

Comparative Studies of the Scales in Japanese Freshwater Fishes, with Special Reference to Phylogeny and Evolution

(continued from vol. iii, p. 86)

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[IV] Particular Lepidology of Freshwater Fishes

I. Suborder Isospondyli (continued)

[2] Dorosomatidae

Japanese members of Dorosomatidae belong to the genus *Clupanodon*; they are usually marine, but as they sometimes come into freshwater, they have been studied.

(3) *Clupanodon punctatus* (TEMMINCK et SCHLEGEL) (fig. 12, 15)

As to outline of scales, those of c. b. s. are of hexagonal form a little broader than long; basal tip and apex are projected; lateral margin is gently swelled out; those of s. c. p. are almost hexagonal, whole shape being more or less irregular.

Focus is situated in geometrical center of scales; both grooves and ridges run almost transverse, and longitudinal grooves are rarely found. Number of grooves is comparatively small, some having only one transverse groove. Some s. c. p. scales have several lines of lateral transverse grooves, besides a line of main transverse grooves, and yet these sometimes form a more or less irregular network. Ridges are very fine, delicate, transverse and curved a little forward; there also exist some behind the main transverse grooves. Scales have basal and lateral ridges, but no apical ridges; in apical area are observe growth lines. In s. c. p. scales, where grooves make sparse network, ridges often show a finger-pattern-like arrangement.

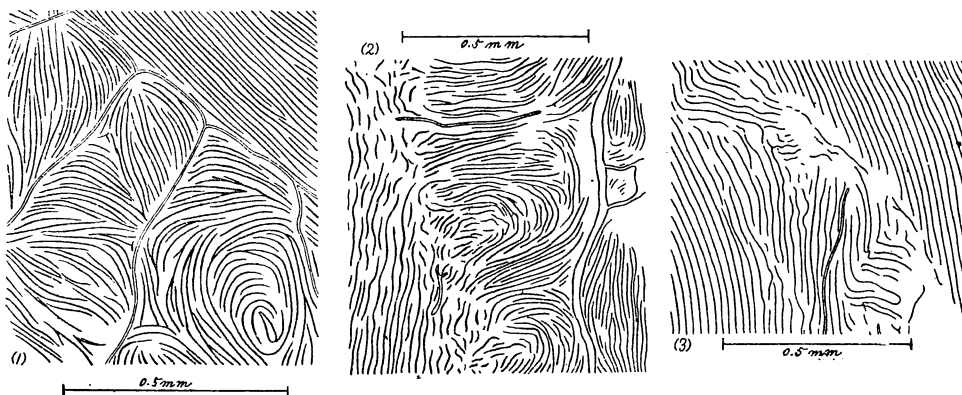


Fig. 12. Finger-pattern-like arrangement of ridges. (1) *Engraulis japonica* (Engraulidae); (2) *Clupanodon punctatus* (Dorosomatidae); (3) *Clupea pallasii* (Clupeidae).

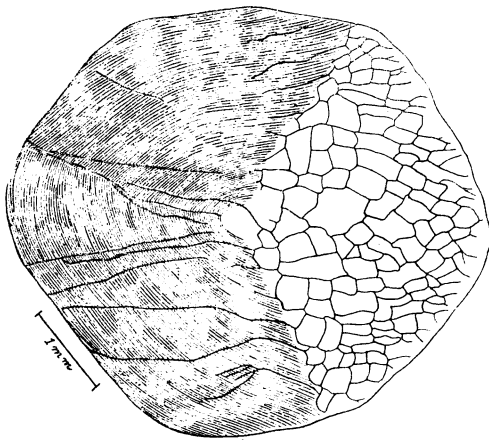


Fig. 13. *Coilia mystus* (Engrauridae). 28 cm, from posterior part of body side, River Tikugo, Kyūsyū.

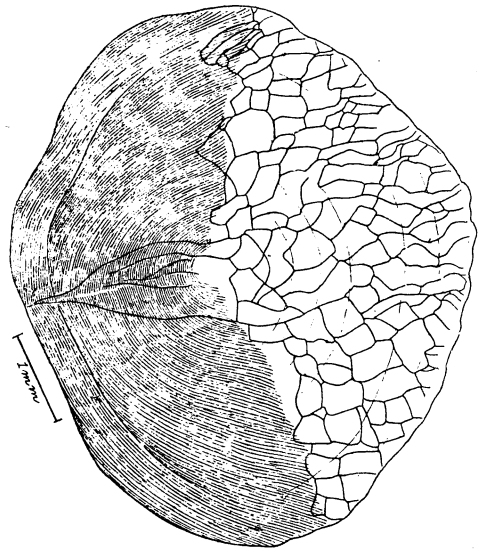


Fig. 14. *Coilia ectenes* (Engraulidae). 24.5 cm, from upper part of anal fin insertion, Soul, Corea.

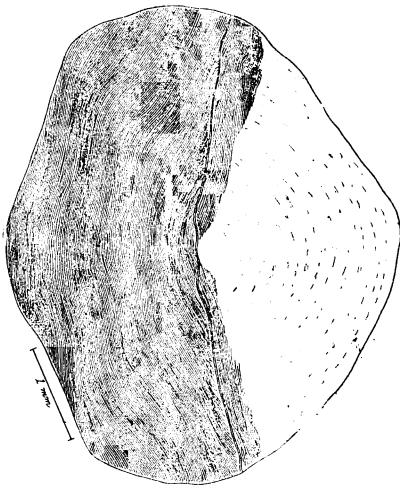


Fig. 15. *Clupanodon punctatus* (Dorosomatidae). 14 cm, from c. b. s., Ise Bay.

Discussion

The important characteristic of this species is that the scales have both transverse grooves and transverse ridges; this is common to scales of some species in Clupeidae and Engrauridae, and the scales are especially similar to those of *Harengula* and *Engraulis*.

That ridges sometimes form a finger-pattern-like structure is one of the common characteristics of these families. In short, it is clarified that the scale character of this species has a deep connection with its related families and the characteristics of this species which it shows as one species of Dorosomatidae in c. b. s. scales, are as follows: (1) focus is distinct, (2) transverse grooves are small in number, among which only one is typical, (3) it has transverse grooves curved a little forward, and (4) grooves sometimes form a network with large meshes.

[3] Coregonidae

Though no fishes belonging to Coregonidae are found in Japan, under the necessity of comparison with scales of Salmonidae and Osmeridae, two genera, *Coregonus* and *Brachymystax* found in the adjacent Continent and Sakhalin, two species from the former and one from the latter, three species in all, were used as materials for study.

Scales of Coregonidae have cycloid scales of the so-called Salmonidae type, with no grooves at all, but have the sculpture made up of ridges only. The scale character resembles that of Salmonidae or Osmeridae, and thus Coregonidae is regarded by some systematists even today as well as in the past as Subfamily Coregoninae in Salmonidae; scales of these fishes are so similar that such a method of classification may be used also in scale character.

In scales of Coregonidae, focus is situated near center, and outline of scales is a little different from that of foregoing two genera; in *Brachymystax*, basilateral angles are distinct and nearly right-angled, basal margin being greatly waved, but in *Coregonus*, angles, though they exist, are not so distinct, outline of scales being subsphaerical, basal margin not wavy. That c. b. s. scales are broader than long was reported by Cockerell (1913) in his study of *Coregonus coulteri*, which may be considered to be the characteristic of Coregonidae as well as of Genus *Coregonus*. He says that this is always the same as the *Salmo* group, but in *Salmo shasta* found in this country and studied by the author (though this species was introduced from U. S. A.) they are longer than broad as in *Oncorhynchus* or *Salvelinus*. And again Cockerell says in the same paper that the characteristic of Subfamily Coregoninae is that scales are nearly always longer than broad, and that laterobasal angles are more or less developed, and this must be the characteristic of Coregonidae in which it differs from Salmonidae.

What is interesting, moreover, is that the scale character of *Brachymystax* resembles that of genus *Thymallus* in Thymallidae giving enough evidence to show the close phylogenetic relation between *Brachymystax* and *Thymallus*. It is not too much to say that *Brachymystax* resembles *Thymallus*, a different family, more than *Coregonus* in the same family. Scales of *Thymallus* are longer than those of *Brachymystax*, and degeneration is seen in apical ridges, but both very closely resemble each other in that basal margin and ridges are wavy, and that basilateral angles are prominent, so that *Thymallus* may be said to have its origin in *Brachymystax* in Coregonidae.

The key by scale character is shown as follows :

- A₁ Scales subsphaerical in outline, angles inconspicuous, basal margin not wavy
*Coregonus*.
- A₂ Scales semisphaerical in outline, basilateral angles distinct, basal margin wavy
*Brachymystax*.

Genus *Coregonus*

That scales of *Coregonus* resemble those of *Brachymystax* mentioned below, and are common in principle, was already stated, and it is needless to say that there is a very close affinity between both genera, but as has been shown in the key, there is such a

considerable difference in the outline of scales, that both genera should not be mixed together.

(4) *Coregonus ussuriensis* BERG (fig. 16)

Specimen from River Esutori, Nayoro-gun (o. n. abbreviation for old name), Sakhalin, 32 cm.

Outline of scales is subsphaerical; basilateral angles are somewhat distinct; center of basal margin is projected; whole lateral margin is swelled out; it is characteristic of scales of this species that they are broader than long. Focus is a little apical; ridges

exist in each area, being arranged around focus rather in regular concentricity, and are curved outward on boundary between lateral and apical areas, decreasing in number in this part. Apical ridges in early stage of growth are distinct, but they become more or less inconspicuous later. In lateral and basal ridges winter bands appear distinctly, by which age of fishes can be known.



Fig. 16. *Coregonus ussuriensis* (Coregonidae). 32 cm, from c. b. s., River Esutori, Nayori-gun (o. n.), Saghalin.

Discussion

Scales of this species are very different in outline from those of Salmonidae, and are clearly distinguished even from those of *Brachymystax* in the same family. They are rather distant in affinity from any species of Salmonidae, and are supposed to be primitive as was described by

COCKERELL, and this will be the same when considered from other morphological characters of this fish.

When compared with *Alvula* found in North Germany, both are quite similar and known to be phylogenetically the same.

(5) *Coregonus alvula* LINNE (fig. 17)

Specimen from Ploen See, North Germany, 14 cm.

Outline of scales is like that of *Ussuriensis*, breadth being equal to length, or they are much broader than long ($\times 1-1.3$); focus is situated a little toward base from center, anterior $1/2.2-3$ of scales. Focal ridges are very thick and sparse, but they become dense as they stretch outward, until they are densely spread in winter zone with smallest space between them; after passing the same zone, they become suddenly sparse. These ridges in winter zone all disappear, leaving behind basal ridges and only anterior part of lateral ridges. This is one of scale characters of this species. Several to ten ridges around focus disappear as they gradually stretch backward. In short, besides



Fig. 17. *Coregonus alvula* (Coregonidae). 14 cm, from c. b. s., Ploen See, North German.

Genus *Brachymystax*

One species from Heiho Province, *B. lenok* (PALLAS), body length 17cm, was observed. As the characteristic of the genus was already explained in detail, it will not be repeated here, but scales of *Brachymystax* are similar to those of *Thymallus* in Thymallidae, and there is such a close phylogenetic relation between them that it is considered with reason that probably *Thymallus* has its origin in *Brachymystax*.

(6) *Brachymystax lenok* (PALLAS) (fig. 18)

Whole shape of scales is semisphaerical; basilateral angles are almost right-angled; basal margin is truncated as a whole, but margin has big waves; apical margin is also a little waved; scales are broader than long, breadth being $\times 1.15-1.25$ length. Focus is situated nearly in center or a little inclined toward base of scales, anterior $1/2-2.4$ of them. Ridges are perfectly concentric, thick and distinct, spreading all over scales, but apical ridges are rather inconspicuous. Basal ridges are dense, and run parallel with basal margin, being greatly waved, until on boundary of lateral area, they pass into lateral ridges, making acute angles. Lateral and apical ridges are more or less widely spaced, some apical ridges which lie near margin being more or less waved; winter band is indistinct.

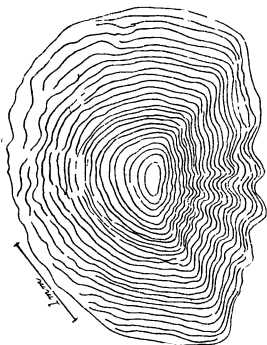


Fig. 18. *Brachymystax lenok* (Coregonidae). 17 cm, from c. b. s., Heiho Prov., Mauchhria.

focal ridges, apical ridges exist, but they are more or less indistinct and broken; basal and lateral ridges are very distinct except winter zone; basal ridges are greatest in number; lateral ridges decrease in number as they run backward.

Discussion

The scale character of this species resembles that of *Ussuriensis* very much, showing clearly that there is a close affinity between both species. It is to be noticed, however, that in *Alvula*, apical ridges become indistinct, and that winter zones are distinct, ridges disappearing in these zones, and such a structure is considered to be the characteristic of this species. It is similar to *Ussuriensis* in that winter zone is seen distinctly.

Discussion

The scales resemble those of *Coregonus* very much, which shows the close affinity between both genera, but the remarkable difference between them is that in scales of *Brachymystax*, basal margin is waved, and basilateral angles are distinct, making nearly right-angles. By this difference it is known that scales of this species are more similar to those of *Thymallus jaluensis*, and the author cannot but consider that it shows a close affinity with *Thymallus* after all.

(to be continued)

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第参卷 第3/4/5號

昭和29年6月20日印刷・昭和29年6月30日發行

定價1部 400圓 送料30圓 1ヶ年分会費700円(送料共)

編集者 岡田 彌一郎・發行者 相澤 喜一郎

印刷者 成島 信義 東京都中央区日本橋本石町3ノ4

發行所 日本魚學振興會 東京都中央区築地5丁目1番地

電話築地(55) 1171-9・2171-9・3171-9

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