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THE EFFECT OF DESTRUCTION OF THE SPINAL CORD ON OSMOTIC CONTROL IN ELASMOBRANCHS.

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ABSTRACT.

Destruction of the spinal cord in *Raja erinacea* results in the destruction of the mechanism which normally maintains the concentration of the blood above that of sea water.

Unlike the blood concentration of the marine teleosts on which we have data, that of the elasmobranchs, as measured by its freezing point depression (△), is greater than the concentration of the sea water in which the animals are living. Portier and Duval[1] found that the blood of *Scyllium canicula* taken in water of △ 2.08° C. had a △ of 2.17° C. At St. Andrews, N. B. the blood △ of *Raja erinacea* living in sea water of average △ 1.72° C. was 1.80° C. and the greatest variation among the fourteen animals on which the determinations were made was ± .01° C.

The most extensive study of the changes in the blood concentration of elasmobranchs produced by modification of the salinity of the external medium was made by G. G. Scott[2] who used the dogfish *Mustelis canis*. The tail was cut off and the spinal cord destroyed by a wire as far forward as the level of the anterior dorsal fin. The caudal artery was then plugged and the fish transferred to fresh water. It was re-

1. Portier and Duval, *Compt. rend.*, **174**, 1693-5 (1922).
2. Scott, *Ann. N. Y. Acad. Sci.*, **23**, 1-75 (1913).

moved from time to time and a 5 cc. blood sample was taken from the caudal artery. Scott's assumption was that the difference between freezing point depressions of successive blood samples was a measure of the dilution brought about by the unusual medium.

In the course of some experiments carried out during the summer of 1927 at the Atlantic Biological Station, St. Andrews, the writer had occasion to test Scott's technique on the skate, *Raja erinacea*, which is the most common elasmobranch found in the vicinity of the Station. The tail was cut off and a small wooden plug inserted in the caudal artery. The stump of the tail was wrapped in thin sheet rubber. Some of the animals so treated were returned to the tanks in the above condition. Others had the spinal cord destroyed as far forward as the level of the vent and still others had the spinal cord destroyed up to within an inch of the base of the skull.

After twenty-four hours the animals were removed from the tanks and a sample of the tank water was taken at the same time. The heart was exposed ventrally and a canula was tied into the ventral aorta. The heart action served to bleed the animal into a test-tube. The freezing point of the blood sample was determined immediately afterwards by means of the Beckmann apparatus. In every case whole blood was used, the technique being that of Garrey[3]. The freezing points of the samples of tank water taken at the same time the fish were removed were also determined.

Two animals with the tail alone removed and taken from water of Δs 1.732 and 1.752 gave blood Δs of 1.798 and 1.810 respectively. Two animals with the tail removed and the cord destroyed as far as the vent both showed a blood Δ of 1.798 in comparison with tank water Δs of 1.768 and 1.756. In the three animals with the greater part of the cord destroyed the blood Δs were 1.755, 1.746 and 1.723 in comparison with tank Δs of 1.757, 1.746 and 1.722 respectively. These results indicate that destruction of the greater part of the spinal cord of *Raja erinacea* is correlated with the destruction of the

3 Garrey, *Biol. Bull.*, 8, 257 (1905).

mechanism which normally maintains the concentration of the blood above that of the sea water. The result is that the blood concentration drops until it becomes equal to that of the sea water and apparently varies directly with it.

With respect to the effect of immersion in fresh water on *Mustelis canis*, Scott[2] remarks that after the return of the animal to sea water the blood △ is lowered and the osmotic pressure is increased again but the normal osmotic pressure of the blood is not regained, even though the return to sea water is as long or longer than the time spent in fresh water. This effect cannot, however, be attributed to the fresh water and it is evident from Scott's results that by his technique he has destroyed the mechanism he was attempting to study. Using a different technique the writer[4] has found that *Raja erinacea* may be transferred to fresh water for periods up to forty minutes, after which time the blood concentration was lowered to △ 1.71° C., yet upon return of the animal to sea water, the concentration of the blood returned to its "normal" concentration at △ 1.80° C.

Just how destruction of the spinal cord breaks down the mechanism that normally maintains the concentration of the blood above that of the sea water is a problem regarding which little of a definite nature can be said. In the case of the skate used in these experiments an internal medium, the blood, of △ 1.80° C. and an external medium, sea water, of △ 1.72° C. are separated in the gills by only a layer or two of epithelial cells yet this difference in potential across the membrane is maintained under normal conditions. Apparently the cells next to the water are able to control not only the osmotic pressure but also the proportional salt content of the internal medium[5]. Scott and Denis[6] have shown definitely that in the dogfish the gill membranes constitute the surface where exchange between internal and external media takes place and that the skin does not act as a pathway of absorption. Presumably the gill membranes act similarly in the skate.

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4. Chaisson, *Contr. Canad. Biol. Fish.*, N. S., **5**, 477-84 (1929).
5. Huntsman, *Trans. Roy. Soc. Can.*, Sect. V, **20**, 187 (1926).
6. Scott and Denis, *Am. J. Physiol.*, **32**, 1-7 (1913).

In the destruction of the potential differences across the gill membranes in the animals with the spinal cord destroyed it seems highly probable that shock plays an important part. It is well known that such products of tissue destruction as histamine increase the permeability of capillary walls, and may, in the skate, be responsible for the effect obtained. It is interesting to note in this connection Greene's[7] findings in the case of the chinook salmon, *Oncorhynchus tschawytscha*, taken in fresh water. He reports a direct correlation between low vitality and battered condition of the fish and degree of dilution of the normal blood concentration. In the case of the salmon however, the possibility of surface abrasions complicating the situation must also be kept in mind.

Destruction of the spinal cord is not the only way in which the mechanism which normally maintains the concentration of the blood above that of the sea water may be destroyed. While this mechanism is apparently capable of maintaining much greater differences of potential across the gill membranes than it does normally, it ceases to function if the blood Δ is raised beyond 1.71° C. by placing the animals in suitable sea water dilutions[4].

7. Greene, *Bull. U. S. Bur. Fish.*, **24**, 429-56 (1905).

THE ALGAL FLORA OF HUDSON BAY. H. P. Bell, Dept. of Biology, Dalhousie Univ., Halifax, N. S. (Read Dec. 14, 1931). During the summers of 1927 to 1930 inclusive, collectors sent to Hudson Bay by the Biological Board of Canada, made sixty-eight collections of marine algae. From these it was possible to make only one hundred and seventy-one identifications, comprising forty species. None of these are peculiar to this region alone, but the distribution and appearance of the plants indicate that the algal association of Hudson Bay is estuarial and Arctic. The fewness of the species compared with the number reported for Hudson Bay, Baffin Bay and other Arctic waters would suggest tha t th i