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Biological Characteristics of Simushir Snailfish *Polypera simushirae* (Liparidae) from the Pacific Waters of the Northern Kuril Islands in Autumn

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Abstract—The size and sex composition, diet, and fecundity of Simushir snailfish *Polypera simushirae* in the Pacific waters of the northern Kuril Islands are considered. In August–November 1997, catches contained individuals with a length of 41–71 (57.0 ± 0.7) cm and a weight of 1200–8800 (4035 ± 171) g. The number of females was higher than that of males at a ratio of 8.4 : 1.0. Simushir snailfish feeds mainly on fish (97.7% of the food weight), in particular, Liparidae (85.3%), including representatives of the genus *Careproctus* (32.1%) and dimdisc snailfish *Elassodiscus tremebundus* (29.0%). The individual absolute fecundity varied from 36683 to 82992 (57367 ± 1558) eggs.

Keywords: Simushir snailfish *Polypera simushirae*, size and sex composition, diet, fecundity, northern Kuril Islands

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Simushir snailfish *Polypera simushirae* (hereinafter, the snailfish) is a wide-boreal near-Asian species; it is an endemic in the Pacific waters of the central part of the Kuril Chain, where it lives mainly at elitoral depths (0–833 m); it often occurs within the upper bathyal zone (Orlov and Pitruk, 1996; *Katalog* ..., 2000; Parin et al., 2014). The species was described based on individuals captured in the littoral zone of the Simushir Island (Gilbert and Burke, 1912). Data on its captures pertained to the waters of this island for many years (Burke, 1930; Soldatov and Lindberg, 1930; Taranets, 1937; Schmidt, 1950; Matsubara, 1955; Lindberg and Krasyukova, 1987). The snailfish was later caught off the northern coast of the Hokkaido Island (Ueno, 1971), as well as off the coast of the Paramushir Island, up to the First Kuril Strait (Orlov and Biryukov, 2003), and even off southeast Kamchatka (Orlov, 2010). In 1992–2002, data on the diet (Orlov and Pitruk, 1996; Tokranov, 2000a, 2017, 2020), size and age composition (Tokranov, 2000b), and spatial distribution (Tokranov, 2000c; Orlov and Biryukov, 2003; Orlov, 2003) of the snailfish in the waters of the eastern coast of the northern Kuril Islands were obtained within the framework of the research of poorly studied fishes on the continental slope of the Far Eastern seas.

This research presents data supplementing the available information about the snailfish, as well as the first data on its fecundity.

MATERIALS AND METHODS

The spatial distribution of the snailfish was assessed based on 22 bottom trawl catches in which this species was present (Fig. 1). Trawlings were carried out in September–October 1997 off the eastern coast of the northern Kuril Islands (Onekotan and Shiashkotan islands). The vertical and horizontal opening of the trawl was 6 and 18–25 m, respectively. Materials on the size and sex composition and diet were analyzed for the entire study area and for its four spatially isolated areas: (I) the northernmost area, located opposite the Fourth Kuril Strait (depths 380–415 m, one trawling, one ind.); (II) the area stretching along the islands (270–530 m, four trawlings, six ind.); (III) the area in the north of the largest submarine plateau (180–240 m, two trawlings, 22 specimens); and (IV) the area in the south of this plateau (170–303 m, 11 trawls, 46 ind.). A total of 75 individuals from 18 trawlings were studied.

The fork length (*FL*) of all fish individuals was measured. The contents of their stomachs were studied based on generally accepted methods (*Rukovodstvo* ..., 1961). In some cases, the weight of food items was calculated from their proportion (% by eye) in the food bolus with the predefined weight, assuming that the resulting values corresponded to the proportions by weight. The value of separate components in the diet of the snailfish was estimated by the fraction of their

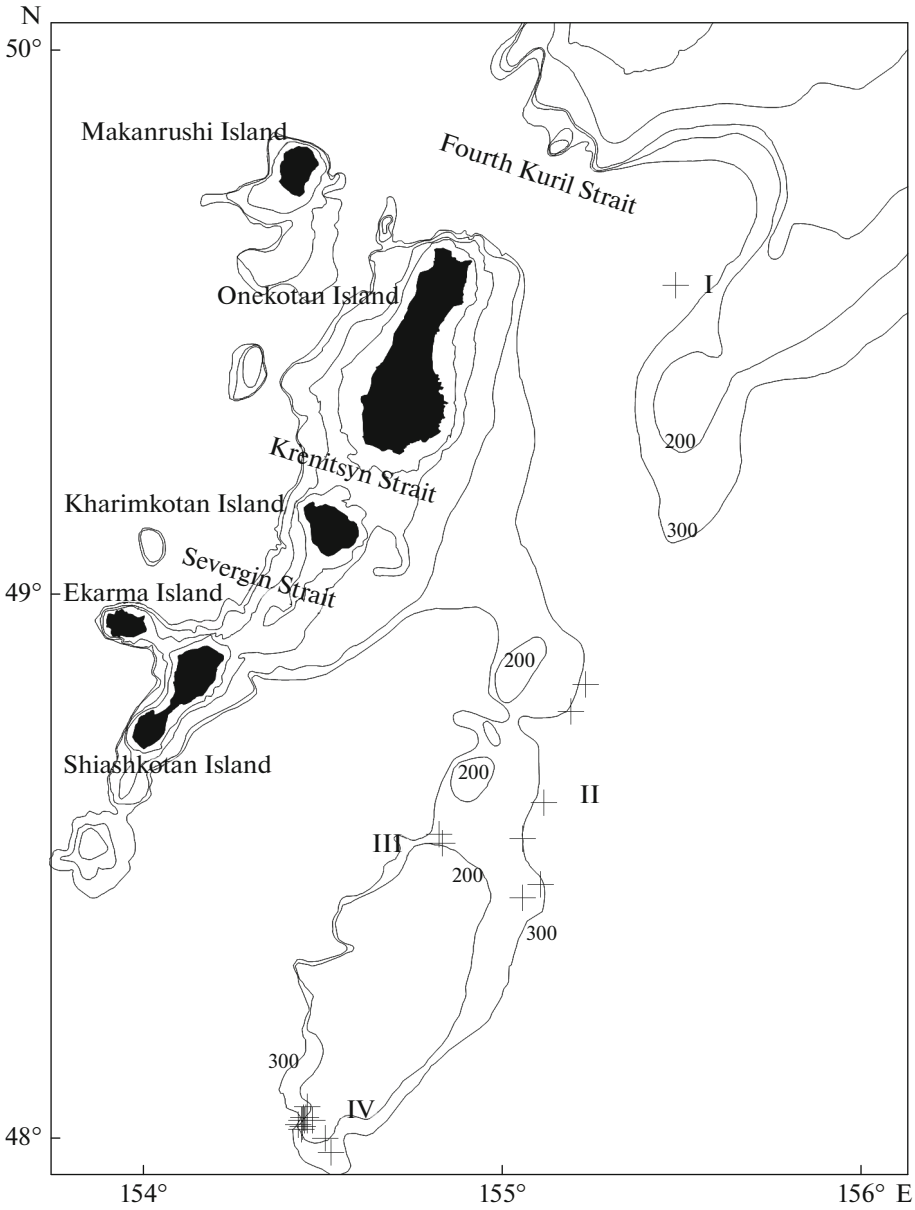

Fig. 1. Capture sites of (+) Simushir snailfish *Polypera simushirae* in the Pacific waters of the northern Kuril Islands in September–October 1997; (I)–(IV) sites, (—) 200 and 300 m isobaths.

weight (% of the total food weight). The ovaries of 39 females (at maturity stages III–IV) were selected and fixed in 4% formaldehyde solution. Laboratory treatment was carried out by the weight method (Anokhina, 1969). The ovaries extracted from formalin were kept in running water for several hours, followed by their drying on filter paper. The weight of ovaries was measured on an electronic balance with an accuracy of 0.001 g. The individual absolute fecundity (IAF) was determined in samples with a weight of 1.882–5.459 g that were taken from the middle part of the ovary; the diameter of ten eggs was measured in each sample.

The correlation between the parameters was assessed as very strong (>0.90), strong (0.71–0.90), significant (0.51–0.70), moderate (0.30–0.50), or weak (<0.30) (Lakin, 1973).

RESULTS AND DISCUSSION

In the study area, the snailfish occurred in bottom trawl catches between 47°58′–49°32′ N and 154°26′–155°30′ E. Within these coordinates, this species has also been recorded by other authors (Orlov and Pitruk, 1996; Tokranov, 2000c; Orlov, 2003). The snailfish abundance was significantly lower in August–October

1997 (up to 17 ind./h of trawling) than in May–December 1995–1997 (up to 323 ind./h) (Tokranov, 2000c) and in 1992–2000 (up to 100 ind./h) (Orlov, 2003). In 1993–1999, the average snailfish abundance in catches was 1.2 ind./h of trawling (Orlov, 1998; Orlov, 2005). The spatial isolation of trawlings with snailfish catches makes it possible to compare the data from different sites. The catch of the snailfish was 0.2 ind./h of trawling in site I, 0.1–7.0 (mean 2.7) ind. in site II, 11–14 (12.5) ind. in site III, and 1–17 (7.8) ind. in site IV. These data are consistent with the opinion that the snailfish most often occurs in the area of the submarine plateau in the south of the northern part of the submarine Vityaz Ridge (Orlov and Pitruk, 1996).

Catches contained snailfish individuals with *FL* 41–71 (57.0 ± 0.7) cm and a weight of 1200–8800 (4035 ± 171) g. Its abundance was represented mainly by size groups with *FLs* 51–55 (23.9% for females and 24.0% for both sexes), 56–60 (28.4 and 26.7%), and 61–65 (32.8 and 32.0%) cm. The size ranges are the same for females and both sexes (Fig. 2). In September–December 1995–1997, the length of the snailfish in trawl catches was 39–67 cm and its weight was 900–7200 g; individuals with *FL* 45–65 cm and a weight of 1000–5000 g prevailed (87 and 88%, respectively) (Tokranov, 2000b).

Our catches contained significantly more females than males (8.4 : 1.0); in addition, females exceeded males in size and weight (*FL* 57.4 ± 0.7 (41.0–71.0) vs. 53.0 ± 2.5 (45.5–64.5) cm and 4172 ± 173 (1200–8800) vs. 2888 ± 574 (1300–5200) g, respectively). On the contrary, these parameters were higher for males in September–October 1993 and April–May 1995 (1.7 : 1.0) according to the generalized data for this period (Orlov and Pitruk, 1996) and the average values of length and weight were also higher in males than in females (59.18 cm and 5086 g vs. 53.21 cm and 3420 g). The differences between our and previous data may be due to the fact that the fishing areas did not coincide with the predominant habitats of males, including larger ones.

Comparison of the size and sex composition of snailfish catches in different sites shows a trend towards an increase of both the average length and weight of individuals and proportion of females in the southwestern direction (Table 1).

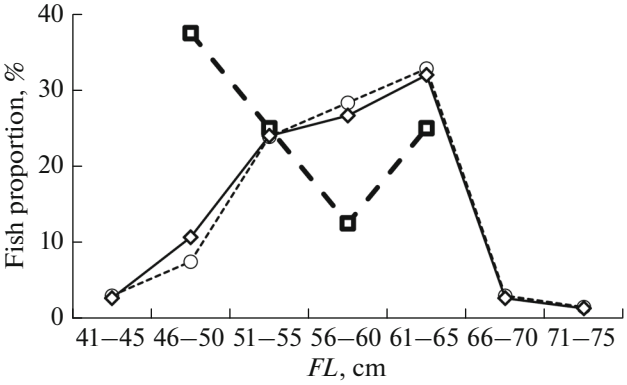

Fig. 2. Size composition (*FL*) of Simushir snailfish *Polypera simushirae* in catches from the Pacific waters of the northern Kuril Islands: (–○–) females, 67 ind.; (–□–) males, eight ind.; (–◇–) both sexes, 75 ind.

With respect to the type of diet, Simushir snailfish is an ambush predator, mainly an ichthyophage (Orlov and Pitruk, 1996; Tokranov, 2000a, 2017, 2020). Our data are consistent with this fact: the fish proportion is 97.7% of the food weight (Table 2). The fish diet includes mainly Liparididae—85.3% (mainly representatives of the genus *Careproctus* (32.1%) and dimdisc snailfish *Elassodiscus tremebundus* (29.0%)). In September–October 1996, Tokranov (2000a) obtained similar values for the consumption of Liparididae by Simushir snailfish (84.0%). Therefore, this species can be more exactly characterized as a predominantly liparophagous species. The most important food item for the snailfish in the studied site is dimdisc snailfish. As the most important food item for the snailfish, this species was also recorded in 1993–1995; its occurrence was 16.51% of the food weight during this period (Orlov and Pitruk, 1996) and reached 64.8% in 1996 (Tokranov, 2000a).

The snailfish stomachs are dominated by fish in all studied sites (90.00–99.73% of the food weight) and Liparididae in sites II–IV (83.17–92.38%) (Table 2). In site II, Liparaceae identified to the species level are represented by dimdisc snailfish (52.78%). Both dim-

Table 1. Size and sex composition of catches of Simushir snailfish *Polypera simushirae* in different areas of the Pacific waters of the northern Kuril Islands

Site	Fish number, ind.	Length (*FL*), cm		Weight, g		Fish proportion, %	
		min–max	*M*	min–max	*M*	females	males
I	1		50.5		1500	0	100
II	6	41–59	52.4	1200–4500	2992	83.3	16.7
III	22	46–65	57.1	1300–5800	3900	90.9	9.1
IV	46	45–71	57.6	1400–8800	4291	91.3	8.7

min–max, limits of variation of the parameter, *M*, mean value.

Table 2. Food composition in Simushir snailfish *Polypera simushirae* in different areas of the Pacific waters of the northern Kuril Islands, % weight

Food component and other parameters	Site				Entire area
	I	II	III	IV	
Amphipoda		0.56			0.01
Isopoda				0.05	0.03
Decapoda	10.00	1.76	0.05	2.25	1.68
Caridea, undetermined remains		1.76	0.05	0.75	0.58
Pandalus sp.	10.00				0.05
Lebbeus groenlandica				1.50	1.05
Teuthida (*Berreteutis magister*)				0.51	0.36
Pisces	90.00	96.01	99.74	96.94	97.64
Cottidae:		8.33	1.38	4.59	3.81
Hemilepidotus gilberti				1.59	1.11
Icelus sp.				0.17	0.12
I. canaliculatus				0.17	0.12
Triglops scepticus				2.32	1.62
undetermined remains		8.33	1.38	0.34	0.84
Psychrolutidae (*Malacocottus zonurus*)				1.61	1.13
Liparidae:		83.98	92.38	83.17	85.85
Elassodiscus tremebundus		52.78	54.01	18.49	29.16
undetermined remains		31.20	30.71	21.59	24.37
Careproctus:			7.66	43.09	32.32
C. furcellus				10.66	7.47
C. rastrinus				2.03	1.43
C. zachirus				1.27	0.89
C. cypsellurus				9.15	6.42
C. rozeofuscus			6.71		1.84
C. macrocephalus				8.92	6.25
undetermined remains			0.95	11.06	8.02
Blennidae			3.03		0.83
Undetermined fish remains	90.00	3.70	2.95	7.57	6.02
Eggs:		1.67	0.21	0.25	0.28
Liparidae				0.11	0.08
undetermined		1.67	0.21	0.14	0.20
Number of stomachs, pcs.	1	6	22	46	75
Number of trawlings	1	4	2	11	18

disc snailfish and *Careproctus* species were recorded in site III (54.01 and 7.66%, respectively). In site IV, the proportion of dimdisc snailfish is significantly lower (18.49%) as a result of an increase in the proportion of careprocts (43.09%), represented by five species.

Taking into account the body shape and color that are typical for sedentary fishes living on the bottom or near the bottom, Orlov and Pitruk (1996) believe that the snailfish lies in wait for its prey in shelters or disguises itself as the color of the ground. Data on the food composition in individuals from site III suggest that the snailfish can also actively search for prey: in this site, it fed mainly on dimdisc snailfish, which was absent in trawl catches. This difference can be explained by food migrations of individuals from areas occupied by them to areas of dimdisc aggregations and vice versa.

Table 3 presents species with a relatively high abundance that occur with Simushir snailfish in catches. Darkfin sculpin *Malacocottus zonurus* and spectacled

Table 3. Species composition of catches with Simushir snailfish *Polypera simushirae* in different sites of the Pacific waters of the northern Kuril Islands

Species	Site			
	I	II	III	IV
Berryteuthis magister	244	134	132	108
Bathyraja maculata	11	33	25	–
B. interrupta	11	–	–	–
Albatrossia pectoralis	–	12	–	–
Theragra chalcogramma	708	398	105	19
Sebastes alutus	–	763	393	624
S. borealis	–	35	*	–
Sebastolobus macrocir	19	35	–	*
Pleurogrammus monopterygius	–	–	1139	9623
Hemilepidotus gilberti	–	37	38	142
Triglops scepticus	–	47	205	437
Dasycottus setiger	35	–	–	–
Malacocottus zonurus	104	361	242	292
Sarritor frenatus	*	14	–	–
Careproctus cypsellurus	–	87	–	–
C. furcellus	12	34	–	*
C. rastrinus	*	–	–	10
C. roseofuscus	16	–	11	*
C. macrocephalus	–	23	*	*
Elassodiscus tremebundus	–	572	–	36
Paraliparis grandis	14	*	–	–
Polipera simushirae	*	*	13	*
Bothrocarina microcephala	13	–	–	–
Lycodes albalinneatus	21	*	–	–
L. brunneofasciatus	11	*	–	*
Bothrocara brunnea	11	–	–	–
Zaprora selena	–	–	*	19
Atherestes evermanni	*	13	*	–
Total	25	45	17	32
Number of trawlings	1	4	2	11

The table includes the most abundant species (≥10 ind./h of trawling), –, absent in catches, *, <10 ind./h of trawling.

sculpin *Triglops scepticus*, recorded in the diet of the snailfish are the most abundant species (104–361 and 47–437 ind./h of trawling, respectively); their length (11–29 and 16–28 cm) make them accessible for the snailfish; however, their role is insignificant in its diet (1.13 and 1.61% of the food weight). The proportion of Commander squid *Berryteuthis magister* (at an abundance of 108–244 ind./h of trawling) is even lower (0.36% of the food weight). Atka mackerel *Pleurogrammus monopterygius*, the most abundant species (1139–9623 ind./h) on the slopes of the plateau during the study period, was completely absent in snailfish stomachs. This species was also not recorded in the diet of the snailfish in September–October 1996 (Tokranov, 2000a); however, in 1993–1995, it was one of the most important items (along with dimdisc snailfish and Careproctus species) in the diet of the snailfish (Orlov and Pitruk, 1996).

The material collected from site IV makes it possible to compare the diet of different size groups of Simushir snailfish (Table 4). The main diet of individuals with *FL* 46–50 cm includes sculpins (Cottidae) (43.0% of the food weight) and liparid species (32.3%), as well as decapods (Decapoda) (16.8%). The proportion of Liparididae in the diet of Simushir snailfish increases with its growth, while the contribu-

Table 4. Food composition of Simushir snailfish *Polypera simushirae from* different size groups in the Pacific waters of the northern Kuril Islands (site IV), wt %

Food component	Size group (*FL*), cm			
	46–50	51–55	56–60	61–65
Isopoda			0.13	0.02
Decapoda:	16.82	7.72	0.66	0.40
Caridea, undetermined remains	5.15	3.53		0.11
Lebbeus groenlandica	11.67	4.19	0.66	0.29
Teuthida (*Berreteutis magister*)		5.07		
Pisces:	83.18	86.10	99.21	99.30
Cottidae:	43.01	8.41		1.84
Hemilepidotus gilberti	10.31			1.84
Icelus sp.		1.68		
I. canaliculatus		1.71		
Triglops scepticus	31.34	2.50		
undetermined remains	1.36	2.52		
Psychrolutidae (*Malacocottus zonurus*)	1.36			
Liparidae:	32.29	73.33	88.69	90.83
Elassodiscus tremebundus	20.62	35.81	11.20	21.47
undetermined remains	11.67	16.71	28.92	20.17
Careproctus:		20.81	48.57	49.19
C. furcellus			28.00	6.85
C. zachirus				2.57
C. cypsellurus				18.52
C. macrocephalus			11.43	7.92
undetermined remains		20.81	9.14	13.33
Undetermined fish remains	6.52	4.36	10.52	6.63
Eggs:		1.11		0.28
Liparidae		1.11		
undetermined				0.28
Number of stomachs, pcs.	6	9	11	16

tions of sculpins and decapods become insignificant. The proportion of dimdisc snailfish varies from 11.2 (in individuals with *FL* 56–60 cm) to 35.8% (*FL* 5155 cm). For individuals with *FL* 56–60 and 61–65 cm, careprocts become the most significant food items (48.6 and 49.2%, respectively). The diet of the fish with *FL* 61–65 cm is characterized by the highest species diversity of careprocts.

All the studied snailfish females (*FL* 41–71 cm) were mature. The length of females with ovaries at maturity stages III–IV varies from 46.0 to 65.5 (57.41 ± 0.77) cm and weight from 1800 to 6000 (4124 ± 180) g; the weight of their ovaries is 102.6–562.8 (309 ± 19 g). The correlation between the body length and weight ($r = 0.90$), as well as the correlation between the ovary length and weight (0.73), is assessed as strong. The dependences are described by the exponential ($y = 140.98e^{0.0581x}$, $R^2 = 0.8181$) and power-law ($y = 2E-06x^{4.6564}$, $R^2 = 0.5952$) equations, respectively (Figs. 3a, 3b).

The average IAP of the snailfish is 57 367 ± 1558 eggs and varies from 36683 pcs. in the female with FL 54 cm and a weight of 3500 g to 82 992 pcs in the female with *FL* 62 cm and a weight of 5300 g (Fig. 3c). The correlation between the length and IAP is significant (0.64). The dependence is described by the exponential equation: $y = 14224e^{0.024x}$ ($R^2 = 0.4302$).

The average diameter of oocytes is 1.70 ± 0.039 mm; the minimum value (1.23 mm) was recorded for the female with *FL* 46 cm and a weight of 1800 g, while the maximum value (2.2 mm) for the female with *FL* 64 cm and a weight of 5100 g (Fig. 3c). The correlation between the body length and egg diameter is moderate ($r = 0.416$). The dependence is described by the power-law equation $y = 0.0855x^{0.7365}$ ($R^2 = 0.1922$).

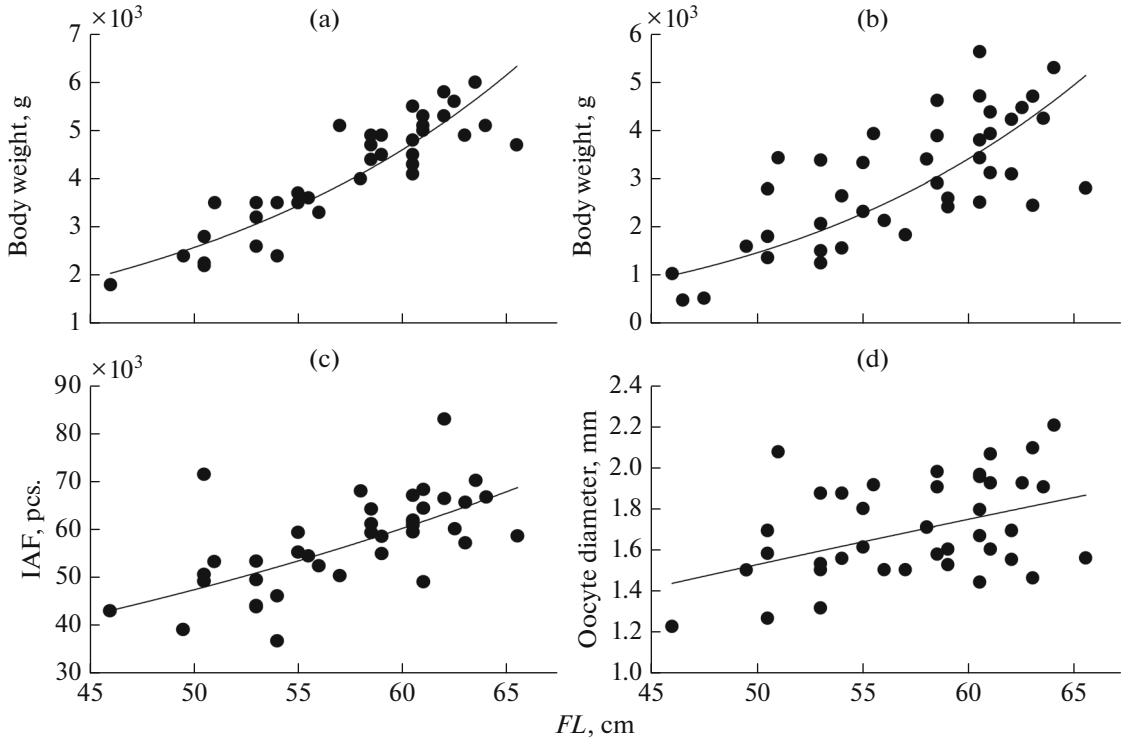

Fig. 3. Dependence of the body weight (a), ovary weight (b), absolute individual fecundity (c), and oocyte diameter (d) on body length (*FL*) in Simushir snailfish *Polypera simushirae* from the Pacific waters of the northern Kuril Islands.

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COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interests. The author declares that he has no conflicts of interest.

Statement on the welfare of animals. All applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

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