1953 to conform with those of the parent society. A further change in by-laws became necessary in 1957 to have them conform with clauses in the parent society constitution when that society was incorporated in 1955. Mrs. Jean Adams (1965), in her popular write-up of the 50th anniversary of the Acadian Entomological Society, and speaking of both the national body and its affiliate, had this to say: "The second world war had passed . . . . the ranks of professional entomologists in Canada as a whole had begun to swell. Many felt the need for a truly national society to speak for so wide a group . . . . In the Maritime area, what the nature of the affiliation should be was debated at considerable length. The outcome was the revitalization of the Acadian Entomological Society, to include all interested entomologists, in the four Maritime Provinces and Maine."

The proceedings of the society have been issued each year since 1961 in multigraph form as a record for the future. That future looks good because of what the society has done, and promises to do, for entomology in this geographic area.

The Period From 1915 to 1939

As was pointed out the erecting of an entomological laboratory in Annapolis Royal in 1915 with G.E. Sanders in charge had provided facilities for the investigation of orchard problems. The main effort thereafter went into field and laboratory investigations on the development of combination sprays for insect and disease pests. In addition, Mr. F.C. Gilliat devoted the rest of his life to the study of the bionomics of apple insects. Sanders had already been involved, at least as a consultant, in Brittain's orchard experiments when he made what he considered to be a fateful visit in 1915 to the orchard of Mr. G.L. Thompson in South Berwick. There, he was able to verify the suspicion that the heavier use of lime-sulphur was cutting the apple crop drastically, even though it provided excellent finish to the fruit. The fortunate observation probably simply speeded up a study of spray damage to fruit that had become inevitable.

Research on Insecticide-Fungicide Combinations

Beginning in 1916 the major role of the entomologists (after 1924 in cooperation with the Plant Pathology Laboratory in Kentville) at Annapolis Royal was the evaluation of a very large number of insecticides and fungicides and combinations of them. Lead arsenate combined with lime-sulphur, the hitherto common mixture, was found to be more dangerously phytotoxic than when calcium arsenate was used. Alone, lead arsenate was fairly safe and calcium arsenate dangerous. Calcium arsenate was safe in Bordeaux mixture which, by the post-war years, was being used with an excess of lime to make it less toxic to foliage. The spray calendar by 1918 was recommending the higher lime Bordeaux with calcium arsenate (or lead arsenate) in the early and late sprays and lime-sulphur with or without calcium arsenate in the bloom period sprays. A considerable amount of nicotine sulphate was being used then for such pests as aphids and the green apple bug, *Lygocoris communis novascotiensis* (Knight).

When dusting achieved popularity in the period after 1918 the most successful combinations were: elemental sulphur with lead arsenate in the proportions of 90 to 10, Bordeaux mixture with calcium arsenate, and nicotine sulphate in Bordeaux or with hydrated lime. Unfortunately, despite the high hopes generated for dusting, it failed to meet expectations. After 1924, growers began to abandon the practice and revert to spraying. Kelsall (1939) says of the decline of dusting, "This period of seven or eight years during which dusts were so extensively used was terminated by two factors. Extreme outbreaks of the eye-spotted budmoth, *Spilonota ocellana* D. and S. occurred in the years between 1924 and 1927, causing great damage to the crops. These could not be controlled by any known dusting method. At the same time, in large numbers of orchards, the European red mite, *Paratetranychus pilosus* C. and F. [now *Panonychus ulmi* (Koch)] became a serious pest and this, likewise, was not amenable to dust treatment. These two factors coupled with the development of improved high-powered spray outfits led to a decline of the dust method of control and to the revival of the spray system".

The addition of the European red mite to the list of major pests complicated the spray program still further. Mineral oils, later with such additives as the "dinitros", provided temporary relief for one to three years. Often the concentration of the oil was increased to check the abundance of the oystershell scale and other pests. A still further cause of concern following the outbreak of the budmoth was a marked increase in the gray banded leaf roller, *Eulia mariana* Fern.

Arsenicals and the Bee Populations

Growers had long been aware of the scarcity of hive bees and the identity of the

cause, though suspected, was not established. When Brittain (1933) began his investigations on bees in 1928 it was to ascertain the effects of arsenicals on pollination through destruction of the bee population. It soon broadened into an outstanding piece of research on all factors affecting pollination of apples in the Annapolis Valley. It was already known to be impossible for the bee-keeping industry to exist in the apple producing area. Also, although it was recognized even then that hive bees can be the main agent in pollination, they were normally a negligable factor in the sprayed areas. Brittain's research soon showed that, with the avoidance of arsenicals in the bloom period, 1 hive of bees per acre gave effective pollination. Occasionally, 1 hive might be sufficient for as much as 3 acres. In general, however, the finding was largely academic as there was no large supply of bees. Most apiaries had been wiped out or had moved from the Valley during the years in which dusting was popular. Following that period the high-powered sprayers, with greater drift of materials, continued to inhibit beekeeping. Although sulphur dust caused trouble in hives, the lead and calcium arsenates were the main cause of death among honey bees. While most of the poisoning took place in the bloom period of apples, that was not the only period of danger. The drift of sprays to wild flowers, such as the dandelions, was also a common cause of poisoning.

Of the other Hymenoptera, the bumblebees were less deterred by weather than either the hive bees or the solitary bees. Brittain found it impossible to determine in the field if the minor importance of bumblebees in orchards was a result of poisoning. Only 5 species of them, all in the genus *Bremus*, were recorded during the bloom period in the years the research project was in effect.

The solitary bees were far more important than any other insect in arsenic treated orchards. This included, in particular, the hive bees because of their susceptibility to arsenic poisons. The 5 year study of solitary bees revealed 12 species of *Halticus* and 10 species of *Andrena* on apple blossoms. Of these, *Halticus smilacinae* Robt. was the most important pollinator because it far outnumbered all other bees. As with the bumblebees, evidence of poisoning was, by its very nature, impossible to obtain in the field.

Dead broods of wild or solitary bees were seldom found, and dead adults too rarely to determine if they had died of poisoning. Brittain (1933) sums up his observations on the poisoning of wild bees this way: "The fact that such a large proportion of the pellets, collected at random, contained measurable amounts of arsenic would lead one to suppose that poisoning among wild bees should be common; but if so, it is difficult to demonstrate, and over the period studied we have not been able to detect any diminution in the effective population traceable with certainty to this cause". Also, according to his report, solitary bees were found nesting in great numbers in areas where most severe losses in hive bees took place.

Poisoning of all kinds of bees by materials other than arsenicals has never ceased to be a danger of serious concern to entomologists.

The Period of the use of Precipitated Lime-Sulphur and Flotation Sulphurs

Even as the studies by Brittain were being pursued in the late 1920's, alternatives to the lime-sulphur and calcium arsenate mixture, normally used in the bloom period, were being sought by entomologists at Annapolis Royal and by plant pathologists at Kentville. As early as 1924, lime-sulphur precipitated with aluminum sulphate was showing value as a safe material to use on apple foliage. Unfortunately, it left much to be desired as a fungicide and its use was short-lived. Kelsall's (1939) first attempts to increase the fungicidal value of lime-sulphur by precipitating it with iron sulphate were not notably successful. But, upon increasing the calcium arsenate from 3 lb to 5 lb per 100 gallons the mixture proved

to have the desired qualities. Its use gave satisfactory control of apple scab and did not mar the skin of the fruit. Many growers began to use the mixture in the bloom period, and some in all sprays.

The testing of a wide range of insecticides, both in combination with fungicides, and alone became the main effort of entomologists during the 1930's. There was, however, no fundamental change in the concept of using sulphur-based fungicides. Nor did there appear to have been thought given to any other means of controlling arthropod pests than by insecticides.

Among the new sulphur fungicides given a high rating in the early 1940's was flotation sulphur, a by-product of the coke industry. It was elemental sulphur in very fine form precipitated by hydrogen sulphide in the production of artificial illuminating gas. In the period mentioned it largely supplanted the lime-sulphur-iron sulphate mixture. It provided excellent control of apple scab, and gave the fruit a beautiful finish. Its shortcomings will be examined in considerable detail later.

Investigations on the Life Histories of Pests

It was imperative, in developing spray programs after 1915, that there be knowledge of the cause of each kind of damage and of the life histories of the casual agents. Studies on the bionomics of the pest species became, therefore, an important correlative part of the control investigations. Unfortunately, although information on the natural enemies was gathered as well, it was considered to be of relatively minor importance. Nevertheless, in spite of the shortcomings a valuable body of biological information was built up.

Two of Gilliat's papers in particular, both published in 1935, proved in time to be very significant contributions. One (Gilliat 1935a) was on the biology of the European red mite, *P. ulmi* and the other on its predators (Gilliat 1935b). This information was fundamental to later studies (to be described) on the evolution of spray programs that made great use of natural enemies. Gilliat had said, significantly, "As a summary, the many predators must be considered in the light of a common enemy of the European red mite, a natural balance being established under normal environments. Where there is interference with the factors of natural control there follows a rise in the numbers of pests which end in destructive outbreaks". His personally expressed, but unpublished view, that spray policies should consider natural enemies was not acted upon. The time was not then ripe as entomologists were still continuing the search for the ideal combination of spray materials for all pests. The general view was that the destruction of natural enemies was not important if all their food animals were dead. That philosophy remained popular long after 1940 among many entomologists, with a growing number of exceptions. Before the 1940's the few who decried the ill-advised use of spray materials had been voices crying in the wilderness of misconceptions about nature.

The Background of Integrated Control

The day of a fundamental change in concepts of control of orchard insects was not far away when war broke out in 1939. The initiative and basis for change was an economically depressed apple industry which had lost the British market.

The reshuffling of personnel in 1939 that had seen Kelsall become superintendent of the Kentville Experimental Station had brought A.D. Pickett to the Annapolis Royal Laboratory. The latter, as Provincial Entomologist since 1928, following the resignation of W.H. Brittain, had promoted and directed an extensive spray circle service for farmers. The service was designed to help growers by

providing technical information quickly. Special problems were brought to the best specialists. Such a liaison was highly necessary at the time as the acreage was large and the problems many. These experiences had placed Pickett in an ideal position to observe that the recommendations had weaknesses, although no one knew why at the time. Increased spraying only seemed to bring about more problems.

By the time war broke out in 1939 the control of apple pests had become complicated and expensive. The costs were tolerable only if there was both a large market and prices sufficient to cover costs. The so-called "best" growers were applying a combination of pesticides in a series of applications lasting late into the summer. By 1940 growers were including more and more flotation sulphur, sometimes in all applications. Beginning with dormant oils, the schedule often ended the season with four or more applications of lead arsenate and final sprays of fixed nicotine or cryolite for the codling moth. If high quality fruit is considered to be free of blemishes, then Nova Scotia was producing high quality apples. Grading standards based on this criterion, deemed so desirable by the public, were stringent. Skin quality, no doubt, will always set the standard of acceptable quality, and thus be the determinant of spray policy.

By 1939, the oystershell scale had moved to top position as a destructive pest. If growers failed to check its increase with dormant oil every two to three years the life of whole blocks of orchard was threatened. Yet, Brittain (1913) had told fruit growers that this insect had many natural enemies and that it was easy to understand why it had never been more serious.

The European red mite, too, had reached a level where, at a distance, orchards often appeared red because of huge numbers of winter eggs. Lower concentrations of the same dormant oil used for the oystershell scale were recommended.

The eye-spotted budmoth was also a major pest and was controlled with a summer application of nicotine sulphate. There were several other lepidopterous pests but the codling moth had achieved top place. In 1941, for example, it was demanding more and more attention, particularly among those making the heaviest applications of spray; yet Sanders (1915) had dismissed the pest with these words: "Owing to its comparative scarcity in Nova Scotian orchards the codling moth has received little attention as yet in this province. It is very rare to find even an unsprayed orchard which gives over five percent wormy apples . . . ."

There were many other pests but the above four ranked highest in importance at the time. To summarize, it was anomalous that when the economic crisis of 1940 hit, the more intensive the spraying the more intense were the problems from insects. After 1940 the real crisis was survival of the apple industry. The only compromise was to produce at minimal costs and maintain the health of the orchard until the return of better times. All reduced their spraying and some ceased entirely. The situation provided a whole new environment demanding a more economical approach to pest control. It forced entomologists to modify spray recommendations and A.D. Pickett put the machinery into gear as the new officer-in-charge.

Warnings against the dangers of interfering with natural processes through the injudicious use of sprays had been voiced for years past by prominent entomologists on this continent. Unfortunately, circumstances had left these warnings unheeded. Suddenly they were very apropos to the conditions caused by the war. Pickett's background of 10 years' experience in chemical pest control had made him aware that spray practices contained some inexplicable contradictions; just what they might be was not at all clear to anyone. Pickett, with typical determination, persuaded headquarters in Ottawa that the adverse effects of sprays should be investigated carefully. Thereafter, the energy of the staff was devoted to

unravelling the many intricacies determining the interactions of natural enemies with pests in a sprayed environment. The new line of approach at first exploited the misfortunes of the apple growers to a marked extent. Strange situations with respect to natural control began to turn up in blocks where spraying had been reduced or abandoned.

Unexpected decreases in pests in some of these in 1943 and after, provided conditions for an early understanding of the importance of natural controls. For example, in one such orchard, scalicide tests proved worthless because the scales in the check plot all died of natural causes. In other neglected orchards there was no large resurgence in pests.

Integrated and Modified Control in the Earlier Years

Research soon showed that a parasite, *Aphytis mytelaspidis* (LeB.), and a predacious mite, *Hemisarcoptes malus* (Shimer), normally held the scales in check. The influence of spray on them was an early project in the new approach. Sulphur fungicides were found to set the stage for an outbreak of scales.While lime-sulphur fungicide had some toxicity to scales it was not sufficient to hold them completely in check once the natural enemies were killed. Flotation sulphur, on the other hand, was particularly disastrous. It had no toxicity to scales but it was extremely harmful to the natural enemies. A new fungicide, first under test in 1943, might have failed to find commercial use but for its role in solving the scale problem. Ferbam (ferric dimethyl dithio-carbamate) was by no means ideal for apple scab suppression, but it was harmless both to scales and their natural enemies. The substitution of this fungicide for sulphur in commercial orchards allowed natural enemies to clean up the scale populations, usually in one year. This phenomenal success was, perhaps, equally important in its service as an object lesson on the adverse effects of sprays. It was not soon forgotten by the farm population.

Because Bordeaux mixture and the fixed coppers were also innocuous they, too, were of value for some years in maintaining a low density of oystershell scale. The organic fungicides introduced after 1953 also had this favourable property.

The European red mite, *P. ulmi*, was the second important pest to respond positively to changes to sprays with minimal effects on predators. Studies on mites and their predators, initiated in 1944, increased the list of known predators discussed by Gilliat (1935b), while also evaluating their relative importance. After 1944, a great many poisons and combinations were evaluated for their effects on predators and parasites. It will be pointed out in context that the general predators attacking mites also attack a wide range of other species. As with the oystershell scale the prime villain at first was the sulphurs. Ferbam was detrimental to a few of the predacious species but not to a disastrous extent. It did not prove difficult to find spray materials to allow the natural control of mites to function normally, provided mites were the only important problem. As expected, mites were seldom the only major pest problem in orchards.

The codling moth and the eye-spotted budmoth, both simultaneously under investigation with scales and mites did not yield to modifications in the spray program so easily or quickly. Nevertheless it was observed that the same general predators were a valued addition to the parasite fauna attacking Lepidoptera. Even if the subtle benefits from predators were not as readily discernable, a policy of non-interference with them paid dividends in the general control of all pests.

Intensive research on the interrelations of the predacious species with all other insects and mites began to provide a better picture of the effects of predators on prey and vice versa. Information on the overall effects of general predators on the arthropod populations in and near orchards began to suggest an explanation of how environmental factors worked to supply orchards with predators. Firstly, all

the important predacious species living on apple trees have been observed on vegetation other than apple trees; broad leaf trees in the vicinity of orchards seem to be particularly important. Secondly, it is supposed that when drift of toxic sprays upsets the balance in the nearby wooded areas, it thus provides conditions, when there is no further toxic drift, for a build-up of predators. These disperse into orchards in search of food. The vegetation surrounding orchards, therefore, is a reservoir which resupplies orchards with predators when the spray program is corrected. The third supposition, which is supported by many observations, is that general predators feeding on a complex of prey tend to feed on the kind of prey most frequently encountered. This last effect, though highly probable, is too complex to unravel in the field. It was, however, demonstrated that the predacious fauna can be of great benefit when detrimental materials are avoided. The principles outlined above probably apply to parasites as well, but it is not clear how surrounding vegetation may affect parasitism.

Among the many papers published on the ecology of insects in Nova Scotia a number were devoted to short and to long term effects of chemicals on the orchard fauna. These are considered in a series of papers under the general title of, "The Influence of Spray Programs on the Fauna of Apple trees in Nova Scotia". The first by Pickett, Patterson, Stultz and Lord (1946) was subtitled, "I. An Appraisal of the Problem and a Method of Approach." There were also many other papers not included in this series.

DDT and the Integrated Control Program, 1945 - 1953

The program evolving for a time after 1945 relied heavily on natural enemies, partly because many growers had little choice. The expression "Modified Control Program", perhaps, then expressed procedures more aptly than the later term "Integrated Control Program" which, in time, became rather sophisticated. One pest, in particular, the codling moth, began to present difficulties by not responding sufficiently to the principles of the "Modified Spray Program". In the late 1940's most growers struggling with a codling moth problem were using four cover sprays of lead arsenate in the summer and ending the season with a spray of fixed nicotine or cryolite. These were expensive but not, in themselves, highly toxic to predators.

Grower pressure for cheaper and more effective control measures was the main reason for their acceptance of DDT despite warnings by entomologists in Nova Scotia and other areas as to its disastrous effects on natural enemies. Almost simultaneously with the acceptance of natural controls in Nova Scotia a divergence of opinion arose because of DDT. The first sample of DDT reached the Annapolis Royal Laboratory in the spring of 1944. Its reputation as a remarkably toxic insecticide was soon verified. It had some use in commercial orchards very soon but, for a short time, a majority of growers continued to favor the idea of protecting natural enemies. Those growers chose to continue with the lead arsenate program rather than suffer the red mite and other problems that the use of DDT and a miticide entailed. Farmers who used DDT for the codling moth got the expected clean-up of the pest and the expected side effects.

By 1953 the high cost of insecticides, combined with too much confidence in predators, and lack of knowledge of their own fauna, led too many growers to omit poisons. Unfortunately, they met with disappointment. Next year, despite both the generally high level of predator populations, and weather unfavorable to the codling moth, there was a swing to DDT, even among those with an adequate population of predators. The entire integrated control program was threatened.

At about that time the revelation of the special qualities of the poison ryania for the control of the codling moth gave growers renewed confidence integrated control. This poison is the ground-up wood of *Ryania speciosa* Vahl., a plant native to

Trinidad. While the producing company was still testing it Dr. D.W. Clancy of West Virginia tested ryania against the codling moth in his attempt to initiate an integrated control program for his area. He found it was not only highly toxic to the codling moth, but had only rather mild adverse effects on the predators. Although expensive, fewer applications were required and it was selective. It was, therefore, economically feasible to use in an integrated control program. Dr. Clancy, in correspondence with A. D. Pickett, suggested ryania as a promising material for testing in Nova Scotia. Accordingly, in 1952, Patterson and MacLellan (1954) began testing it.

After two years of experimentation and observation on its effects on the predator fauna it was found to be even more suitable for Nova Scotia conditions than it had been in West Virginia. It fitted the criteria of a selective insecticide so well it was included in the 1955 spray guide. For almost ten years it continued to do the job and thus lengthened that form of integrated control. A comment by Pickett and Patterson (1959) is revealing. They said, "It is not possible to locate orchards heavily infested with codling moth for testing insecticides."

The ultimate failure of ryania had its origin in the control of the winter moth, *Operophtera brumata* (L.), which had arisen, it appears, from the discontinuance of the pre- and post bloom arsenicals. Ryania had little use after 1970.

The Winter Moth and Cankerworm after 1950

A new and combined problem from the cankerworm and the wintermoth crept in slowly and rather subtly. The cankerworm had been a problem even before Smith (1885) discussed it. In the intervening years until 1940 it was a pest of varying seriousness, depending upon spray policies and parasitism. The cankerworm showed signs of revival just before 1950 as the arsenicals fell into disuse because of DDT and ryania. The 1949 insect forecast simply noted that it was causing damage to shade trees in the towns in the Annapolis Valley. In a few years it merited control measures in some orchards. Still further increases by the mid 1950's led to the recommending of a single pre-blossom application of DDT at a very low dosage (2 oz. per 100 gal.). At that concentration, carefully timed, its use was consistent with the natural control program. It was assumed that sufficient numbers of the predators could escape, particularly the later emerging species.

Initially the winter moth was confused with the cankerworm as both cause damage at the same time. Because the winter moth was more difficult to control, the DDT treatment was increased to a pre- and a post bloom application and azinphos methyl was offered as an alternative. The winter moth is a relatively new imported pest of forest and shade trees, and apple trees. The following summary of its history is based on studies by Embree (1965) and by MacPhee (1967). The initial infestation appears to have been in or near Queens County, Nova Scotia, starting about 1930. It spread over Nova Scotia and into parts of New Brunswick. For a time it was confused with the fall cankerworm, *A. pometaria*, and with the spring cankerworm, *Paleacrita vernata* (Peck). By the mid 1950's it had become sufficiently abundant to require separate descriptions in the control recommendations. The materials suggested for both species were the same, however.

Forest entomologists, in their attempt to reduce damage to forest and shade trees imported and liberated five species of parasites in the two provinces. Only two, viz. the tachanid *Cyzena albicans* (Fall.) and the ichneumonid *Agrypon flaveolatum* (Grav.), were recovered. Parasitism proved to be effective in the forests where survival of the trees was the criterion. That standard is insufficient in apple orchards where minimal damage to fruit is imperative and where the chemical approach to control was the only feasible one. The insecticides, however, reduced the effec-

tiveness of the parasites. Also, increased dosages of poisons were required at times that coincided with the emergence of the better predators.

The greatly reduced abundance of the codling moth by the late 1950's has been mentioned but that condition was about to change because of the winter moth. The routine repeated applications, usually at increased dosages, of the organophosphates for the winter moth had an adverse effect on the predator populations. Indirectly, this was a most important, if not the primary, factor in triggering a major outbreak of the codling moth (MacLellan 1969). Because there was insufficient help from predators under these circumstances it became the policy to control the codling moth with materials more widely toxic than ryania. The change marked the beginnings of a new strategy of pest control called Pest Management.

The Beginnings of Pest Management

Events long past have the advantage of perspective in their interpretation; the role played by the older form of integrated control before 1974, is however, too recent for accurate appraisal, and viewpoints vary. The faintly pessimistic one contained in Dr. David Crowe's address to the Fruit Growers' Convention in 1974 has many points of interest as a summary. He told the growers (Crowe 1974): "The contribution of the integrated pest control program to net profit is not well documented. Certainly the cost of pest control was becoming excessive when we started the program 35 years ago. In Nova Scotia we went the biological control route and accepted a fair degree of injury while we learned how to work chemicals into the program without undue loss of natural control. Other areas utilizing the new and powerful chemicals are attempting to work biological controls into their programs. Certainly we saved money and have now developed very satisfactory controls within the integrated program but there are occasionally some losses of quality and total yield. This is true for both types of programs of course. It is likely that the chemicals developed since World War II have, and will, contribute more to net profit than does the integrated control concept *per se*".

That form of integrated control based on exploiting the limited selectivity in available pesticides and the avoidance of broad spectrum ones changed in the late 1960's. Ryania lost popularity, became scarce, and was dropped after 1970. Because of problems from the winter moth and the apple brown bug *Atractotomus mali* (Meyer) growers, as mentioned, seriously disrupted predator populations by using organophosphates. This, according to MacLellan (1979) triggered the codling moth outbreak previously discussed. In the hope of obtaining sufficient reduction in the codling moth population and a return to less generally toxic materials azinphos methyl, at larger dosages, was recommended for a 1-year period. The codling moth was controlled but there was no change back to less drastic poisons.

With exploration and development of all efforts in commercial insecticides directed into a search for pesticides as broadly toxic as possible, there seems little likelihood of selective materials being produced. No one will argue against the inference in Crowe (1974) that making maximum use of natural enemies through the use of selective pesticides holds little promise.

The control of pests at the low level demanded by the fresh fruit trade, without destroying natural enemies, it is true, limits the choice of materials. Yet this is being done to a fair degree through pest management. In this respect it is of considerable benefit to growers that over half the apple crop is sold under the less stringent skin quality demands required by the processing industry. The economic returns of production, whether for the processing or for the fresh fruit trade, are the final determinant of the treatments to be applied.

The monitoring system using sex pheromone for determining whether or not a poison treatment is needed for the codling moth is one of the best in use. These

very successful moth traps show promise of similar developments for other pests. Densities of many, but not all, pests can be monitored at present in a number of ways. With monitoring tools the benefits of using the least widely toxic materials at the lowest practical dosages, carefully timed, and applied only as required, makes the pest management system the main form of integrated control today.

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