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Feeding of Blunt-Snouted Lenok *Brachymystax tumensis* Mori, 1931 (Salmoniformes, Salmonidae), in Korbokhon Lake (Left Bureya River, Khabarovsk Krai) in Summer

V. A. Teslenko[a], P. B. Mikheev[b], A. L. Antonov[c], T. M. Tiunova[a], and M. A. Makarchenko[a]

[a] *Institute of Biology and Soil Science, Russian Academy of Sciences, Far Eastern Branch, pr. 100-Letiya Vladivostoku 159, Vladivostok, 690022 Russia*

[b] *Pacific Scientific Research Fisheries Center, Khabarovsk Branch, Amurskii bul. 13, Khabarovsk, 680000 Russia*

[c] *Institute of Water and Ecological Problems, Russian Academy of Sciences, Far Eastern Branch, ul. Dikopol'tseva 56, Khabarovsk, 680000 Russia*

e-mail: teslenko@ibss.dvo.ru

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Abstract—Characteristics of feeding of blunt-snouted lenok *Brachymystax tumensis* in the mountain moraine Korbokhon Lake (Left Bureya River, Khabarovsk krai) in summer is presented. It was established that individuals at an age of 3+ to 13+ use all accessible seasonal types of preys both near bottom and in surface water layers as food. In total the contents of all studied stomachs, 88 components of animal origin (bottom invertebrates, lenok roe, larvae, pupae, and imagoes of aquatic and terrestrial insects), as well as three plant components, were found. With age, the spectrum of feeding of lenok widens. In stomachs of individuals at an age of 9+ to 13+, besides invertebrates, bearded stone loach *Barbatula toni* and fur small murine rodents were recorded. Selectivity of feeding with respect to weight and type of preys was revealed: lenok older than 9+ prefers larger food items; individuals at an age of 11+ to 12+ more frequently include beetles and other terrestrial insects in the diet, and the ratio of aquatic and terrestrial food items changes in favor of the latter.

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Keywords: blunt-snouted lenok, *Brachymystax tumensis*, food spectrum, age groups, Korbokhon Lake, Khabarovsk krai

INTRODUCTION

In the mountain part of the Amur River basin within Russia, there are dozens of lakes. Most frequently, they are located in mountain areas of drainage basins of the Onon, Ingoda, Zeya, Bureya, and Amgun rivers. Until recently, there were no data on the fauna of fish of mountain lakes of the Amur basin because of their low inaccessibility. In recent years, several publications appeared (Antonov, 1999, 2003, 2005, 2009, 2012, 2013) in which it was demonstrated that a typical representative of ichthyofauna of mountain lakes of the upper, middle, and lower Amur (Bukukunskoe, Korbokhon, Prevalnoe, and Bolshoi Suluk) is blunt-snouted lenok *Brachymystax tumensis*. Habitation of this species in mountain lakes is determined by its relatively high ecological flexibility. It may inhabits slow watercourses, bays, and oxbows; in the period of migrations and wintering, it occurs in floodplain lakes and Amur riverbed and can penetrate via its mountain tributaries, as a rule, higher than other species (Antonov, 2013). In these lake populations, *B. tumensis* differs from river individuals by higher values of indices of eye diameter and head length (Fig. 1) and violet-red coloration of muscles and swim bladder (Antonov, 2001, 2003, 2009). Common specific features of biology of lake populations are small sizes, low rate of growth, and relatively high life duration. At the same time, one of the main issues of biology—feeding—remains unstudied thus far; there are only rather scarce data on the food composition of blunt-snouted lenok. According to Antonov (2003, 2009), in mountain lakes, a considerable role in the feeding of lenok is played by terrestrial and amphibiotic insects and their larvae, fish is also found singly in stomachs. Slightly more is known about the composition of feeding of blunt-snouted lenok in river populations.

The purpose of the present study is to determine food spectra, food preferences, and ways of obtaining food by different age groups of blunt-snouted lenok in mountain Korbokhon Lake.

MATERIALS AND METHODS

Mountain moraine Korbokhon Lake of glacial origin is located on the western slope of Dusse-Alin Ridge at the watershed of the Bureya River and tributaries of the Amgun River—Kerbi and Nilan—over

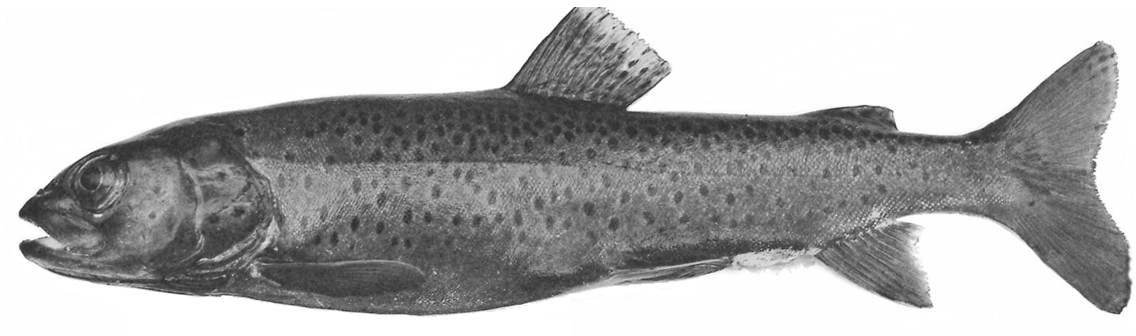

Fig. 1. Spent male of blunt-snouted lenok *Brachymystax tumensis* from the basin of Korbokhon Lake, FL 401 mm.

the territory of Bureinskii Reserve (Verkhnebureinskii raion of Khabarovsk krai). The lake is at an altitude of 1165 m above sea level in the upper reaches of the Korbokhon River, tributary of the Left Bureya (52°01′37″ N 135°04′47″ E) (Fig. 2a). The lake is flow-through, oval shape (0.6 × 0.4 m), and extended in the trough valley in a meridional direction; the space water area is 0.2 km^2 (Fig. 2b). Malyi Korbokhon Stream with a width of 1–2 m and a length of 2.5 km (water discharge is ~0.1 m^3/s) gradually flows down a wide valley and meanders before inflow in the lake flows into the northern part of the lake; its peaty coasts have grown up with bog bilberry and Arctic birch. From the southern side, Korbokhon Stream, having at the outlet width up to 4.5 m and a depth of 0.4–1.0 m (water discharge is ~0.2 m^3/s), flows out of the lake. Approximately 8 km downstream, there is a site with micro waterfalls with an altitude to 1 m (Shesterkin and Antonov, 1996).

A small area of drainage basin (~4 km^2) determines the stable level conditions of the lake (Shesterkin, 1998). The littoral with a depth of 1.5–2.5 m overgrown with aquatic vegetation by 20–30% recedes at a distance of 20–25 m from the coast; then, the depth drastically increases to 6–8 m and comprises 10–12 m at 50 m from the coast (Fig. 2b). In the northern part of the lake, the depth increases not so drastically; it reaches 8–10 m only at a distance of 100–125 m, and maximum depths (up to 14 m) are in the northwestern part (Fig. 2c). Since bottom near coast gradually declines and then drastically drops off down and is flat in the middle, from adjacent altitudes and from a helicopter, the lake looks like a black oval with a light margin, despite an ideal water transparency.

Water in the lake is soft and ultra fresh; feeding is exercised by thaw snow and rainwater. Rocks forming the bed of the drainage basin are represented by not easily leached granites, which provides low (>10 mg/dm^3) water mineralization (Shesterkin and Antonov, 1996; Shesterkin, 1998). Concentrations of silicon and iron compounds are also low. The content of biogenic substances experiences a large effect of big forest fires that cause an increase in the concentration of nitrogen compounds. For instance, after the biggest forest fires in the Amur region in 1998, the concentration of ammonium and nitrate nitrogen in water of Korbokhon Lake in 2002, compared to 1996, increased by a factor of 1.5 and 5, respectively (Shesterkin and Shesterkina, 2003). At the same time, main ions of potassium and magnesium are absent in water composition. Therefore, according to the classification of Alekin (1970), waters of Korbokhon Lake belong to a hydrocarbonate class, calcium group, first type by chemical composition (Mordovin et al., 2006).

Climatic conditions are extremely severe, and climate is drastically continental. Per year, up to 800–1200 mm of precipitation fall, more than 80% in the warm period of the year. In winter, air temperature can decline lower than –50°C. In summer in August, cold spells occur. The lake is covered by ice more than 9 months per year, and the period of open water lasts from the mid–end of June to the mid–end of September (Antonov, 2013). In the period of material collection (June 27–28, 2011, phenological spring) in the day hours, water temperature in Korbokhon Lake comprised 6.5–7.5°C; along the coasts of the lake, in hollows, and valleys of streams, snow patches still remained.

Sample volume is 33 individuals. More than half of fish were caught at the site of inflow of Malyi Korbokhon stream in the lake where their concentration was maximal. Fish caught by a spinning in the light hours of the day; several individuals were caught by fixed net at night. In each individual, fork length (*FL*) and body weight were determined. Age was determined from scales and otoliths using a LOMO MCP-2 binocular and a DCM-510 Scope ocular chamber at magnification 40–80°. Stomachs were fixed with 4% solution of formaldehyde. The weight of food bolus was calculated as the difference between the weight of full and empty stomach. Analysis of food bolus was performed under an MBS-10 binocular; the surviving animals were identified up to species, counted, dried on filter paper, and weighed with a TH-213 electron balance (50 g/0.01 g). Index of fullness of stomach (IFS, ‱) was calculated as the ratio of the food

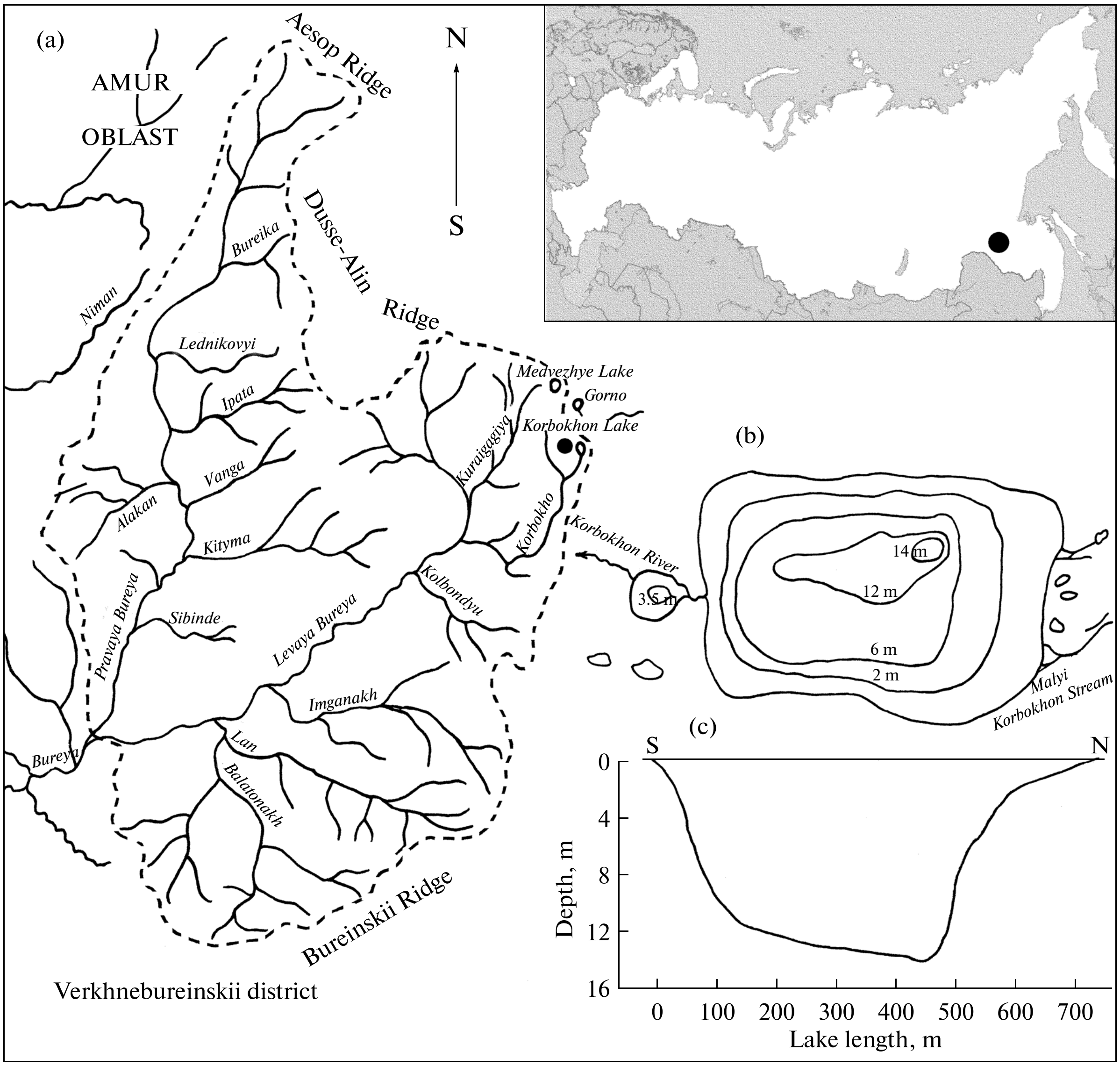

Fig. 2. (a) Map scheme of the area of material collection, (b) distribution of depths in Korbokhon Lake (according to Shesterkin, 1998), (c) profile of Korbokhon Lake (according to Shesterkin, 1998); (- - -) boundary of Bureinskii Reserve.

weight and the total body weight (*Metodicheskoe posobie…*, 1974). To estimate values of different food items in feeding, frequency of occurrence, as well as their mean number and weight in relative magnitudes, were determined.

Statistical data processing was performed in Microsoft Excel program package.

RESULTS AND DISCUSSION

According to data of measurements and age estimates from scales and otoliths, in the composition of the sample from the population of blunt-snouted lenok from the basin of Korbokhon Lake, ten age groups were distinguished: 3+ to 13+ (Table 1). Fish length varies within 262–425 mm and weight varies within 161.9–770/0 g.

Weight and linear growth of Korbokhon lenoks is considerably slower than in fish of river populations from the Nimelen and Khor rivers (lower Amur) (Antonov, 1999; Mikheev and Vdovichenko, 2009). The low rate of growth of lenok in Korbokhon Lake can be related to severe climatic conditions, first of all, to low water temperature of the mountain lake. The limitedness of the vegetation season also considerably determines the development of food resources, fish behavior, including feeding, and the site and duration of periods of feeding and spawning.

The sample is represented mainly by mature individuals, except for 1 ind. at an age of 3+ FL 262 mm and a weight of 161.9 g, in which gonads were at matu-

Table 1. Size-weight indices and index of fullness of stomachs of blunt-snouted lenok *Brachymystax tumensis* of different age from Korbokhon Lake in 2011

Age, years	Number of fish, ind.	Length (*FL*), mm	Weight, g	Index of fullness of stomach, ‰o
3+	1	262.0	161.9	81.5
5+	1	355.0	377.8	72.0
6+	3	$\frac{333.33 \pm 11.547}{320.0–340.0}$	$\frac{354.80 \pm 22.003}{336.0–379.0}$	$\frac{104.4 \pm 42.6}{55.8–135.4}$
7+	4	$\frac{362.50 \pm 17.078}{340.0–380.0}$	$\frac{369.35 \pm 54.427}{313.0–437.4}$	$\frac{90.4 \pm 56.3}{32.9–167.7}$
8+	2	$\frac{360.0}{360.0}$	$\frac{374.2}{338.0–340.5}$	$\frac{55.2}{30.2–74.3}$
9+	7	$\frac{363.57 \pm 16.257}{345.0–390.0}$	$\frac{386.6 \pm 31.421}{345.0–439.0}$	$\frac{121.4 \pm 116.5}{31.6–346.2}$
10+	7	$\frac{375.0 \pm 27.988}{330.0–400.0}$	$\frac{451.66 \pm 46.957}{390.0–503.0}$	$\frac{94.9 \pm 55.6}{52.2–213.6}$
11+	4	$\frac{388.75 \pm 11.814}{380.0–405.0}$	$\frac{461.78 \pm 59.208}{386.0–515.0}$	$\frac{132.4 \pm 83.6}{66.0–251.3}$
12+	2	$\frac{407.5}{390.0–425.0}$	$\frac{536.70}{464.0–609.4}$	$\frac{170.2}{120.7–219.7}$
13+	2	$\frac{415.0}{410.0–420.0}$	$\frac{749.5}{729.1–770.0}$	$\frac{110.0}{102.9–117.1}$

above the line is average value and standard deviation and under the line are limits of index variation.

rity stage II. Male to female ratio is 1 : 1.3. Apparently, material was collected after spawning since most caught females had gonads at maturity stage VI (spawned females).

All studied stomachs were filled with food. The values of SFI characterizing stomach fullness and reflecting, to a certain degree, the intensity of feeding of blunt-snouted lenok vary within 30.2–346.2°; maximum values were recorded in ten-year olds (Table 1). Average indices of IFS increase with age. Maximum average value of this index (170.2°) was recorded in individuals at an age of 12+.

Food spectra of analyzed age groups of blunt-snouted lenok are wide and diverse. On the whole, in the contents of all studied stomachs, 88 components of animal origin and three plant components—remains of higher terrestrial (fragments of leaves and wood, needles, seeds), higher, and lower (moss, algae) aquatic vegetation—were found (Table 2). Small pebbles that evidently got into stomachs together with caddis flies were assigned to arbitrary food items. Food items of animal origin were represented by benthic organisms, mainly amphibiotic insects from the orders Diptera, Plecoptera, Trichoptera, Ephemeroptera, Megaloptera, and Heteroptera, as well as by aschelminthes, hairworms, water mites, and mollusks, that were collected by lenok to a greater extent from the bottom of the stream than of the lake. Besides aquatic invertebrates, animal food included terrestrial insects collected by lenok from the water surface. They include beetles flying over water, Hymenoptera, Heteroptera, and Mecoptera flies; larvae of butterflies that fell from the coastal vegetation; and earwigs and centipedes dwelling in the soil litter. In the feeding of lenok, vertebrate animals (or their fragments) were recorded: a second representative of ichthyofauna of Korbokhon Lake—bearded stone loach *Barbatula toni*; fur of small murine rodents; and roe of blunt-snouted lenok *B. tumensis*. Thus, Korbokhon lenok belongs to predators; it efficiently uses all types of preys accessible to it as food.

In all studied individuals, by frequency of occurrence, larvae of chironomids *Abiskomyia* sp., flies from the family *Ceratopogonidae*, and terrestrial click beetles Elateridae dominated. In more than half of stomachs, nematodes, remains of higher terrestrial vegetation, and small pebbles were found (Table 2). Because of the fact that determination of food items was performed with different degrees of accuracy, aquatic fauna was identified mainly up to genus or species, terrestrial fauna was identified up to family, and the sample contained different number of individuals of each age group, analysis of feeding of lenok was performed

Table 2. Food spectra of blunt-snouted lenok *Brachymystas tumensis* of different age from Korbokhon Lake and common frequency of occurrence of food items in stomachs, June 2011

Food items	Age, years										FO, %
	3+	5+	6+	7+	8+	9+	10+	11+	12+	13+	
Aquatic											
Type Nemathelminthes											
Class Nematoda			1.01/0.09	0.41/0.11	0.65/0.10	0.14/0.01	0.16/0.05	1.59/0.01	0.68/0.01	0.6/0.01	58
Type Nematomorpha											
Class Gordioidea			0.11/0.01			0.14/0.02	0.02/0.01	0.18/0.02			12
Type Mollusca											
Class Gastropoda			46.15/44.78	0.09/0.80		0.03/0.01	0.77/1.63	0.18/0.05	10.18/10.25		27
Class Bivalvia			0.45/0.10								3
Type Arthropoda											
Class Arachnida											
Order **Hydracarina**				0.03/0.01					1.09/0.01		6
Class Insecta											
Order **Diptera** indet.		0.11/0.83	0.11/0.18					0.88/0.09			12
Fam. Chironomidae indet. (l.)						0.10/0.02					3
Protanypus sp. (p.)							0.02/0.01				3
fam. Orthocladiinae indet. (p.)							0.15/0.02				3
Abiskomyia sp. (p.)		94.59/45.00	11.51/0.93	90.95/39.82	65.52/29.00	73.16/3.15	79.80/17.77	10.62/0.26	6.78/0.43	82.4/4.96	61
Chaetocladius gr. *piger* (p.)						0.03/0.01					3
Cricotopus (*Isocladius*) sp. (l.)						0.03/0.01	0.02/0.01				6
Criñotopus (*Cricotopus*) *magus* (p.)					1.49/0.60	0.03/0.01					6
Diplocladius cultiger (p.)				0.03/0.02							3
Eukiefferiella sp. (p.)				0.02/0.01							3
Procladius sp. (l., p.)		0.11/0.32	19.44/2.01	4.37/3.04	0.28/0.10	4.11/0.74	1.10/0.19	22.10/1.78	33.79/3.14		45
P. choreus (l., p.)								0.02/0.01			3

Table 2. (Contd.)

Food items	Age, years										FO, %
	3+	5+	6+	7+	8+	9+	10+	11+	12+	13+	
Psectrocladius gr. *limbatellus* (l., p.)			0.45/0.12	0.03/0.02		0.28/0.05	0.55/0.10	0.18/0.01			27
Zalutschia tornetraeskensis (p., im.)			0.11/0.02	0.02/0.02	3.81/1.50		0.77/0.12				12
Chironomini indet. (l., p.)			3.13/0.32	0.20/0.10	10.87/4.90	0.76/0.08	0.49/0.08		14.52/0.99		45
Eudochironomus sp. (l., p.)		0.11/0.30	0.67/0.06		0.28/0.10	0.03/0.01	0.15/0.05	0.88/0.03	2.58/0.29		30
Tanytarsini (p.)		0.11/0.30	0.45/0.07	1.22/0.62		0.03/0.01	0.05/0.01	0.71/0.02		2.63/0.13	27
Fam. Blephariceridae (l.)			0.22/0.05			0.14/0.03			0.41/0.07		9
Fam. Ceratopogonidae (l.)		3.97/1.18	8.49/0.79	1.02/0.44	5.20/1.40	2.45/0.19	10.74/1.65	18.94/0.46	10.85/0.49	4.31/0.16	79
Fam. Culicidae (l., im.)				0.02/0.12					0.14/0.02		6
Fam. Empididae (l.)			0.34/0.21	0.03/0.06		0.07/0.05	0.02/0.03	0.53/0.15	0.27/0.04		21
Fam. Limoniidae (l., im.)							0.02/0.01		0.68/0.15		9
Fam. Muscidae (im.)				0.05/0.16	0.19/0.2	0.59/0.26	0.02/0.07		0.27/0.03		21
Fam. Simuliidae (l.)				0.03/0.02		0.31/0.02					6
Fam. Tabanidae (l.)										0.12/0.02	3
Fam. Tipulidae (l.)				0.03/0.08			0.02/0.02				6
Order **Ephemeroptera** indet.						0.03/0.01					3
Ameletus sp. (l., sub., im.)			0.22/0.31			0.31/0.42	0.07/0.18	0.18/0.02	1.90/1.43		27
Baetis sp. (l.)							0.02/0.01				3
Order **Plecoptera**											
Taenionema japonicum (im.)						0.03/0.05					3
Nemoura arctica (l., im.)			0.56/0.37			2.69/0.92	0.24/0.32	2.83/0.43	2.17/0.29		27
Capnia nearctica (l., im.)				0.05/0.12		0.14/0.04	0.02/0.01	0.35/0.06		0.96/0.24	18

Table 2. (Contd.)

Food items	Age, years										FO, %
	3+	5+	6+	7+	8+	9+	10+	11+	12+	13+	
Paraleuctra zapekinae (im.)							0.02/0.03				3
Arcynopteryx dichroa (l., im.)			0.22/0.87	0.02/0.26		0.03/0.11			0.27/0.51		12
Diura majuscula (im.)						0.10/0.10	0.02/0.13			0.12/0.35	9
Megarcys pseudochracea (im.)							0.02/0.19				3
Isoperla asiatica (im.)									0.14/0.01		3
Alloperla rostellata (im.)						0.03/0.03		0.18/0.02	0.14/0.08		9
A. mediata (l., im.)			0.34/0.09			0.03/0.01					6
Order **Trichoptera** indet. (l., p.)				0.08/0.27	0.09/1.00	0.03/0.15			0.14/0.01	0.6/0.46	15
Brachycentrus sp. (l.)			0.22/0.33			0.07/0.15					9
Micrasema gellidum (l.)						1.59/1.24	0.07/0.08	1.24/0.13			9
Fam. Limnephilidae (l.)		0.11/1.84		0.09/5.92		0.03/0.02					12
Hydatophylax variabilis (l., im.)			0.22/1.11	0.02/0.18			0.20/3.55	13.45/3.22	0.41/0.71		33
Apatania zonella (l., im.)				0.03/0.21			0.07/0.35				12
Architremma ulachensis (l.)				0.05/0.11			1.92/3.01	1.95/1.93			9
Goera sp. (l.)		0.11/2.20		0.06/1.72		0.28/2.29	0.38/7.22		1.09/1.22		18
Molanoides tinctus (l.)						0.38/2.20					3
Ceraclea sp. (l.)						0.69/0.79	0.02/0.01				9
Rhyacophila gr. *sibirica* (l.)						0.14/0.11		0.35/0.11			6
Order **Megaloptera**											
Sialis sp. (l.)		0.11/1.10	0.70/20.20			0.14/0.54	0.18/0.96	0.18/0.14			21
Order **Hemiptera**											
Fam. Gerridae (im.)						0.03/0.09	0.05/0.16	0.18/0.04			12

Table 2. (Contd.)

Food items	Age, years										FO, %
	3+	5+	6+	7+	8+	9+	10+	11+	12+	13+	
Order **Heteroptera**											
Fam. Hydrometridae (im.)										0.12/0.08	3
Order **Coleoptera**											
Fam. Hydrophilidae								0.53/0.22		0.12/0.28	6
Type Chordata											
Class Pisces											
Barbatula toni						0.07/17.71	0.05/28.74	+/19.55	0.27/26.55	0.24/42.38	21
Brachymystax tumensis (egg)	+/100					3.66/22.92					6
Stone		+/6.17	+/0.30	+/2.77	+/3.10	+/2.47	+/7.88	+/4.64	+/0.17	+/21.42	58
Lower aquatic vegetation (moss)				+/0.08		+/0.04	+/0.21	+/0.04	+/0.01	+/0.29	27
Higher aquatic vegetation		+/7.16									3
Terrestrial											
Type Arthropoda											
Class Insecta											
Order **Coleoptera**											
Fam. Elateridae		0.55/14.58	1.79/6.55	0.50/13.88	1.86/35.50	2.66/14.17	0.66/10.77	11.50/15.61	4.34/22.05	4.19/10.75	94
Fam. Chrysomelidae			0.22/0.58			0.21/0.20	0.09/0.11	0.53/0.27	0.54/0.11	0.36/0.18	36
Fam. Dytiscidae						0.55/0.04					3
Fam. Scolytidae				0.09/0.52	0.28/0.60	0.41/0.43	0.15/0.33	0.88/0.27	0.54/0.19	1.08/0.46	42
Fam. Staphylinidae			0.11/0.05	0.11/0.19		0.38/0.15	0.01/0.01	0.53/0.06	0.68/0.08	0.48/0.11	39
Fam. Scarabaeidae				0.02/0.39		0.10/0.05	0.02/0.03				9
Fam. Cantharidae			0.34/0.48	0.02/0.09	0.28/0.60	0.10/0.07	0.02/0.02	0.35/0.13	0.27/0.11		24
Fam. Carabidae			0.11/0.27	0.03/0.13	0.09/1.20	0.07/0.10	0.09/0.08	1.06/0.68	0.27/0.06		27
Fam. Cerambycidae			0.11/0.34	0.03/0.26	0.19/1.20	0.03/0.07	0.06/0.16	1.06/4.09	0.81/1.12		24
Fam. Curculionidae			0.22/0.11			0.03/0.03	0.02/0.19	0.18/0.47			12

Table 2. (Contd.)

Food items	Age, years										FO, %
	3+	5+	6+	7+	8+	9+	10+	11+	12+	13+	
Fam. Buprestidae								0.18/0.09			3
Fam. Silphidae									0.14/0.07		3
Fam. Coccinellidae		0.11/0.62		0.02/0.63		0.14/0.42				0.12/0.02	12
Order **Hymenoptera**											
order Symphyta			0.45/0.47	0.02/0.05	0.09/1.20	0.14/0.16	0.18/0.72	0.53/0.68	0.41/0.53		21
Fam. Apoidea			0.45/0.72		0.19/0.20	0.17/0.32	0.07/0.32	0.71/0.23	0.14/0.01		27
Fam. Formicidae						0.66/1.87	0.15/0.52	1.42/2.29	2.44/4.87		18
Fam. Pompilidae					0.09/0.20	0.14/0.44	0.15/0.52	0.18/0.10			12
Fam. Ichneumonidae			0.89/0.37	0.06/0.27	0.19/1.60	0.48/0.17	0.09/0.04		0.27/0.14	0.6/0.3	42
Order **Hemiptera**											
Fam. Aphididae			0.45/0.21	0.08/0.27		0.14/0.05					9
Fam. Acanthosomatidae						0.03/0.01					3
Fam. Cicadidae				0.02/0.03	0.09/1.20	0.10/0.10	0.05/0.16		0.27/0.19		15
Fam. Notonectidae				0.02/0.03							3
Order **Dermaptera**							0.02/0.06				3
Order **Lepidoptera**						0.03/0.02					3
Order **Mecoptera**								0.18/0.05			3
Class Chilopoda											
Fam. Lithobiidae								0.35/0.15			3
Class Arachnida											
Order **Aranei**			0.22/0.31	0.08/0.16		0.35/0.32	0.09/0.19	0.88/0.21	0.14/0.02	0.84/0.96	45
Type Chordata											
Class Mammalia (fur of murine rodents)						+/4.61					3

Table 2. (Contd.)

Food items	Age, years										FO, %
	3+	5+	6+	7+	8+	9+	10+	11+	12+	13+	
Remains of terrestrial insects		+ / 16.92	+ / 15.21	+ / 6.72	+ / 12.20	+ / 8.41	+ / 5.69	+ / 20.99	+ / 11.76	+ / 12.78	58
Remains of animal origin			+ / 10.71	+ / 16.08		+ / 8.29	+ / 4.80	+ / 17.48	+ / 10.16		21
Higher terrestrial vegetation		+ / 1.47	+ / 0.27	+ / 0.03		+ / 0.90	+ / 0.65	+ / 2.52	+ / 1.20	+ / 0.61	60
Total	+ / 1320	906 / 2722	895 / 11 120	6544 / 12 837	1076 / 4070	2895 / 34 069	5455 / 30 846	565 / 23 270	737 / 19 600	835 / 16 516	
Total number of food items, including::	1	15	38	44	22	66	56	45	41	22	
– aquatic	1	11	23	27	11	41	36	26	24	13	
– terrestrial		4	15	17	11	25	20	19	17	9	

Above the line is average number of preys, % of the total number; under the line is average weight of the food item, % of total weight; FO—frequency of occurrence; l.—larvae; p.—pupae; subim.—subimago; im.—imago of aquatic insects.

with regard of the proportion (%) of components by numbers and weight in the food bolus.

Food spectrum of lenok at an age of 3+ to 8+ is represented by 15–44 components (single stomach of four-year old was completely filled by roe of *B. tumensis*). Among aquatic objects, the bulk of feeding was formed by dipterans, mainly larvae and pupae of the family Chironomidae; only at an age of 6+, gastropod mollusks *Anisus* sp. dominated in the food of lenok, and their weight reached 45% (Fig. 3). In age groups 5+ to 8+, the relative weight of flies varied from 0.01 to 45.0% of the contents of stomachs (Table 2, Fig. 4). Mass objects of feeding by the frequency of occurrence, proportion of numbers, and weight included larvae and pupae of chironomids *Abiskomyia* sp., *Procladius* sp., Chironomini tribe, and biting midges of the family Ceratopogonidae (Table 2). Other amphibiotic insects (mayflies, stoneflies, caddis flies, alderflies) were recorded comparatively more seldom than dipterans; their proportion in the food bolus did not exceed 20.2%. Among amphibiotic insects, larvae and imagoes of caddis flies of the family Limnephilidae and alderflies were the most accessible food. The main food items also included terrestrial insects; on the whole, their proportion varied from 0.02 to 35.5% of the weight of the food bolus. Highest frequency of occurrence, average numbers, and weight in stomachs were in click beetles Elateridae. The role of the remaining representatives of terrestrial fauna in the feeding of lenok 3+ to 8+ is secondary.

Food composition of lenok at an age of 9+ to 13+ is wider: 22–26 taxa. The most diverse spectrum of feeding was revealed in 10-year olds. The spectrum widened at the expense of water bugs, some species of chironomids, flies, stoneflies, mayflies, caddis flies, terrestrial beetles, hymenopterans, larvae of butterflies, earwigs, scorpion flies, and centipedes. On the whole, chironomids gave up their leading position; their proportion decreased to 17.8% of the weight of the food bolus, although frequency of occurrence of chironomids remained rather high: they were recorded in almost all examined stomachs (Fig. 3, Table 2). The proportion of amphibiotic insects in the food bolus of individuals at an age of 9+ to 13+ remained at a level similar to younger age groups. Lenoks 9+ to 13 fed on imaginal stages of stoneflies (*M. pseudochracea*, *I. asiatica*, *D. majuscula*, *A. rostellata*), mayflies (*Ameletus* sp.), and caddis flies (*H. nigrovittatus*, *A. ulachensis*, *Goera* sp., *Molanoides* sp.) during their emergence (Table 2).

A distinguishing feature of feeding of individuals older than 10 years is consumption of aquatic and terrestrial vertebrates: in their stomachs, bearded stone loach and remains of fur of small murine rodents were found. In other words, on reaching an age of 9+, predatory feeding of large items assumes a considerable importance for lenok. The number of preys with age increases insignificantly (Fig. 4a); displacement of lenok from small to larger food objects is traced (Fig. 4b). For instance, the average weight of preys in age groups of lenok 9+ to 13+ that fed on fish was considerably higher than in lenok at an age of 5+ to 8+. The main object of feeding of elder age groups of lenok was Siberian char: the proportion of its weight in the food bolus was 17.7 to 42.4% (Table 2).

Other no less important objects of feeding of lenok of older age, terrestrial insects, in particular, beetles, remained as before. In the period of open water, the proportion of coleopterans in the feeding of lenok is rather considerable; apparently, these insects are

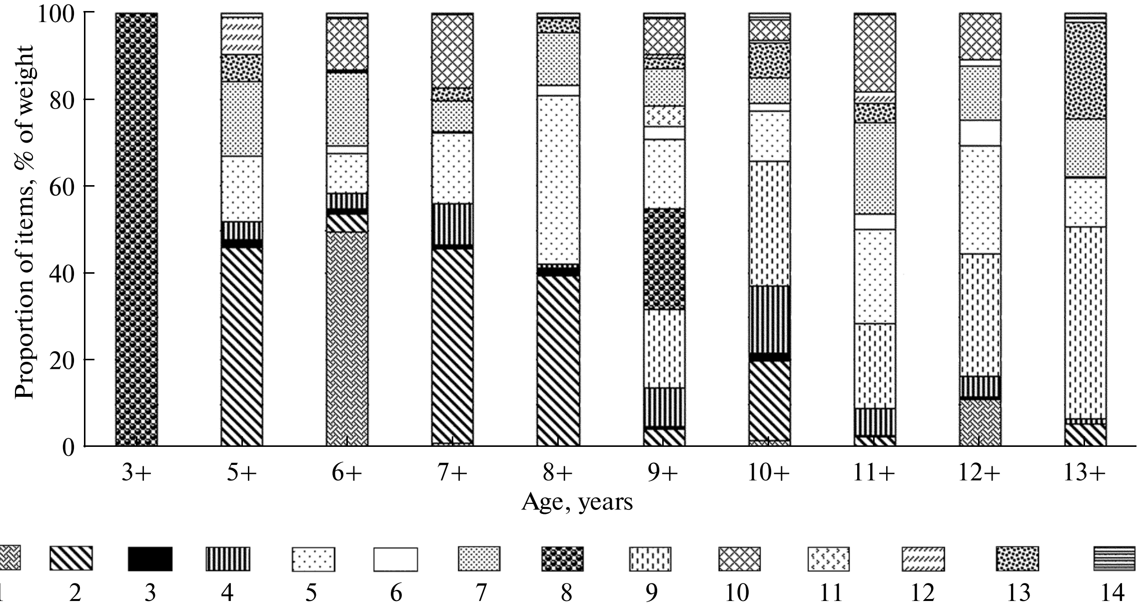

Fig. 3. Food spectrum of blunt-snouted lenok *Brachymystax tumensis* of different age from the basin of Korbokhon Lake, June 2011: (1) mollusks, (2) chironomids, (3) other dipterans, (4) aquatic insects (mayflies, stoneflies, caddis flies, orl flies), beetles, (6) hymenopterans, (7) remains of terrestrial insects, (8) lenok roe, (9) Siberian char *Barbatula toni*, (10) remains of animal food, (11) fur of small murine rodents, (12) plant remains, (13) pebble, (14) the remaining.

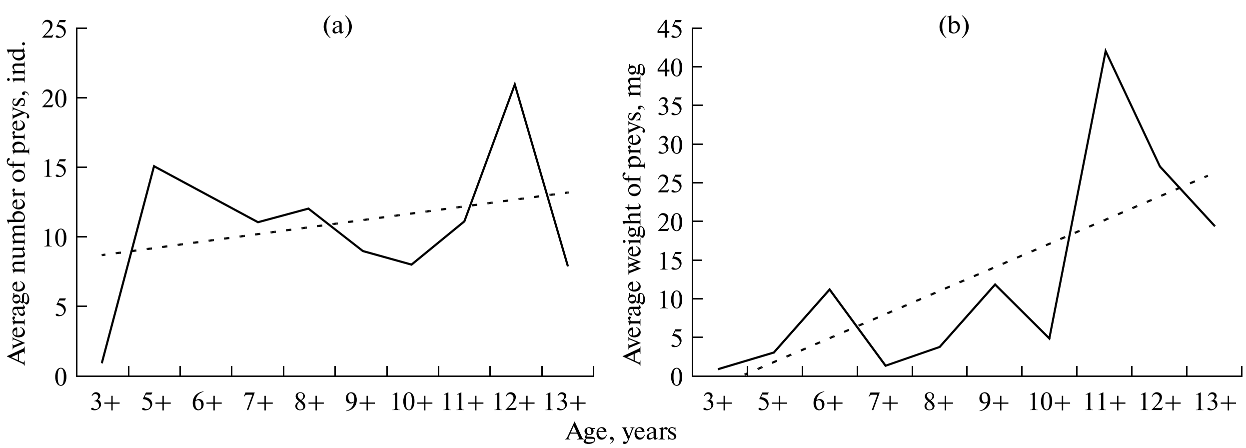

Fig. 4. (a) Average number and (b) weight of preys in stomachs of blunt-snouted lenok *Brachymystax tumensis* of early age from the basin of Korbokhon Lake, June 2011.

favorite and easily accessible food, especially in the period of mass flight. The proportion of the weight of beetles and other terrestrial insects (and their remains) in the chimus of individuals of elder age groups at a high frequency of occurrence reached 10.8–22.1% (Fig. 5). At the expense of terrestrial beetles that get on the water plane in multitude during mass flights, the ratio of the weight of aquatic and terrestrial food changed in Korbokhon lenoks of elder age groups. Although aquatic animals were main items of feeding of all age groups of lenok, note that the proportion of the weight of terrestrial food at an age of 11+ to 12+ increased considerably due to click beetles (Elateridae), long-horned beetles (Cerambycidae), and ants (Formicidae) (Fig. 5, Table 2). It is possible that active feeding of lenoks on terrestrial insects is retained throughout the period of open water when the emergence of one species is replaced by another. For instance, according to our observations, at the end of July–beginning of August 1996, lady beetles (Coccinellidae) were found in stomachs of 13 lenoks caught in the lake. At this time, mass flight of these insects occurred here. In our June samples in 2011, lady beetles in stomachs were not numerous, frequency of their occurrence did not exceed 12%. Hence, in the feeding of blunt-snouted lenok, seasonal changes in food

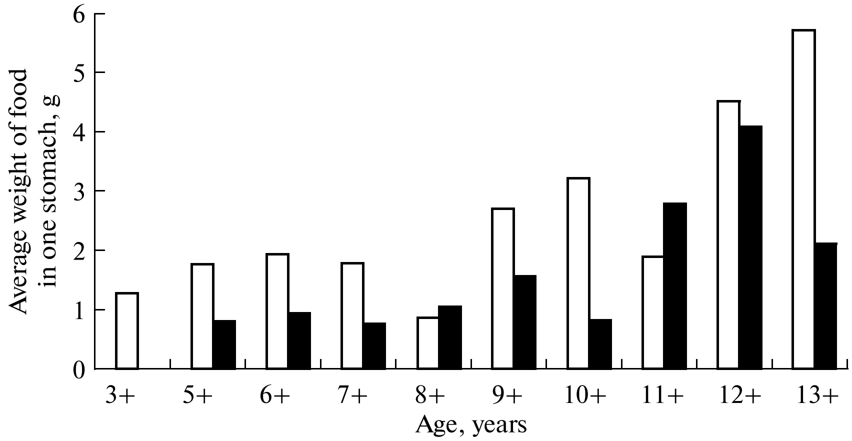

Fig. 5. Ratio of (□) aquatic and (■) terrestrial food in the feeding of blunt-snouted lenok *Brachymystax tumensis* of different age from the basin of Korbokhon Lake, June 2011.

composition are distinctly reflected. This was first mentioned in papers of the 1960s, when taxonomic differentiation of sharp-snouted or common lenok *B. lenok* and blunt-snouted lenok in zones of their sympatric habitation was not yet performed. At the present time, differentiation causes no doubts, since it is confirmed by morphological and genetic data (Shed'ko, S.V. and Shed'ko, M.B., 2003). According to data of Levanidov (1959), in mountain and foothill tributaries of Amur (Khor, Ussuri, and Khivanda rivers), *B. lenok* occurs in most diverse stations of the current, and its diet is characterized by an exceptional diversity. On the whole, its food spectrum includes organisms, such as leeches, oligochaetes, planarians, hair worms, mollusks, crayfish, scuds and hog slaters, mites and larvae of aquatic insects represented by caddis flies (38 species), mayflies (18), stoneflies (11), and chironomids (28–30); larvae of other Diptera, orl flies, beetles, and bugs occur more seldom. In addition, lenok swallows different rodents (shrews, water rats) and frogs. Of great importance in the feeding of lenok are also fish: brook lamprey *Lethenteron reissneri*, minnow *Rhynchocypris lagowskii*, gudgeon *Gobio gobio cynocephalus*, bearded stone loach *Barbatula toni*, bitterling *Rhodeus sericeus*, and juveniles and roe of chum salmon *Oncorhynchus keta*. Seasonality in feeding is pronounced very distinctly: a considerable role is played by fish, mollusks, crayfish, and larvae of aquatic insects in spring in the food. In summer, lenoks feed mainly on larvae of insects and other representatives of benthos. In autumn, the role of fish increases again, rodents, frogs (Levanidov, 1951), and roe of chum salmon are recorded in noticeable amounts. In winter after migration from tributaries to the mainstream of Ussuri and Amur, lenoks behave themselves as typical predator: feed exclusively on fish: (sawbelly *Hemiculter leucisculus*, blackbelly *Xenocypris argentea*, stone moroco *Pseudorasbora parva*, spotted barbel *Hemibarbus maculatus*, gudgeon, and smelt *Hypomesus olidus*); IFS reach 250–500‱ (Levanidov, 1959). It is difficult not to agree with the fact that, under conditions of small food supply, the importance of any seasonal food increases, of that delivered from beyond and of that present in the water body constantly, whose accessibility drastically increases in definite periods. According to results of our studies and the data of Levanidov (1951, 1959), such seasonal food in June were mature larvae and imaginal stages of stoneflies, mayflies and pupae of caddis flies and chironomids floating up from the bottom surface for metamorphosis, and hair worms (Gordiodea) that accumulated on the bottom as balls in the period of reproduction. An important kind of seasonal food brought from the outside for lenoks of Korbokhon Lake was its own roe that did not get into spawning hillocks and was drifted by the current. Unlike data presented in papers of Levanidov, in our studies, of great importance in the feeding of *B. tumensis* were terrestrial insects that reach mass development in June.

According to data of Mikheev and Vdovichenko (2009), benthos prevails in the upper reaches of the Nimelen River (basin of the Amgun River, lower Amur) in the diet of blunt-snouted lenok of river populations in September–October. Larvae of aquatic insects, caddis flies, mayflies, and stoneflies were found in stomachs of 97% of fish; imagoes of aquatic and a terrestrial insects was found of 63% of fish. In lenoks from the mountain part of the Nimelen River, frequency of occurrence of murine rodents in stomachs is 19%, while that in lenoks from the multiarm riverbed is only 3%; the proportion of fish food (13%) and roe of autumn chum salmon (14%) brought out from the hillocks during spawning increases. During spawning of autumn chum salmon, its roe was found in 78% of individuals of blunt-snouted lenok that concentrate in mass on the spawning grounds. The data of Mikheev and Vdovichenko (2009) completely agree with results of studies of Levanidov (1951, 1959) and indicate a similar seasonal pattern of feeding spectra of *B. lenok* and *B. tumensis*. At the same time, Shuba (1989), in a comparative study of *B. lenok* and *B. tumensis* in the basin of the Oldoi and Khaikta rivers (upper Amur), revealed differences in their feeding that, in his opinion, are apparently related to morphological specific features of the mouth structure. In blunt-snouted form of the lenok, the mouth is terminal typical of Salmonidae and its main food are fish; in the sharp-snouted form, the mouth is closer to the inferior inherent to benthophages, therefore benthic organisms dominate in feeding. In the diet of sharp-snouted lenok (weight 111–1504 g), 14 food items were found, while in blunt-snouted form (weight 112–3573 g), nine food components were found. The bulk of predatory feeding of blunt-snouted lenok is formed by fish and aquatic and terrestrial insects. The proportion of Amur ide and minnows—common minnow *Phoxinus rhoxinus* and Lagowski's minnow *Rhynchocypris lagowskii*—in stomachs of blunt-snouted lenok reaches 35%, larvae of caddis flies subdominate at 28.9%, terrestrial beetles do not exceed 10.1%, and larvae of water bugs are 8.7%. Whereas, in the feeding of sharp-snouted lenok, larvae of caddis flies dominate at 42.8%, ants comprise 18.5%, larvae of tipulids are 9.7%, and larvae of diving beetles are 8.9% (Shuba, 1989).

Undoubtedly, besides seasons of the year and possible morphological differences, specificity of feeding and other biological indices of lenoks are influenced by a complex of interrelated abiotic and biotic environmental factors in which they dwell. According to data of Matveev et al. (2009), in Balan-Tamur Lake (basin of the Barguzin River) characterized by optimal for habitation summer water temperature (8–12°C) and high quantitative indices of zoobenthos, the bulk of feeding of *B. lenok* in June is formed by mollusks, amphipods, and larvae of caddis flies, stoneflies, chironomids, syrbid flies, and representatives of air-terrestrial entomofauna. Of aquatic insects, *B. lenok* consumes mainly large larvae of stoneflies, tipulids, syrphid flies, and long-legged flies. Mass proportion of food from the water surface (beetles and hymenopterans) does not exceed 14%. Fish consumption (bearded stone loach) is also rather high (12.7% of the weight of the food bolus) in this period. In August, the leading role of benthos in the feeding of lenok remains; however, the group of dominant now includes gastropods (31.6%), amphipods (12.9%), and larvae of aquatic insects (15.7%), mainly larvae of large caddis flies (15.6%). Consumption of fish represented by juveniles of grayling *Thymallus arcticus baicalensis* and minnow also increases (~29.4%). Despite a considerable number of invertebrates, their consumption by lenok does not exceed 5.7% at nearly equal proportion of air-terrestrial arthropods and imagoes of aquatic insects.

Another pattern of feeding in the similar period of the year is described by Matveev et al. (2009) in lenok in ultraoligotrophic high-altitude Amut Lake (1210–1240 m above sea level), which is characterized by a short period of open water and low temperature values (up to 5–6°C). In the first half of summer, the bulk of the diet of *B. lenok* is formed by roe of black Baikal grayling (up to 40% of the weight of the food bolus). Subdominant group are larvae of alderflies (24.2%), caddis flies (6.8%), and dragonflies (2.9%). Fish consumption is rather high (18.9%). In August, lenoks of different age disperse to different trophic niches. Fish at an age of 1+ to 2+ feed mainly on larvae and pupae of dipterous simuliids (46.7%) and small dragonflies (45.4%); fish at an age of 3+ to 4+ feed on air-terrestrial insects (beetles) (40–54%) and larvae of caddis flies (up to 24%). In fish of older age, the bulk of the diet is formed by mammals (insect-eating and murine rodents), whose consumption increases from 56.4% of the weight in fish 5+ to 7+ to 73.2% in fish older than 10 years. The intensity of feeding of lenok in the studied lakes also differs. In Balan-Tamur Lake, this index (346–486‱) is higher by a factor of 1.2–1.8 than in Amut Lake, which, together with the high intensity of food digestion in warmer water, possibly determines high biological indices of lenok in this lake (Matveev et al., 2009).

CONCLUSIONS

Blunt-snouted lenok is a predator that makes the most use of food resources of Korbokhon Lake in a short period of open water and efficiently uses all accessible seasonal types of preys near bottom and in surface water layers. In the food spectrum of age groups 3+ to 8+, organisms of zoobenthos and terrestrial insects dominate; lenok roe and mollusks occur singly. Preferred food items include larvae and pupae of chironomids and biting midges obtained in the near-bottom horizon and terrestrial beetles swimming on the water surface. Food composition of blunt-snouted lenok of older age (9+ to 13+) is more diverse: bottom invertebrates, lenok roe, larvae, pupae, and imagoes of aquatic and terrestrial insects drifting in the water column or present on its surface. Most considerable changes in food composition were found at an age of 10 years and older, because of which food spectrum of the population on the whole and food provision increase. A distinguishing feature of feeding of lenok of older age groups in June is consumption of fish food and small murine rodents. Selectivity of feeding with respect to the weight of preys is observed: lenok at an age of 9+ to 13+ prefers larger food items. Lenoks at an age 11+ to 12+, to a greater extent than lenoks of other age, include beetles and other terrestrial insects collected from water surface or under it into their diet; the ratio of water and terrestrial food items changes in favor of the latter. However, no distinctly pronounced segregation by horizons in different age groups is traced. One can assume that different age groups of lenok feed in different horizons where food items preferred by them are most numerous and easily accessible. This supposition requires additional studies.

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