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By O.A. Zvyagina

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DATA ON THE PROPAGATION AND DEVELOPMENT

OF FISH OF LAPTEV SEA. 1. EAST-SIBERIAN COD

(ARCTOGADUS BORISOVI, GADIDAE)

East-Siberian cod (Arctogadus borisovi) is prevalent in the Arctic seas from Sterlegov Cape (Taimyr Peninsula) to Billings Cape (East-Siberian Sea). There is no data in the literature on the conditions of its propagation and development. Hitherto, the eggs and larvae had not been known. Therefore, even the little material which we have collected in the Laptev Sea (13 larvae, 24 fingerlings and one mature female) enable us, in some degree, to speak about the structure of larvae and fingerlings and about the propagation of this species.

A comparison of our data with data obtained earlier on the development of other cod (Gadus morhua morhua - Schmidt, 1905; Ehrenbaum, 1905-1909; Rass, 1948; G. morhua macrocephalus - Kamiya, 1925; Inaba, 1931; Uchida, 1936; Rass and Zheltenkova, 1948; Gorbunova, 1951, 1954; Mukhacheva and Zvyagina, 1960; Boreogadus

saida - Rass, 1945; Gorbunova, 1954) enabled the establishment of the morphological distinguishing features of East-Siberian cod. Larvae and fingerlings were collected from July 24 to August 26, 1958 on / the experimental vessel "Polyarnik" in the Laptev Sea between 124°00' E. 77°00' - 71°30' N. and in the coastal part.

At each of the 82 stations, we conducted one vertical haul from the bottom to the surface and one ten-minute horizontal haul with the vessel at low speed (according to the manual of Rass, 1939). Larvae were collected by means of an ichthyoplankton net (diameter - 50 cm, gauze N° 140 - 150). The haul of fry and mature fish was conducted in the coastal zone of the Laptev Sea (Buorkhaya Bay) from the fishing vessel "Uragan". An otter trawl was used as the basic fishing gear. The catches of trap nets situated in the inlets of Buorkhaya Bay were also inspected.

Only one mature fish was found in the hauls - a female with mature sexual products in stage IV of maturity. Thirty-two thousand six hundred eggs were found in the ovaries plus the membranes.

From 1 to 10 larvae, 11 to 21.5 mm long, were obtained to a haul, at three stations situated west of the Novosibirsk Islands (141 - 142 E.) above depths of 18 - 44 m, at a temperature range of 0.7 - 2.2° at the surface and 1.1 - 1.72° at the bottom. Fingerlings, 54 - 68 mm long, were only found in places of fattening - in the shallow, well warmed-up zone.

There is good agreement between the dimensions of the larvae of East-Siberian cod which we collected and those of Pacific cod found in analogous periods in the Bering Sea which, possibly, suggests a similarity in the seasons of propagation. But spawning of Pacific cod, as is known, occurs in the Bering Sea from February to April.

Considering the length of the incubation period in /321 conditions of low temperatures and the dimensions of larvae obtained in July, we would assume that spawning of East-Siberian cod as well as Pacific cod occurs in January - March; but, individual retarded semi-mature specimens are encountered throughout the entire summer and autumn (the female mentioned above, with almost mature sexual products, was obtained in the coastal zone, September 12)¹.

Winter spawning of East-Siberian cod is possibly conditioned by the intense freshening of the pre-estuary parts of the sea in the period of spring flooding and also by the

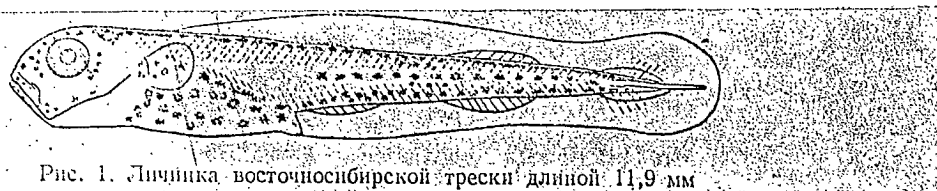


Рис. 1. Личинка восточносибирской трески длиной 11,9 мм

Fig. 1 - Larva of East-Siberian cod, 11.9 mm long.

¹ After this work was submitted for publication, the article of B.K. Moskalenko (1960) appeared, pointing out that he observed spawning of East-Siberian cod beginning with December.

adaptation of hatching and the transition to independent feeding of larvae to the time of mass development of phyto- and zooplankton in the period of spring - summer melting of ice.

Judging by the structure of the thick, very compact membrane of the ovarian eggs of East-Siberian cod taken from the gonads of stage IV maturity, it may be assumed that the eggs of the cod described are benthonic.

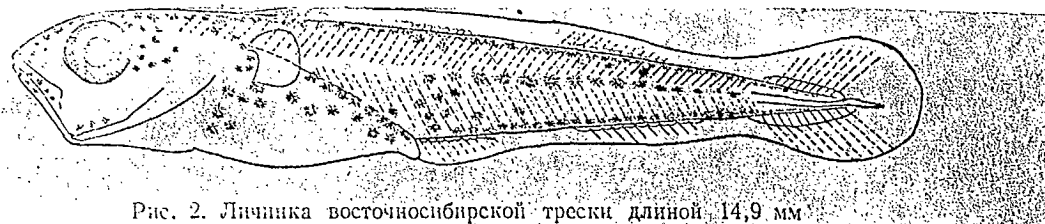


Рис. 2. Личинка восточносибирской трески длиной 14,9 мм

Fig. 2 - Larva of East-Siberian cod, 14.9 mm long.

In larvae 11.9 mm long (Fig. 1), the dorsal and anal fin folds are well delineated. A laying of pterygiophores is noted in the mesenchymal thickening. There are five pterygiophores in the first anal fin, nine in the second and four in the dorsal fin. An accumulation of mesenchyma is noted at the place of the dorsal fin. Distinctly discernible rays occur in the lower and upper edges of the caudal fin: there are five in the tail lobe and four in the upper tail lobe. The larvae are strongly pigmented. Individual stellate melanophores are arranged on the upper and lower jaws, the end of the snout, the interorbital and postorbital areas and on the base of the pectoral fins; there is a group of melanophores on the occiput and the peritonium. In the caudal

part of the body, the pigment is presented in the form of three longitudinal rows. The dorsal row, beginning behind the occiput, extends along the base of the dorsal fins and ends almost at the base of the caudal peduncle; the lower caudal row, beginning immediately behind the anus, also ends at the base of the caudal peduncle. A shorter mid-lateral row of pigment extends along the sides of the body, beginning two - four myotomes from the anus and ending several myotomes earlier than do the upper and lower marginal rows.

In larvae, 14.9 mm long (Fig. 2), the height of the fin fold is noticeably diminished. Rays appear in the anal and dorsal fins. In the second dorsal fin, laying of pterygiophores #322 is observed. The rays in the caudal fin lengthen and their numbers increase up to ten in the lower lobe of the tail and up to 8 in the upper lobe. Curvature of the urostyle is noticeable. In comparison with the previous stages, the body proportions are somewhat changed, the pre-anal distance and the length of the head are greater, and the diameter of the eyes and the height of the body behind the anus are relatively smaller (Table I). Sharp differences in the nature of pigmentation are not noticed.

In larvae, 16.7 mm long (Fig. 3), rays appear in the third and second dorsal fins. The caudal fin is almost formed. The curvature of the urostyle is clearly delineated. In comparison with the previous stage, the diameter of the eye is somewhat smaller, but the pre-anal distance, the height of the pectoral girdle and the height beyond the anus is greater (Table I). The

nature of pigmentation does not change.

Fingerlings, 54 - 68 mm long, are already completely formed. The mouth is terminal, the lower jaw sometimes protrudes slightly forwards and there is a thin barbel devoid of pigment on the chin. There is a marked interval between the anal and dorsal fins. The distance between the first and second dorsal fins is 3.5 mm; between the second and third, 4 mm; between the first and second anal, 2.8 mm. The base of the third dorsal fin is 10.0 - 17.3 mm; the base of the second, 8.6 - 14.2 mm. The body proportions are shown in Table 1.

Table 1

I Пропорции тела личинок восточносибирской трески

1. Длина личинок, мм	2. Количество экз.	3. % к длине тела			4. % к длине головы		
		i) длина головы, С	ii) преданальное расстояние, Аа	iii) высота плечевого пояса, H ₁	i) высота за пилусом, h	ii) диаметр глаза, о	iii) длина рыла, ао
11,9	1	22,1	42,3	16,9	10,1	34,4	20,3
14,6	1	25,2	44,1	16,08	8,6	29,6	20,1
16,8	1	25,0	45,6	18,6	10,0	27,5	22,0
21,5	1	24,2	44,1	17,7	11,1	28,8	25,0

Key to Table I:

I. Body proportions of larvae of East-Siberian cod.

- | | |
|--|------------------------------|
| 1. Length of larvae, mm | 4. % of head length |
| 2. Number of specimens | i) height behind the anus, h |
| 3. % of body length | ii) diameter of eye, о |
| i) length of head, С | iii) length of snout, ао |
| ii) pre-anal distance, Аа | |
| iii) height of pectoral girdle, H ₁ | |

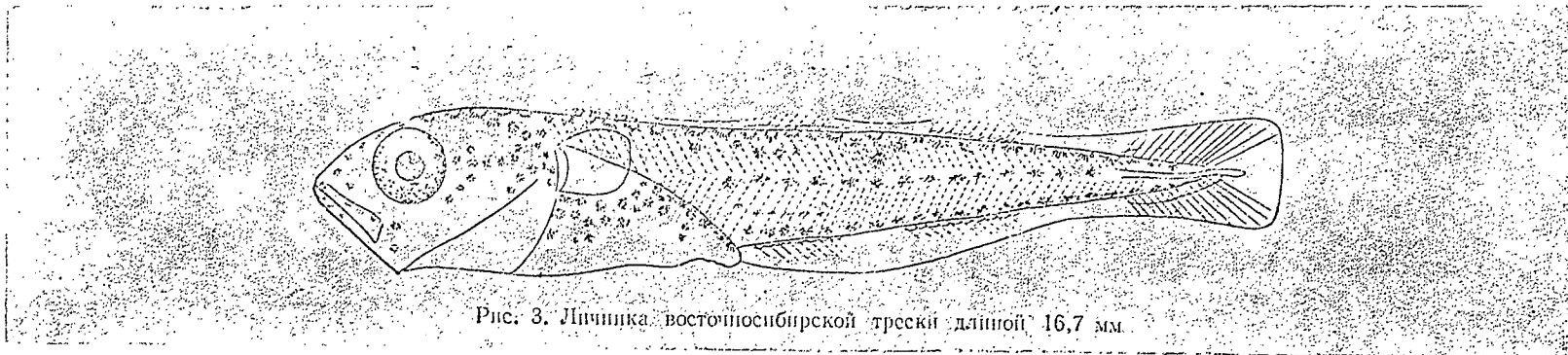


Fig. 3. - Larva of East-Siberian cod, 16.7 mm long.

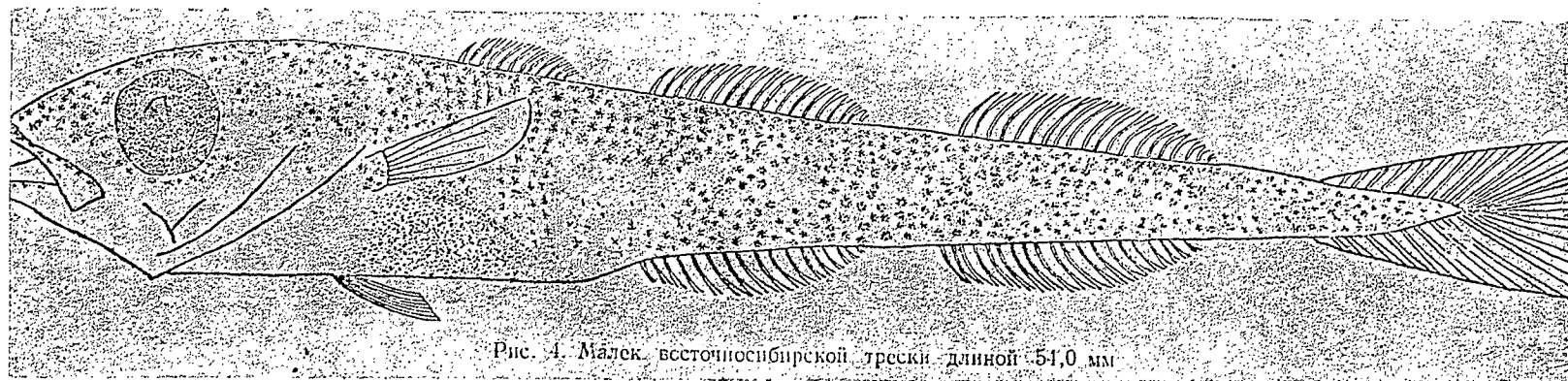


Fig. 4. - Fingerling of East-Siberian cod, 51.0 mm long.

The distribution of pigment cells on the body of fingerlings (Fig. 4) in comparison with that of the larval stage changes in the following way: pigmentation of the snout intensifies; a ring of pigment cells appears around the eyes; a group of fine punctate melanophores appear among which large stellate pigment cells are distinctly noticeable on the occiput and the back. The peritoneal epithelium is covered with a deep layer of melanine pigment. A row of large melanophores is situated along the middle line of the pelvis, extending from the pelvic fin to the anus. On the sides of the body, pigment cells form transverse stripes which are separated by light-coloured intervals, the number of which varies from four to six.

Larvae of East-Siberian cod are similar to larvae of Pacific cod, Atlantic cod and Arctic cod in structure and pigmentation features. Common to the larvae of all of these species is an accumulation of pigment cells on the occiput and the peritoneum and also the presence of pigmented rows along the unpaired fins and along the lateral line of the body.

In addition, each of the afore-mentioned species has its own characteristic features. Thus, larvae of East-Siberian cod differ from larvae of Pacific cod and Atlantic cod by a smaller pre-anal distance, a shorter snout and head, a lower pectoral girdle, a lower body behind the anus and a smaller eye diameter (Table 2). They have more abundant and brighter /325 pigmentation. Their pigment cells are large and ramose. The rows along the base of the unpaired fins are long; the mid-lateral

row is short. There is no pigment on the middle line of the pelvis and on the margins of the isthmus. In larvae of Pacific cod, the marginal rows (dorsal and lower caudal) are short, the mid-lateral is long; there is a mid-pelvic row. In larvae of Atlantic cod, the marginal and mid-lateral rows are short; the margins of the isthmus are pigmented.

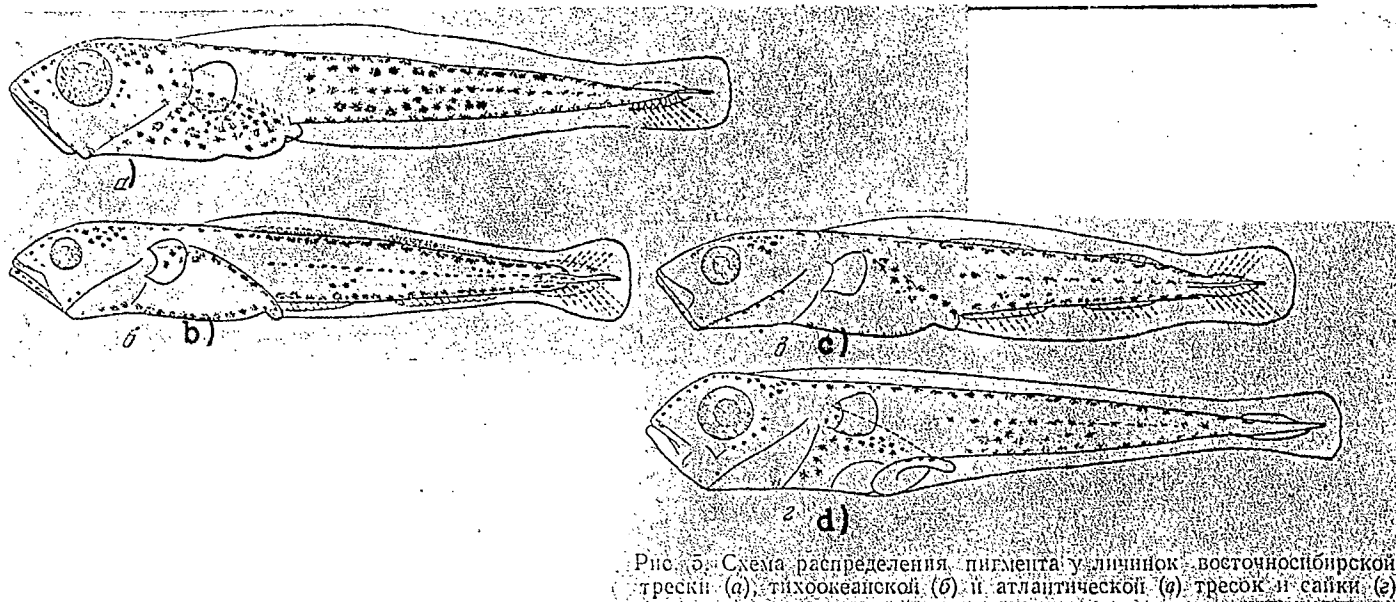


Fig. 5 - Diagram of the distribution of pigment in larvae of a) East-Siberian cod, b) Pacific cod, c) Atlantic cod and d) Arctic cod.

In terms of morphology and ecology, larvae of East-Siberian cod are closest to larvae of Arctic cod. An analysis of the contents of the stomach of two fingerlings of East-Siberian cod revealed that they feed mainly on copepods. Apparently, East-Siberian cod and Arctic cod are primarily planktophags.

However, in spite of the very close similarity, larvae of East-Siberian cod differ from larvae of Arctic cod by a number

of features. For example, in larvae of East-Siberian cod, the pre-anal distance is considerably greater (Table 2), pigment on the jaws extends to the corner of the lower jaw, the peritoneum is more abundantly pigmented and the pigment cells slip onto the margins of the pelvis; there are pigment cells on the middle of the isthmus. In larvae of Arctic cod, the jaws are slightly pigmented, the pigment cells being only on the anterior margin of the jaws; the entire isthmus is unpigmented (Fig. 5). In addition, in larvae of Arctic cod, the melanophores on the occiput are very compactly distributed and the distance between the dorsal rows is insignificant; whereas, in East Siberian cod, the pigment cells on the occiput are thinly distributed and the dorsal rows are arranged farther apart than in Arctic cod.

East-Siberian cod also differs from representatives of /326 genus Gadus by slower rates of formation, due to ecological conditions. According to the data of T.S. Rass (1949) and N.N. Gorbunova (1954), in Atlantic cod, rays in the unpaired fins begin to form when the larva is 10 - 11 mm long; in Pacific cod, when the larva is 9 - 10 mm; in East-Siberian cod, according to our data, when the larva is 14 mm long.

Fingerlings of East-Siberian cod differ from fingerlings of Pacific cod and Atlantic cod by a low body, large eyes, short head, terminal mouth, a long thin barbel devoid of pigment on the chin, a thin caudal peduncle, relatively wide-set unpaired fins (Table 2) and different pigmentation. In East-Siberian cod, the clearly delineated checkered nature of distribution of pigment

I. Пропорции тела личинок и мальков восточносибирской, атлантической и тихоокеанской тресок и сайки

1. Длина, мм	2. Число измеренных экз.	3. % к длине тела				4. % к длине головы	
		aA	C	П ₁	h	o	ao
a) Восточносибирская 11—12	3	42,7—42,4	22,7—22,1	15,5—16,9	10,0—10,1	40,0—42,0	24,0—22,1
b) Атлантическая 13—14	2	45,2—48,1	28,25—27,0	18,2—19,3	13,3—14,6	26,3—30,0	25,0—26,3
c) Тихоокеанская 11—12	10	43,8—46,6	21,8—21,8	14,2—18,0	9,3—12,1	26,4—33,4	17,5—25,5
a) Восточносибирская 14—15	5	43,6—46,2	22,9—25,0	14,1—19,2	9,3—11,0	28,6—32,4	17,1—20,6
b) Атлантическая 14—15	5	45,2—48,3	26,3—28,6	18,4—19,1	13,9—14,8	28,3—30,0	26,7—21,2
a) Восточносибирская 16—21,5	3	45,6—44,1	24,0—24,2	17,0—17,7	9,4—12,0	27,5—28,8	22,2—25,0
b) Атлантическая 16—20,0	3	46,3—50,0	26,8—28,9	17,7—18,4	15,2—13,2	27,0—28,9	27,3—37,8
d) Сайка 13—24	—	37,9—43,8	21,3—27,1	—	7,9—12,8	23,9—35,5	—
a) Восточносибирская 54,0—67,8	24	44,0—43,2	26,0—27,0	15,3—16,8	12,9—14,5	27,4—31,5	35,1—36,7
c) Тихоокеанская 26—156	15	45,7—49,5	28,8—37,5	18,4—21,2	16,5—19,1	21,9—27,6	28,2—37,5
d) Сайка 46—52,75	2	41,0—47,6	25,1	18,0	11,0—14,4	30,2—30,4	—

Пропорции тела личинок и мальков тихоокеанской трески и сайки взяты из работы П. П. Горбуновой (1957).

Key to Table II

I. Body proportions of larvae and fingerlings of East-Siberian cod, Atlantic cod, Pacific cod and Arctic cod*.

*Body proportions of larvae and fingerlings of Pacific cod and larvae of Arctic cod were taken from the work of N.N. Gorbunova, 1951.

1. Length, mm
 - a) East-Siberian cod
 - b) Atlantic cod
 - c) Pacific cod
 - d) Arctic cod
2. Number of specimens measured
3. % of body length
4. % of head length

cells is absent; there is no pigment below the mouth cavity; the pigment along the margins of the isthmus, which is typical of Atlantic cod, is absent. The pigmentation of the pelvis is also a distinguishing feature of fingerlings of East-Siberian cod. In East-Siberian cod, there is row of pigment cells along the middle line of the pelvis, absent in Atlantic cod and Pacific cod (Fig. 6).

Fingerlings of East-Siberian cod differ from fingerlings of Arctic cod, mainly, in size and shape of the barbel, distance between the unpaired fins and distribution of pigment cells on /327 the jaws and in the caudal part of the body. In Arctic cod, the barbel is shorter and thicker, pigmented at the base; the unpaired fins are drawn together, the distance between the second and third dorsal fins was 1.5 mm in a specimen 52.75 mm long; there is practically no distance between the anal fins. The jaws are slightly pigmented. On the body, the pigment cells are concentrated

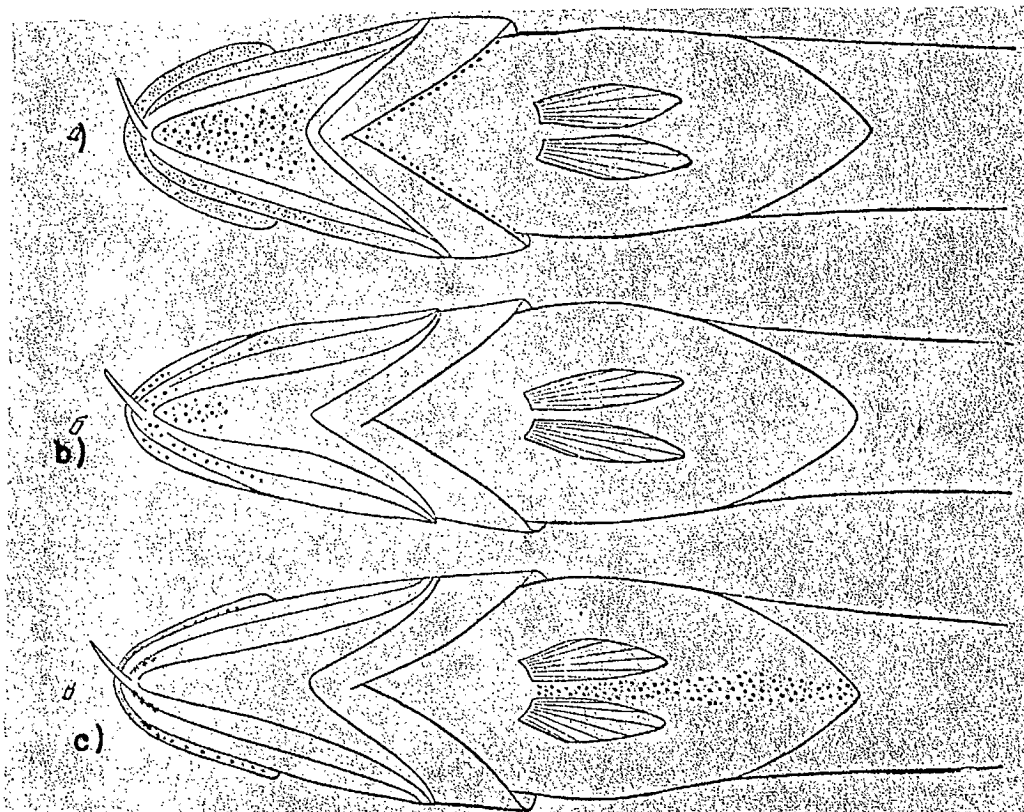


Рис. 6. Схема распределения пигмента у мальков атлантической (а) и тихоокеанской (б) тресок и у восточносибирской трески (с).

Fig. 6. - Diagram of pigment distribution in fingerlings of a) Atlantic cod, b) Pacific cod, c) East-Siberian cod.

on the back and are considerably more sparsely distributed on the ventral side. Along the dorsal fins, there is a characteristic row of large chromatophores. The pigment cells do not form transverse stripes on the body.

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