

ON SOME OF THE AFFINITIES BETWEEN THE GANOIDEI CHONDROSTEI AND OTHER FISHES.

THE group of Ganoidei Chondrostei has hitherto been regarded as one developed during the latest period of the history of the earth. Its structure is so different from that of other classes of fish that its relationship with them cannot be easily detected. The zootomic and embryological works of the last ten years, and especially the works of Zalsensky in Odessa, Parker in London, Davidoff in Munich, and van der Wighe in Holland, have brought together many important facts as to the organization and development of these interesting animals, but the information provided by these writers is either fragmentary or not full enough, and long study and labour will be required before it can be satisfactorily summed up and completed.

During the last two years I have studied the anatomy of *Acipenser ruthenus*, the commonest representative of the Acipenseridæ to be found here; and although my work is far from being completed I may beg the reader's attention to some interesting facts, which must, I think, be taken into consideration by those who try to settle the question as to the relationship of the Ganoidei Chondrostei to this or to that group of fishes.

We may begin with the teeth of these fishes, as an indication of great value, which served to distinguish this group from other Ganoidei. Teeth have been found in *Polyodon folium*, a member of the Ganoidei Chondrostei, inhabiting the rivers of North America; it has been thought that they might also be found in *Psephurus gladius* of the River Yang-tse-kiang, in China; and Prof. Zalsensky has found them in *Acipenser ruthenus*, at the age of from three weeks to three months. I have had the good fortune to find teeth in almost all the Ganoidei Chondrostei of the different ages that I have examined, but they were palatine teeth, not mandibular or maxillary teeth. I have discovered and studied the palatine teeth in a two-months-old sterlet; in an *Acipenser stellatus* of from seven to eight months old; in a *Scaphirhynchus kaufmannii* from Amudaria of a year old; in a grown *Scaphirhynchus fedschenkoii* from Sir-Daria; and in full-grown *Polyodon folium*.

The relationship of the dimensions of the snout of fish to the age at which teeth can be found is very interesting. The long and flat snouted *Acipenser stellatus* has teeth to a more advanced age than the short and narrow snouted sterlet; the teeth of a wide-snouted *Scaphirhynchus* not attaining a good development but are preserved until maturity; the spade-snouted *Polyodon* preserves its teeth during the whole of its life. In all the other representatives of Acipenser and *Scaphirhynchus* can be found at any stage traces of palatine teeth in the shape of two similar prominences, which, by their structure, can be distinguished from the surrounding parts of the mouth.

This dependence of a long preservation of teeth on the development of the snout of Ganoidei Chondrostei, together with the geographical distribution of these fish, shows the greater antiquity of the tooth-preserving kinds of *Scaphirhynchus* and *Polyodon*, than of the Acipenser. Species of one kind, inhabiting such widely separated water-reservoirs as the Aral Sea and Mississippi, or the Yang-tse-kiang and the continental rivers of North America, must be representatives of very old forms, remains of former fauna; their having, at a mature age, organs that do not serve them, but which merely remain as an inheritance from former periods, is a confirmation of their supposed antiquity—a conclusion drawn from zoogeographical observations.

The structure and development of the dorsal shields, which, in the case of Acipenseridæ, spread all along the dorsal surface, from the back edge of the head down to the dorsal fins, may also, I think, help us to discern affinities between Ganoidei Chondrostei and other fish. The first to pay attention to these shields, and to suppose they were an embryonal dorsal fin, was Prof. Zalsensky. About the same time Prof. Goethe described a similar fin of a six-weeks-old sterlet, hinting, by the way, that the dorsal shields might be compared with the dorsal rays of a fossil fish, *Coelacanthus*. I have succeeded in investigating the dorsal shields of a two-months-old sterlet, and in making a whole series of cross sections, and I have arrived at the conclusion that Zalsensky's and Goethe's suppositions are fully established by facts. Indeed, between the shields spreads a membrane, in which can be seen the same horny rays that are generally seen in developing fins of fish; right and left of each dorsal shield there is a muscle, traces of which can also be

found under the shields of grown sterlets. At last, having made cross-sections of oxidized dorsal shields of grown sterlets, a canal could be perceived in them. These canals are particularly well seen in *Scaphirhynchus*, as an older and a better representative of the original type.

Knowing that Dr. Günther in his excellent book on ichthyology places the Acipenseridæ and *Coelacanthi* next to the Polypteroidei, I availed myself of the offer of Prof. Bogdanoff, Director of the Moscow Museum, and my teacher, to let me examine the only dry specimen of *Polypterus negalensis* that was in the Museum. Comparing the numerous small fins spreading all along the back of *Polypterus*, there being a great and wide front bone-ray, and the others being thin and horny, I became convinced of their complete similarity to the dorsal shields of a young sterlet and to the membranes which connect them.

In the wide bone-ray of *Polypterus* a ray channel could also be discerned, and the rays of the membrane that spreads behind the wide ray were also horny, like the rays of the membrane of an embryonal fin of a sterlet. This brought me to the conclusion that the ancestors of both the Acipenseridæ and the Polypteroidei had not only a back fin, but also well developed front dorsal fins, with great bone-rays and smaller horny rays, and were, perhaps, nearer to each other than their present descendants.

A study of other organs, especially those in young Acipenseridæ and *Scaphirhynchus*, convinces me that there is a closer relationship between the Ganoidei Chondrostei and the Polypteroidei than has hitherto been supposed. It is well known that the conus arteriosus of Acipenser is distinguished from the same organ of the *Polypterus* and *Lepidosteus* by a much smaller number of transversal rows of valves. In young sterlets I have found, besides developed valves, undeveloped folds lying between the valves. In place of such undeveloped valves, in the case of grown fish, as for example in a specimen of *Acipenser huso* which I dissected, and which was about 10 feet long, an unevenness and roughness of surface are noticed. The air-bladder, which in *Lepidosteus* and *Polypterus* partly resembles the lung of *Dipnoi*, when attentively studied in the Acipenseridæ does not appear to be so well adapted to its new functions. Its coatings include many ramifications of vessels, the histological structure of which is so similar to the structure of the coatings of the digestive organs that it is much easier to recognize their relative layers than in those of other fishes, where the air-bladder is fully adapted to its functions. The ductus pneumaticus, in young sterlets especially, is very wide; a two-months-old sterlet has it of almost the same width as an oesophagus, and the food of the small fish, consisting mostly of forms of *Cladocera* and *Ostracoda*, and also of statoblasts of *Polyzoa*, especially *Alcyonella*, fills the cavity of the air-bladder like the cavity of the stomach.

Though the brain of these fishes has been well investigated, yet in its organization one finds much that is interesting. For example, the cerebral hemispheres of the prosencephalon of *Scaphirhynchus* proved to be more similar to the hemispheres of *Dipnoi* and *Lepidosteus* and *Protopterus*, than to those of Acipenser. The lateral layers are turned upward, so that the upper portion of the hemispheres proved to consist, not of one pallium, as in Acipenser, but also of the coating of the cerebrum. The epiphysis cerebri, being a changeable organ, proved to vary even in the limits of the genus Acipenser. Thus, its front end in *Acipenser sturio* reached as far as the line connecting the two lower nostrils, forming an angle of nearly 28° with the surface of the brain, whereas in *Acipenser ruthenus* the epiphysis forms an angle of almost 80°, and becomes a much shorter organ. In some sterlets the end of the epiphysis cerebri went through the cranium, and was only covered by the bone shields of the exterior coating. *Scaphirhynchus* had the epiphysis less changeable and more similar to the epiphysis of other Ganoidei and *Dipnoi*. In other respects the brain of *Scaphirhynchus* also proved to have a closer resemblance to the other Ganoidei than to the Acipenser. Thus, its valvula cerebelli and lobi inferiores are more developed than those of a sterlet, and even remind one of the brain of *Amia* and its near relatives *Telosteii*.

Notwithstanding the scantiness of the facts stated here, I indulge the hope that they may add something to the means at our disposal for the settlement of the relationship between Ganoidei Chondrostei and other Ganoidei.

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