A Study of the Lateral-line System in Fish
II. On the Relation between the Function of the Lateral-line Organ and the Habits of Fish

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I

In a previous paper by the writers (1957) a quantitative analysis was made of fiber calibers in the lateral-line nerve of fishes. In this paper is discussed the relationship between the function of the lateral-line organ and the habits of fish from the ecological stand point of view.

There has been one work on the relationship between the function of the sense-organ and the habits of fish which was done by TAMURA (1957). He made study on the eye of many species of fish morphologically as well as physiologically. But, no work has been done on the lateral-line organ of many species from the ecological stand point of view.

II

In the previous paper we described the distribution of fiber diameters in the lateral-line nerve from three points ; 1. the histogram of the fiber diameters had one prominent peak ; 2. three types might be distinguished in their fiber distribution ; and 3. we could divide 81 species into three groups.

Thus, their typical types are shown in Fig. 1.

The following report was made by KATSUKI, YOSHINO and CHEN (1950-52) as results of the experiment on eel, *Anguilla japonica*.

"The response of each lateral-line nerve fiber of fish to various kinds of natural and artificial stimuli is different according to its fiber diameter," and it was concluded, thereby, that "the thinner fibers might be ralated to the perception of the existence of the stimulus, namely the threshold showed of sensation, and the thicker ones rather to its change, the discrimination."

OGAWA (1956) observed in the nerve of *Carassius auratus* that there were two kinds of fibers, which conduction velocity differed in each other.

Judging from the above-mentioned facts, it appears that there are the differentiation in nerve fibers of the laterl-line nerve in physiological point. Besides, the differentiations are found in all fishes, being gradually progressive from type A to type B and to type C.

It is suggested that higher animals have higher sensory organs in the sense that they can response to vibration of higher pitches.

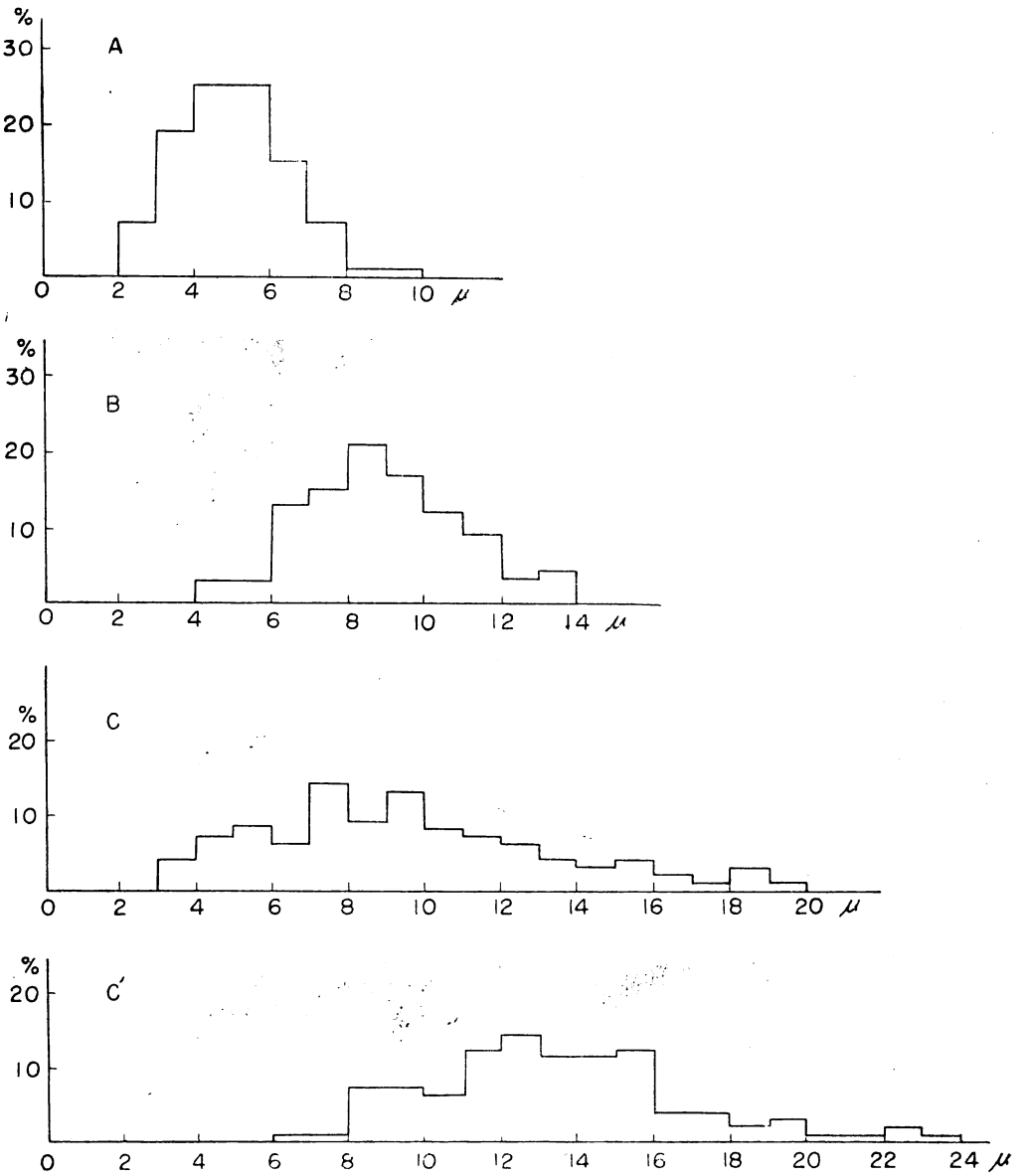

Fig. 1. Histogram of fiber-diameters

A : *Acheilognathus moriokae* (Group Ⅰ)
B : *Salmo gairdnerii irideus* (Group Ⅱ)
C : *Stephanolepis cirrhifer* (Group Ⅲ)
C′ : *Prognichtys agoo* (Group Ⅲ)

Ⅲ

Group Ⅰ. *Acheilognathus moriokae*, *Pseudorasbora parva*, *Carassius auratus*, *Oryzias latipes*, *Sebasticus marmoratus*, *Chasmichthys gulosus*, *Apogon semilineatus* and *Plotosus anguillaris* etc. belong to this group.

Some fresh water fish, such as crussian and killifish etc., live in the pond or in the calm river. Some marine fish, as rocky fish, goby and sea catfish etc., do not show active movement, but stay in underwater-cave or on the side of the rock or in the tide pool. They are relatively inactive and sluggish fishes, and they swim rather solitary. They do not migrate or roar over wide areas.

Group Ⅱ. *Salmo gairdnerii irideus*, *Cyprinus carpio*, *Parasilurus asotus*, *plecoglossus altivelis*, *Scomber japonicus*, *Trachurus japonicus*, *Seriola purpursens*, *Chrysophrys major*, and *Engraulis japonica* etc. belong to this group.

In this group there are found good swimmer, schooling fish, and migratory fish.

Most of them, as anchovy, mackerel and yellow tail, swim in group attractively. They have stronger swimming force, and they are the more active and excellent migratory fish, which more rapidly form school.

Mostly, they are adapted for rapid movement by being "stream-lined" with body form, either fusiform or laterally compressed. They are known to swim near the surface or the middle in water.

And then, there are found also some nocturnal fish in this group.

Group Ⅲ. *Anguilla japonica*, *Astroconger myriaster*, *Gymnothorax kidako*, *Lateolabrax japonicus*, *Oncorhynchus keta*, *Stephanolepis cirrhifer*, *Paralichthys olivaceus* and *Prognichthys agoo* etc. belong to this group.

In this group, there are found migratory fish, nocturnal fish, bottom feeder and flyingfish.

As salmon and pike etc., good swimmer and migratory fish are there. Some of fishes in this groups are known to remain quietly on the bottom. These fishes adapted to the life at the bottom by having the body-form angular or depressed, as the flatfish and sole. And then eel-like fishes belong to this group, and they are almost nocturnal fish. In addition to these fishes, we can find the strange habitant, which fly often over the water as the flying fish.

Ⅳ

As mentioned above, we can find some difference in the lateral-line nerve of many species of fish and describe the relationship between the fiber distribution of the nerve and the habits of fish.

Thus, the lateral-line sense organ is mainly a mechanoreceptor.

It is assumed that the behaviour of fish depends upon its sensitivity to various noises and vibrations under the water.

It is also assumed that the most common vibration in low frequency under the water may be arisen by swimming of fish, and by catching this stimuli through the lateral-line

sense the individuals make the school, especially at night.

The lateral-line sense may play an important role in the life of fish, in feeding, escaping and orientation, in turbid water, at dusk, at dawn and at night, whenever visibility is poor.

More schooling fishes are found in group Ⅱ and Ⅲ.

From this fact, it may be suggested that the vibration arisen by swimming of fish stimulates the fibers in size ranging from 6 μ to 10 μ.

The following results of electrophysiological study has been reported (KATSUKI et al., 1950—52). With a calm water flow only thin nerve fibers could be excited and somewhat higher rate of flow excited the thicker fibers. The thinnest fiber could follow the vibration of under 10 cps. only. On the contrary, most of the thicker fiber could follow that of 50 cps. and the thickest one that of nearly 100 cps.

Considering from these facts, it is assumed that the fibers between 6 μ and 10 μ in size are especially of use to vibration arisen by swimming of fish.

Since there are some surface-swimmer in group Ⅱ, it is suggested that the sounds transmitted on the surface of water also excite these fibers.

We can find some nocturnal fish in group Ⅱ and Ⅲ, especially in group Ⅲ, and the nerve of such a fish consists of many kinds of fibers varying in size, especially of many thicker fiber.

As the thicker and the thickest fibers are excited with somewhat higher rate of vibration under the water, these fishes may respond to the relatively wide range of the vibration, using this sense organ.

These fact suggest that the lateral-line sense play an important role in behaviours at dawn and at night.

Results of our studies lend support to the view that a fish belonged in group Ⅲ may have higher degree of sensitivity to mechanical stimuli.

It is very interesting that the fibers ranging in size between 20 μ and 25 μ are found in the three species of fish, the flyingfish, the saury and a species of half beak. They are relatives each other and have strange habits in all, such as jumping out of water or flying over, the surface. And their lateral-line organ lie near the abdominal margin of body. These facts suggest that these fibers of the above fishes are more sensitive to tactile stimulus than the other fibers.

From the fact that a number of fishes belong to group Ⅰ, it may be concluded that the function of the nerve fiber in above-mentioned range (6 μ to 10 μ) is very significant in the life of fish in general.

The sound arisen by swimming of fish is one of those produced by fish under the water in natural environments, and the range of the sounds is relatively in low frequency, and therefore the lateral-line plays very important role in the life of fish.

But, the fish can produce various sounds, in the case of shoaling, feeding, warming, breathing, and breeding and the mechanism for sound production is varied. We shall report on these noises produced by fish under the water in the near future.

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Summary

Ⅰ. The comparative analysis of the fiber distribution on the lateral-line of fish is made. And we can find the differentiation among them.

Ⅱ. We discuss on the relation between the function of the lateral-line organs and the habits of the fish from the ecological stand point of view.

Results of our studies lend support to the view that the habit of the fish belonged to the three groups may depend upon the function of each own nerve.

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