Japanese Journal of Ichthyology
Vol. 17, No. 1 April 15, 1970

魚類学雑誌
17巻1号 1970年4月15日

# Studies on the Lateral Scutes of Sticklebacks (Gasterosteidae) in Japan—VII. Development of the Scutes of the Ten-Spined Stickleback, *Pungitius tymensis* (Nikolsky)

Kiyoshi Igarashi

(Received November 28, 1969)

**Abstract** Studies were made on specimens of *Pungitius tymensis* collected at four localities in Hokkaido. The species falls on semiarmata type in lateral scute system, and each scute, though provided with a few branched ridges, lacks net-work ridges. This status suggests the species is more primitive than *Pungitius pungitius* and *P. sinensis*. The earliest scutes appear on the caudal peduncle in the fish 23 mm long in total length, showing the most retarded appearance of the scutes among the species in the genus. The scutes on the shoulder region develop in the fish 32 mm long. The development of the scutes are suspended even in adult fish. The number of scutes on caudal peduncle is fewer, the dorsal spines are stouter and shorter, and the geographical range is more restricted in *P. tymensis* than in *P. pungitius*.

In the serial studies on the morphology and development of lateral scutes in the sticklebacks of Japan, I have treated (Igarashi, 1962, 1963, 1964, 1965, 1968, 1969) *Pungitius sinensis*, *P. pungitius, P. kaibarae, P.* sp., *Gasterosteus aculeatus aculeatus* (sea-run and landlocked forms) and *G. aculeatus microcephalus*. The present paper deals with *Pungitius tymensis* or ezotomiyo in Japanese, endemic to the waters of Sakhaline and Hokkaido.

The present form has been treated as a subspecies of *Pungitius pungitius* by Matsubara (1955), Okada (1960) and others, but, Nakamura (1963), Aoyagi (1957), Kobayashi (1957a) and others recognized its validity as a distinct species. Ikeda (1933), Kobayashi (1957a and b) and Ishigaki (1967), especially the last named author have reported on the present form referring to its distribution, morphology and meristic characters. Their studies, however, did not go into details of the structure and development of the lateral scutes. The present study on the lateral scutes convinced me that *Pungitius tymensis* is a species rather than a sub-species of *P. pungitius*.

## Material and methods

Sixty-four specimens of *Pungitius tymensis*, 10 to 72 mm in total length, collected in Hokkadio, were examined:

28 specimens, 10 to 51 mm in total length. A creek connected to the Chitose River at Hiroshima Village; August 8, 1969: collected by Dr. K. Ishigaki.

10 specimens, 32 to 70 mm. A small stream connecting to the Kotanuka River at Nemuro; October 30, 1969; by Mr. M. Hatanaka.

7 specimens, 42 to 72 mm. A small flow pouring into the Kushiro River at Kushiro; October 30, 1969; by Dr. K. Ishigaki.

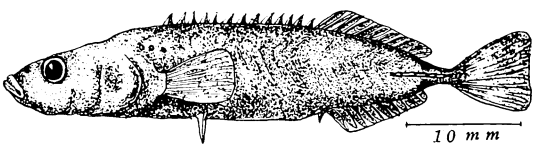


Fig. 1. *Pungitius tymensis* (Nikolsky) collected at Hiroshima Village, Hokkaido on August 10, 1969.

1 specimen, 45 mm. A creek running into the Kuchiaro Lake; May 10, 1968; by Dr. T. Tomoda.

All the specimens collected were preserved in formalin (ca. 10%). The scutes were cleared by Mall's solution and stained with alizarin red through routine procedure (Igarashi, 1968), and the drawings of the scutes were made under a microscope through the Abbe's apparatus.

## Results and discussion

On the individuals over 30 mm in total length the scutes were counted one to four on the shoulder region and four to seven on the caudal peduncle, otherwise, the body is naked thus the scute formation categorized, together with that of *Pungitius pungitius*, into the semiarmata type. The earliest development of the scutes in the present species is represented by four pieces on the caudal peduncle when the fish attain the size of 23 mm. It is noted that the size of fish to show the first appearance of the scutes is the largest in *P. tymensis* as compared with other species of the same genus (20 mm for *P. sinensis*, 18 mm for *P. kaibarae*, and 15 mm for *P. pungitius*).

As to the development of each scute whether on the caudal peduncle or the shoulder region. I have recognized three stages, early, middle and late on the basis of its structure (Igarashi, 1962). In the present species the early stage is, as shown above, seen in the fish 23 mm long, the middle stage in 26.5 mm and the late stage in 32 mm; in the last stage the scutes on the caudal peduncle are provided with mucous tube whereby the scute formation is completed, while, those on the shoulder region are represented by so-called "scale-like particles" numbering two to three (Kobayashi, 1957a and b). The completed scutes on the caudal peduncle show a few branched ridges but lack entirely the net-work ridges, which are well presented in those of *P. kaibarae* and *P. pungitius*. In this respect the present species resemble *Pungitius* sp. ("Musashi-tomiyo", a form without scientific name, of which Igarashi (1968) made a study). These facts found in the present study will lead to believe that development of the scutes are suspended morphologically earlier in *Pungitius tymensis* than in other species of the genus *Pungitius*, and I am inclined to interprete it a phenomenon of neoteny.

In some specimens among 64, it was noted that a small amount of scaly material developing around each neural pore alined between the scute system of the shoulder region and caudal peduncle. This finding will indicate, I believe, that the present species, though typically semiarmata type, must have originated in trachura type, which is represented by *P. sinensis*.

As to the variation in the number of scutes among the species in the genus *Pungitius*, Ikeda (1933), Kobayashi (1957a and b) and Ishigaki (1967) showed a rather wide range of counts in *P. pungitius*, which is believed most closely related to *Pungitius tymensis*. Working on the specimens of *P. pungitius* taken from the waters of Hokkaido, Ishigaki (1967) showed the scutes counts 0–4 on the shoulder region and 8–16 on the caudal region, and the same for *P. tymensis* 0–5 and 4–8 respectively. In the present material, 64 specimens of *P. tymensis*, I counted 0–4 and 4–7 (Table 2). It may be pointed out here that the range of the number of the scutes on the caudal peduncle is wider in *P. pungitius* than in *P. tymensis*.

The dorsal spines, which also give a criterion to separate these two species, were counted in adult fishes of *P. tymensis* 10–13 ($11.46 \pm 0.07$ on 440 specimens) by Ishigaki (1967*r* and Aoyagi (1957) gave the count 8–13. In the specimens here I counted 9–13 (Table 1). For *P. pungitius*, on the other hand, Ishigaki (1967) gave the count 9–10 ($9.24 \pm 0.18$ on 26 specimens), and Aoyagi (1957) 7–12 but demonstrating a slight tendency of north-to-south geographical variation. Also, the specimens examined by me had shorter dorsal spines as compared with those of *P. pungitius*,

Table 1. Measurements of six body parts given in mm of *Pungitius tymensis* collected in Hokkaido, with number of lateral scutes and fin rays.

| Locality | Total length | Body length | Body depth | Head length | Trunk length | Tail length | Length of caudal peduncle | No. of scutes | | | Fin rays | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Shoulder region | Caudal peduncle | Total | D | V | A |
| Kotanuka | 32 | 27 | 6 | 8 | 10 | 11 | 3 | 1 | 6 | 7 | XII, 10 | I, 0 | I, 12 |
| River | 34 | 30 | 6 | 8.5 | 11 | 12 | 3 | 2 | 5 | 7 | X, 10 | I, 0 | I, 10 |
| (Nemuro) | 35 | 30 | 6 | 9.5 | 10 | 12 | 4 | 0 | 5 | 5 | XI, 11 | I, 0 | I, 10 |
| | 40 | 34 | 6 | 11 | 13 | 14 | 5 | 2 | 5 | 7 | XI, 10 | I, 0 | I, 8 |
| | 48.5 | 43 | 9 | 12 | 15 | 17 | 6 | 3 | 6 | 9 | XI, 10 | I, 0 | I, 10 |
| | 53 | 46 | 9 | 13 | 17 | 19 | 5 | 3 | 5 | 8 | X, 9 | I, 0 | I, 10 |
| | 70 | 61 | 13 | 16 | 25 | 25 | 7 | 0 | 6 | 6 | XI, 10 | I, 0 | I, 10 |
| | 60 | 54 | 10 | 15.5 | 23 | 21 | 6 | 2 | 6 | 8 | XI, 10 | I, 0 | I, 10 |
| | 63 | 57 | 10 | 16 | 24 | 23 | 8 | 3 | 8 | 11 | IX, 11 | I, 0 | I, 10 |
| | 66 | 50 | 10 | 13 | 19 | 20 | 6 | 2 | 5 | 7 | XI, 10 | I, 0 | I, 10 |
| Kushiro | 42 | 37.5 | 6 | 11.5 | 13 | 14 | 4 | 3 | 5 | 8 | XI, 11 | I, 0 | I, 9 |
| | 45.5 | 40.5 | 7 | 12 | 11 | 11 | 4 | 2 | 6 | 8 | XI, 10 | I, 0 | I, 10 |
| | 46 | 40 | 7 | 12 | 14 | 16 | 5 | 2 | 7 | 7 | XII, 10 | I, 0 | I, 10 |
| | 46 | 41 | 8 | 12.5 | 15 | 15 | 3 | 3 | 5 | 8 | XI, 12 | I, 0 | I, 10 |
| | 49 | 38 | 7 | 12 | 15 | 17 | 5 | 1 | 5 | 6 | XII, 11 | I, 0 | I, 10 |
| | 51 | 45 | 8 | 11.5 | 16 | 18 | 4.5 | 2 | 4 | 6 | XIII, 10 | I, 0 | I, 10 |
| | 53.5 | 43.5 | 8.5 | 12 | 19 | 20 | 5 | 4 | 4 | 8 | XI, 13 | I, 0 | I, 10 |
| | 54 | 48 | 9 | 13 | 19 | 18 | 4.5 | 3 | 5 | 8 | XI, 11 | I, 0 | I, 10 |
| | 55 | 47 | 9 | 13 | 17 | 18 | 5.5 | 2 | 4 | 6 | XII, 11 | I, 0 | I, 10 |
| | 58 | 51 | 9 | 13 | 19 | 21 | 5 | 2 | 5 | 7 | XII, 11 | I, 0 | I, 10 |
| | 58.5 | 50.5 | 10 | 13 | 21 | 19 | 4.5 | 1 | 4 | 5 | XI, 10 | I, 0 | I, 10 |
| | 66 | 57 | 11 | 15 | 22.5 | 22.5 | 6 | 3 | 5 | 8 | XII, 11 | I, 0 | I, 10 |
| | 66 | 58 | 10 | 17 | 23 | 22 | 6 | 3 | 6 | 9 | XII, 11 | I, 0 | I, 10 |
| | 69.5 | 60.5 | 13 | 17 | 25 | 23 | 6 | 0 | 4 | 4 | X, 10 | I, 0 | I, 10 |
| | 71 | 65 | 13 | 11.5 | 27.5 | 25 | 7 | 3 | 5 | 8 | X, 10 | I, 0 | I, 10 |
| Lake Kuchiaro | 45 | 40 | 10 | 12 | 17 | 14.5 | 4.5 | 2 | 5 | 7 | XI, 10 | I, 0 | I, 10 |

which accord with the description of Aoyagi (1957). Further, it was confirmed that *P. tymensis* lacks soft pelvic rays (Table 1) as observed by Aoyagi (1957), Nakamura (1963) and Kobayashi (1957b).

Kobayashi (1957b) stated that the dorsal, spines in *P. tymensis* are the shortest and stoutest of the genus, and the scutes are the least developed. In my previous work (Igarashi, 1962) and present study I found that *P. tymensis* is, in its basic shape and development of the scutes (Fig. 2) less differentiated than *P. pungitius*, and the number of scutes is fewer as stated above.

The geographical range of *P. tymensis* (restricted to Sakhalin and Hokkaido) is much narrower than that of *P. pungitius* (Siberia and Alaska; extending southward to Hokkaido and middle Honshu, Japan). Kobayashi (1957a and b), reporting the partial sympatric occurence of two species, recorded natural hybridization. Also, Ishigaki (1967) collected the two species together in one stream on the Pacific coast of Hokkaido, but failed to find the hybrid. My collection at Hiroshima Village (see above), where two species were found, did not include the hybrid. Although *P. pungitius* and *P. tymensis* are now sympatric at least in Hokkaido, these two forms must have long been isolated ecologically, physiologically, or genetically from another. The problem of natural hybridization between *P. pungitius* and *P. tymensis* should wait its solution until future studies on large number of material collected on the fields.

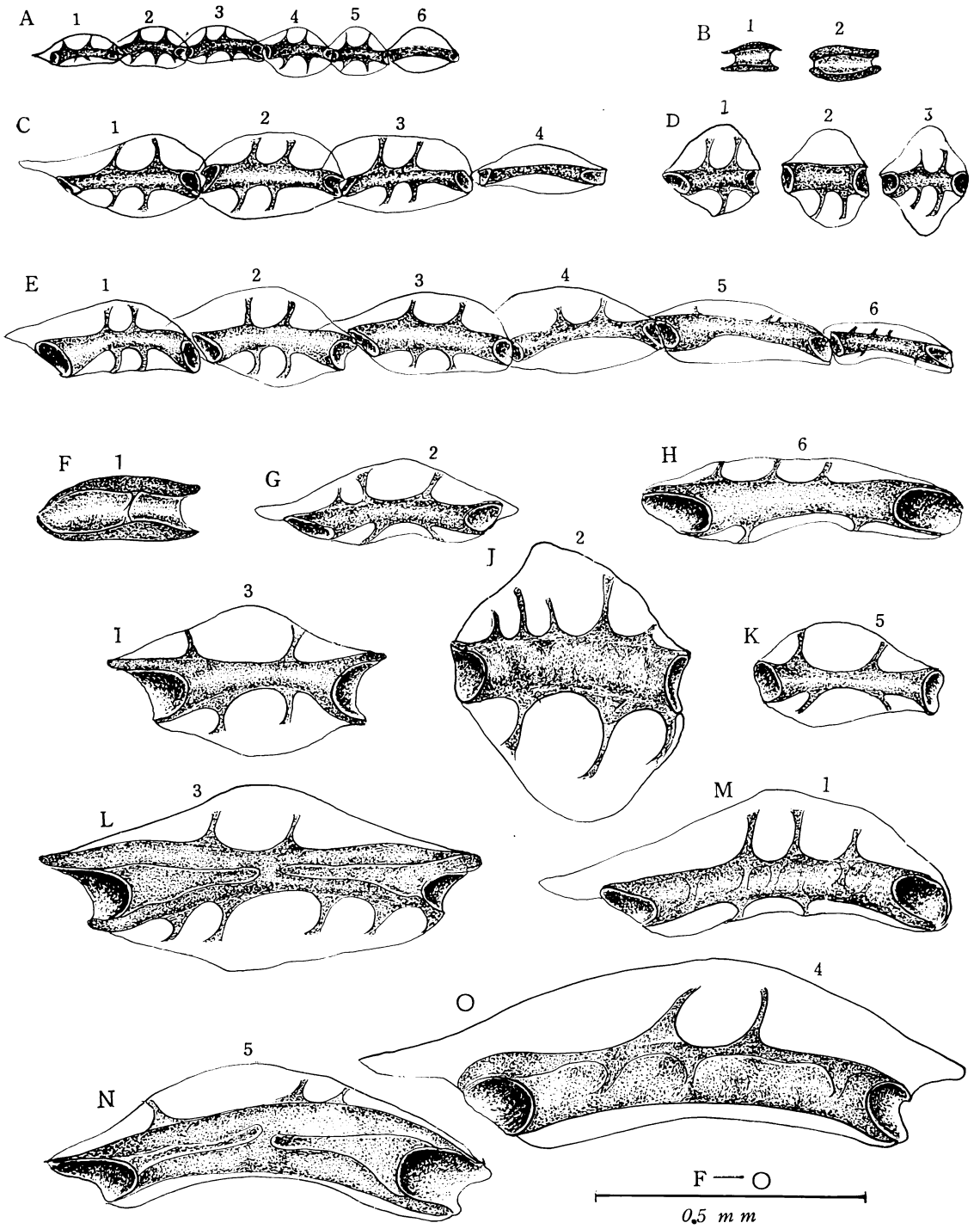


Fig. 2. Lateral scutes of *Pungitius tymensis* to show their arrangement and the structure of mucous tube on some scute. A, posterior scutes on caudal peduncle of a fish 23 mm in total length; B, anterior two scutes on shoulder region (51 mm); C, posterior scutes on caudal peduncle (51 mm); D, anterior scutes on shoulder region (66 mm); E, posterior scutes on caudal peduncle (66 mm); F, an anterior scute (enlarged view)

Table 2. Number of lateral scutes in the two regions of body and fin rays counted on *Pungitius tymensis* collected at Hiroshima Village, Hokkaido (August 8, 1969) to show their development by the size of fish. The scutes are categorized into three developmental stages; early (E), middle (M) and late (L). See text.

| Total length (mm) | Total No. of sutes | No. of scutes by developmental stage | | | | | | Fin rays | | | | No. of specimens |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Shoulder region | | | caudal regiion | | | D | P | V | A | |
| | | E | M | L | E | M | L | | | | | |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | I, 6 | ? | 0 | I, 5 | 1 |
| 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | II, 9 | ? | 0 | I, 9 | 3 |
| 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | II, 10 | ? | 0 | I, 10 | 1 |
| 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | III, 11 | ? | 0 | I, 10 | 2 |
| 14 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | IV, 11 | 10 | 0 | I, 10 | 2 |
| 15 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | V, 10 | 10 | I, 0 | I, 10 | 1 |
| 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | V, 10 | 10 | I, 0 | I, 10 | 1 |
| 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | X, 11 | 10 | I, 0 | I, 10 | 2 |
| 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | X, 11 | 10 | I, 0 | I, 10 | 1 |
| 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | XI, 10 | 10 | I, 0 | I, 10 | 2 |
| 23 | 4 | 0 | 0 | 0 | 4 | 0 | 0 | XI, 10 | 10 | I, 0 | I, 9 | 1 |
| 24 | 4 | 0 | 0 | 0 | 4 | 0 | 0 | XI, 11 | 10 | I, 0 | I, 10 | 2 |
| 25 | 4 | 0 | 0 | 0 | 4 | 0 | 0 | XI, 11 | 10 | I, 0 | I, 10 | 2 |
| 26 5 | 4 | 0 | 0 | 0 | 0 | 4 | 0 | XI, 10 | 10 | I, 0 | I, 9 | 1 |
| 27 | 5 | 0 | 0 | 0 | 1 | 4 | 0 | IX, 10 | 10 | I, 0 | I, 10 | 2 |
| 28 5 | 6 | 0 | 0 | 0 | 0 | 6 | 0 | XI, 11 | 10 | I, 0 | I, 10 | 1 |
| 29 | 5 | 0 | 0 | 0 | 0 | 5 | 0 | XI, 11 | 10 | I, 0 | I, 10 | 2 |
| 32 | 7 | 1 | 0 | 0 | 0 | 0 | 6 | XII, 11 | 10 | I, 0 | I, 12 | 3 |
| 34 | 7 | 2 | 0 | 0 | 0 | 0 | 5 | X, 10 | 10 | I, 0 | I, 10 | 2 |
| 35 | 7 | 0 | 0 | 0 | 0 | 0 | 7 | XI, 11 | 10 | I, 0 | I, 10 | 1 |
| 40 | 7 | 3 | 0 | 0 | 0 | 0 | 4 | XII, 11 | 10 | I, 0 | I, 9 | 2 |
| 42 | 6 | 1 | 0 | 0 | 0 | 0 | 5 | XI, 10 | 10 | I, 0 | I, 8 | 1 |
| 42 | 8 | 3 | 0 | 0 | 0 | 0 | 5 | XIII, 11 | 10 | I, 0 | I, 9 | 1 |
| 43 | 8 | 3 | 0 | 0 | 0 | 0 | 5 | XII, 11 | 9 | I, 0 | I, 9 | 3 |
| 45 | 7 | 2 | 0 | 0 | 0 | 0 | 5 | XI, 12 | 10 | I, 0 | I, 10 | 2 |
| 46 | 7 | 2 | 0 | 0 | 0 | 0 | 5 | XII, 10 | 10 | I, 0 | I, 10 | 2 |
| 47 | 10 | 4 | 0 | 0 | 0 | 0 | 6 | XIII, 11 | 10 | I, 0 | I, 10 | 1 |
| 51 | 6 | 2 | 0 | 0 | 0 | 0 | 4 | XIII, 11 | 10 | I, 0 | I, 10 | 2 |

**Acknowledgments**

It is my pleasant duty to express gratitude to Dr. Mamoru Kusa, Yamagata University, who has shown keen interest in my study and afforded expert guidance to the study, and to Prof. Sajiro Makino, Hokkaido University, for the help in many ways. Drs. Toshio Tomoda, Kenkichi Ishigaki and Mr. Minoru Hatanaka of the Atutoko Junior High Scool presented mateiral to me, for whom I must express my deepest appreciation. I want to record here my heartfelt thanks to Dr. Morizumi Nakamura, National Science Museum, who has given me everlasting guidance and encouragement on my study of the sticklebacks. Dr. Katsuzo Kuronuma was kind enough to assist me in preparing the manuscript.

on shoulder region (51 mm); G, enlarged view of the scute 2 shown in A; H, enlarged view of the scute 6 shown in E; I, enlarged view of the scute 3 shown in A; J, enlarged view of a scute on posterior part of shoulder region (51 mm); K, enlarged view of the scute 5 shown in A; L, enlarged vew of a scute on posterior part of caudal peduncle (66 mm): M, enlarged view of a scute on posterior part of caudal peduncle (66 mm); N, enlarged view of a scute on posterior part of caudal peduncle (66 mm); O, enlarged view of the scute 4 shown in E.

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(Fukui Prefectural Institute of Education, Sen'i-Kyokai Bldg., 3 Ote, Fukui City, Fukui Pref., Japan)

## 日本産トゲウオ科魚類の鱗板の研究 VII. エゾトミヨの稜鱗の発達について

五十嵐 清

エゾトミヨ *Pungitius tymentis* は肩部と尾柄部にだけ鱗板のある semiarmata 型の側線鱗を有し，鱗板の退行化が著しく，側隆起線は僅かに枝分れしているだけである．エゾトミヨの鱗板は全長 23 mm で初めて尾柄部に現われるが，トミヨ属のなかの何れの種よりも鱗板の出現がおそい．全長 32 mm に成長すると肩部に数個の鱗板が現われるが，成魚にいたっても未発達のままの痕跡鱗である．鱗板の形成はイバラトミヨ，ムサシトミヨと同様に稚魚の早い時期に止まり，そのまま成熟して幼態成熟となる．鱗板の出現順序や基本的構造はイバラトミヨ，ムサシトミヨと類似しており，これらと系統的に近縁なことが推察できるが，鱗板の他に背鰭棘の形質などに於て異なり，樺太，北海道の限られた分布域で陸封化にともない分化し，エゾトミヨ特有の形態を示すに至ったと思われる．エゾトミヨをイバラトミヨの一亜種とするより，それに近縁な独立種とすることが妥当と考えられる．

(福井市大手3, 繊維ビル 501 福井県教育研究所)