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Feeding of Juvenile Sterlet (*Acipenser ruthenus*, Acipenseridae) in the Danube River Midstream

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Abstract—The present paper provides the results of the study on feeding of juvenile (underyearlings and age 2+) sterlet (*Acipenser ruthenus*) caught in the Danube River in 2002–2003. The full spectrum of food items found in the fish stomachs was identified. The seasonal patterns of food composition are revealed. It is shown that juvenile sterlet in the Danube feeds mainly on larvae of chironomids and trichopterans, amphipods, and leeches. The organisms typical for lithophilic and lithorheophilic biocenoses play considerable role in the feeding of sterlet. Mean daily gains of body length and weight in the sterlet underyearlings are calculated.

Keywords: feeding in sterlet, seasonal dynamics of feeding, fullness index, frequency of occurrence, growth
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INTRODUCTION

Regulation of river flows by building dams represents one of the types of human impact on natural ecosystems. In different countries, the scales of such building were different, but the consequences were similar. Modification of hydrological characteristics negatively influences anadromous sturgeons (Acipenseridae) in which the reproductive cycle includes spawning migrations: the fish spawn in rivers quite far from the seas and then parental and juvenile fish migrate downstream back to the sea. Sterlet (*Acipenser ruthenus*) is an exclusion: this is a typically riverine fish that does not migrate for long distances (*The Freshwater Fishes*…, 1987; 1989; *The Atlas of Freshwater Fish*…, 2002). This is why the regulation of river flows had no impact upon relevant component of its reproduction. Sustainable populations of sterlet remain in the basins of large European rivers, such as the Volga, Danube, etc. (Jankovic, 1958; Boldina, 1961; 1966). However there are numerous publications indicating that most of these populations are stressed (Dubinin et al., 2000; Kim, 2000; Bartosh, 2004; Zadelyonov, 2004; Zuyev et al., 2004; Novoselov, 2004). Mainly this is determined by the lack of appropriate conditions for reproduction of sterlet owing to decrease in the areas of natural spawning grounds and deterioration of conditions in them due to accumulation of silt. Artificial propagation is the only possible way to preserve and increase the stock of this fish (*Sturgeons*…, 2000). Successful fulfilling of this task necessitates studies on sterlet biology, particularly on its feeding habits during the first months of life.

The present study sets to reveal the peculiarities of feeding in sterlet during the first and second years of life in the Danube River.

MATERIALS AND METHODS

Juvenile fish sampled within a 10 km-long stretch of the Danube River (near Beograd) in November 2002 and in June–October 2003 were studied. In July and September, the sampling was performed twice. The fish were sampled using bottom trawl (8–40 mm mesh at the trawl head) along the navigable part of the river with depths to 18 m. Juvenile fish of three age stages dominated by underyearlings presented in the catches (Table 1).

The contents of the digestive tract were analyzed following the common routine (*Methodic Guidelines*…, 1974). Where possible, the food organisms removed from the digestive tract were identified to the species level; if this was not possible, they were identified to the level of genus or taxonomic group. The organisms found in the digestive tract were counted and weighed. The fullness index for digestive tract was calculated as ratio of the total weight of content to the fish weight and expressed as ‰ (Borutskii, 1974). The frequency occurrence of the organisms in the digestive tract was calculated excluding the fish specimens with empty stomachs. Relative importance of food organisms was determined both by their number and weight. In total, 89 stomachs were analyzed: age 0+, 64; age 1+, 24; age 2+, 1.

Mean daily values of the length and weight gains were calculated according to the equation by Schmal-

Table 1. Age and body sizes of juvenile sterlet (*Acipenser ruthenus*) in the samples from the Danube River near Beograd in June–November

Parameters	Month							
	June		July		August	September	October	November
	Age, years							
	1+	2+	0+	1+	0+			
N, ind.	19	1	80	5	7	23	7	2
Length, cm	24–30 27.0 ± 0.48	45 –	11–24 15.8 ± 0.32	26–36 30.9 ± 1.56	19–23 20.5 ± 0.55	20–27 22.6 ± 0.55	22–26 24.4 ± 0.51	21–26 25.9 ± 4.55
Weight, g	109–223 163 ± 7.88	943 –	13–94 61 ± 2.00	213–356 245 ± 3.23	48–79 61 ± 3.91	56–158 89 ± 7.06	94–141 109 ± 6.50	73–140 107 ± 32.35

Note: above—limits; bottom—mean and error of mean.

Table 2. Importance of main groups of food organisms in the feeding of juvenile sterlet (*Acipenser ruthenus*) of the Danube River

Month	Age, years	N, ind.	Prey								
			amphipods		trichopterans		chironomids		leeches		other
			OF, %	RN, %	OF, %	RN, %	OF, %	RN, %	OF, %	RN, %	OF, %
VI	1+	19	100	76.0	26.3	1.9	68.4	18.2	5.2	0.4	3.5
	2+	1	–	91.2	–	8.5	–	0.3	–	–	–
VII	0+	25	20	0.05	–	–	100	97.3	8.0	0.05	2.6
	1+	5	40.0	3.5	20.0	1.6	100	91.2	20.0	2.1	1.6
VIII	0+	7(2)	60.0	0.1	80.0	2.7	60.0	5.8	100	77.0	14.4
IX	0+	23	30.4	4.5	13.0	1.1	30.4	2.4	100	89.9	2.1
X	0+	7	100	95.0	–	–	42.8	2.9	14.3	2.1	–
XI	0+	2	–	–	–	–	100	80.0	100	20.0	–

Note: OF—occurrence frequency, %; RN—relative number in the digestive tract content, %; number of fish with empty stomachs is in parentheses; number of studied fish is outside of parentheses.

gauzen (1935) as modified by Vinberg (1956) with one day taken as unit of time:

$$C_{av.} = [10^{\,1/n\,(\lg Wn - \lg Wo)} - 1] \times 100,$$

where $C_{av.}$ is the daily gain, %; n is the time interval, days; and W_o and W_n are standard length (weight) of the fish at the beginning and the end of the observation period, mm (mg).

Calculations were performed taking the length as a standard fish length (SL), the distance from a fish's snout top to the beginning of caudal fin. The data on the fish length and weight are given as means and errors of means (M ± m).

RESULTS

The analysis of digestive tract content in the studied fish indicates that, generally, juvenile sterlet in the Danube River is an omnivore. During the study period, the feeding spectrum of sterlet included 11 groups of invertebrates at the levels of classes, subclasses, orders, and families. Chironomid larvae and leeches dominated by the number of species.

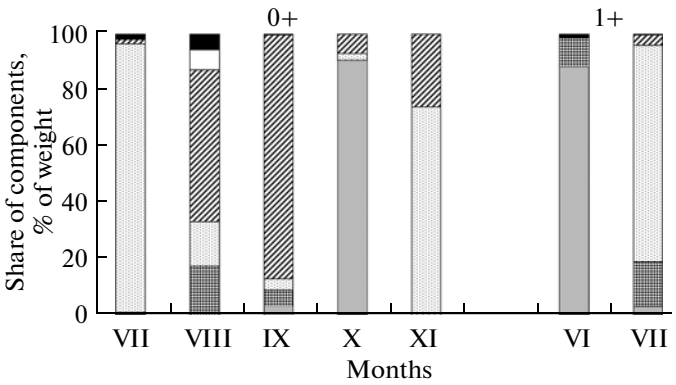
In *July*, at the age 0+, sterlet chironomid larvae composed the base of digestive tract content at 100% frequency of occurrence (Table 2; Fig.). The species of g. *Chironomus* dominated the fish feeding accounting for more than 80% of the number of all chironomids found. Amphipods and leeches were found in inconsiderable numbers. Relative number of cladocerans and copepods and their weight shares were 0.4%. Some changes in food composition in the fish age 0+ caught in the I and III ten-day periods of the month are worth noting: by the end of July, a large amount (more than 70%) of chironomid larvae of the elder age groups at IV developmental stage appeared in the digestive tract. At the same time, eight-fold increase in the number of chironomid pupae (compared to the

beginning of month), many of which were at the terminal stages of metamorphosis, was noted. Changes in the chironomid species composition were also peculiar. In the III ten-day period of July, no specimens of *Cryptochironomus redekei*, typical representative of psammophilic biocenoses inhabiting the river channel were found in the fish food. At the same time, pelophilic larvae of *Polypedium* and other chironomid species developing at the habitats with stagnant water, among aquatic vegetation, silty sand littoral and sublittoral appeared in the sterlet digestive tract. The latter chironomids were *Harnischia fuscimana* and *Tanytarsus* sp. (Mordukhai-Boltovskoi, 1955; *Identification Key-Book*, 1977; *The Volga and Its Life*, 1978). Maximal number of chironomid larvae per single digestive tract increased from 467 individuals at the beginning of the month to 958 ind. by the end. Gut fullness indices varied from 141.7 to 270.8, averaging 197.8‰.

In **August** species composition of food items in sterlet underyearlings was the most diverse. Representatives of almost all groups of invertebrates found in the fish food for the whole observation period were found. Chironomids lost their domination. These invertebrates were represented mainly by large larvae of g. *Chironomus*. Together with pupae, their share in the total weight of digestive tract content was 15.8%. Leeches became dominant food for age 0+ sterlet. These invertebrates were represented by rather small specimens with mean body weight of 4.3 (3.3–7.0) mg. At high relative number and 100% frequency of occurrence, the share (by weight) of these animals was 54.5%. The share of trichopterans in the fish feeding was considerable (Fig.). Sometimes the fish consumed caddisflies with their cases. Only in August did the underyearlings feed on dragonfly larvae (6.9% by weight). Amphipods, mollusks, ostracods, hydroids, copepods, and oligochaetes added to the fish-feeding spectrum. The gut fullness index averaged 175.6 (111.2–418.1‰).

In **September**, leeches remained the dominant food for sterlet underyearlings (Table 2; Fig.) when the number reached 175 ind. per one digestive tract at 100% occurrence frequency. Chironomid larvae were represented mainly by *Limnochironomus nervosus*; the number of chironomid species decreased. Only solitary specimens of hydroids, mollusks, mysids, oligochaetes, amphipods, and ostracods were found. Comparison of the food compositions in sterlet underyearlings at the beginning and the end of September revealed no quantitative difference except for *Corophium curvispinum* that was found in the fish digestive tract in the II decade. The gut fullness index declined compared to August to 140.9 (86.1–262.8‰).

In **October**, *Corophium* became dominant food for sterlet with a share in the total weight of digestive tract content of 90.6% and occurrence frequency of 100%. The number of this invertebrate reached 822 ind. per single digestive tract. Leeches and chironomid larvae accounted only for 5% of total number of found food



Change in the food composition in ages 0+ and 1+ sterlet (*Acipenser ruthenus*) in the Danube River: (□)—Odonata; (▨)—leeches; (▫)—Chironomidae; (▩)—Trichoptera; (▥)—Amphipoda; (■)—other.

items. Furthermore, the species diversity in chironomids increased owing to the appearance of *Polypedium scalaenum, H. fuscimana*, and *Procladius ferrugineus*. Of the former list of chironomid species, the representatives of g. *Chironomus* remained the most numerous. The gut fullness index was 139.9 (113.2–147.2‰).

In **November**, in two studied sterlet underyearlings only chironomid larvae and leeches were found. The amount of consumed preys decreased drastically: 67 to 127 ind. per single digestive tract. Chironomids accounted for 80% by number; leeches accounted for 20%. The gut fullness index was 47.2 (31.5–62.9‰).

In **July** and **September**, sampling was performed twice with the same time interval of 15 days (July 9 and 23; September 2 and 16). Comparison of length and weight growth rates for these time intervals revealed that, in July when chironomid larvae were the dominant food, daily weight gain was 1.3 times higher than in September at consumption of leeches. On the other hand, the rate of length gain in July was higher than in September: 3.2 mm versus 1.5 mm per day. It is not clear yet if these differences were determined by feeding on different food items or reflect physiologically determined seasonal dynamics of growth in juvenile sterlet. Earlier studies of growth of sterlet underyearlings in the Don River revealed that linear growth is most intensive during first three months of their life and retards starting from August (Yakovlev, 2004). This possibly relates to the seasonal changes in the feeding intensity in the juvenile fish. The present study revealed that consecutive decline of gut fullness index values started particularly in August.

In **June**, the base of digestive tract content in the sterlet of ages 1+ and 2+ consisted of higher crustaceans: Gammaridae and Corophiidae accounted for 76 and 91% by number, respectively (Table 2). The content of a single digestive tract contained up to 925 ind. of these organisms. Furthermore, the number of corophiids was much higher than that of gammarids: 844 ind. versus 81 ind. Trichopterans *Ecnomus*

tenellus and *Hydropsyche* sp. also played some role in the feeding of the age 2+ and 3+ sterlet (Fig.). Their share in the weight of digestive tract content was 10.3% in age 1+ fish and 30.6% in the age 2+ specimens. The species composition of consumed chironomid larvae was diverse and included 11 taxa. The larvae of g. *Polypedium* dominated by number (more than 50% of all found chironomids). Leeches, mollusks, mysids, and black gnats were presented as solitary specimens. The gut fullness index in the two year-old fish varied from 110 to 219.3 (121.7‰); it was 98.5‰ in the only analyzed age 2+ specimen.

In **July** in the two-year old sterlet, the forage organisms were dominated by larvae of *Chironomus* sp. at 100% occurrence frequency; there share by weight in the digestive tract content reached 76.8%. Average number of larvae at II and IV age stages (at the ratio of 1 : 2) per single digestive tract was 387. Relative number of caddisflies was low but owing to their high individual weight they played an important role in the feeding of two-year old fish (Fig.). The rest of food consisted of leeches, amphipods and mollusks. The intensity of feeding was comparable to the values of the preceding month: 79.6–202.4 (119.9)‰.

DISCUSSION

Three noteworthy facts were revealed in the studies of juvenile sterlet of the Danube River: seasonal changes in the composition of food organisms; change in the feeding grounds at the deterioration of feeding conditions owing to decrease in number and biomass of macrozoobenthos determined by emergence of imago chironomids; and consumption of leeches (Table 2, Figure).

Most likely the seasonal changes in the composition of food in sterlet underyearlings and change in the dominant groups of invertebrates relate to the life cycles of consumed organisms. The analysis of published data on the feeding of juvenile sterlet in other areas of this species range revealed that dipterans, chironomids in particular, form the base of ration of this species during the whole period of active foraging (Jankovic, 1958; Boldina, 1961, 1966; Rozhdestvenskaya, 1966; *The Freshwater Fishes*, 1987; 1989; *The Atlas of Freshwater Fish*, 2002; Nenashev et al., 2004; Novoselov, 2004). Chironomids are widely spread organisms, which facilitates their consumption as preferable food. According to some researchers (Zhadin, 1940; Pankratova, 1940; Soye, 1957; Shilova, 1976; Filipovic, 1981; Jacobi, 1981; Karaman, 1981), chironomids inhabit the bottom of waterbodies from the shore line to considerable depths, dwell on sandy, silty-sandy, stony, and silty grounds on various substrata and at various water current velocities and sometimes account for more than half of the whole benthic fauna both by number and biomass. The mass emergence of imago chironomids results in the decrease in the number of this food available for fish (especially for juvenile specimens) forcing the fish to turn on feeding on other preys.

In June in the food of juvenile sterlet, the number of elder chironomids and of their pupae at the terminal stages of metamorphosis increased. This determined the quantitative changes in the composition of zoobenthos and close changes in the priorities in the feeding of sterlet. In August, the importance of chironomids in the feeding of underyearlings decreased drastically (Table 2; Figure). Unfortunately, there are no data available on the patterns of seasonal changes in benthos composition in the Danube. However, the studies performed within the same climatic zone in the Moracha River indicate that at the same part of the river high number of chironomids in July (1111.0 ind./m^2) decreased by August to 444.4 ind./m^2 and that in September was as low as 88.8 ind./m^2 (Karaman, 1981). Such decrease was determined by mass emergence of imago chironomids during the period of time from July to September. By the end of October, the number of chironomids in the river increased again to 355.5 ind./m^2 (Karaman, 1981). It is likely that a similar pattern of seasonal dynamics of abundance of chironomid larvae is also a characteristic of the Danube. This may have determined the revealed change in dominating groups of organisms in the food of underyearlings. The fish widened the zone of search for food and fed on the organisms inhabiting other biotopes. The list of food organisms found in the fish digestive tract supports the above assumption. In July, the organisms confined to the silty sand or sandy bottom of littoral and sub-littoral are present in the sterlet food. In August, leeches *Glossiphonia complanata* and *Erpobdella octoculata*, the representatives of the lithorheophilic biocenosis dwelling on the stony bottom at the presence of water current, appeared in the fish food. According to Lukin (1976), *G. complanata* forms aggregations on the stones at the heights of 10–15 cm above the bottom. The biology of the second leech species is poorly studied, but the abundance of this species near the bottom is high: up to 115 ind. were found in the bottom samples (Lukin, 1976). The importance of lithophilous (lithorheophilic according to Zhadin) *Limnochironomus nervosus* increased by several times (Zhadin, 1948; Shilova, 1976). The caddisfly larvae became a noticeable component of sterlet food. These larvae were *Hydropsyche pellucida* inhabiting dense sands with admixture of gravel. Together with the organisms noted above, the digestive tract of juvenile fish contained the representatives of the littoral assemblage of organisms among which was *Glyptotendipes glaucus* attaching its cases to vegetating plants. The fragments of plants and ground were present in the sterlet food.

Several researchers (Boldina, 1966; Rozhdestvenskaya, 1966; Novoselov, 2004) reported on the possibility of change of the feeding grounds at the decline in benthos biomass owing to decreases in the number of chironomid larvae. Such change is accompanied by

the change in the dominant group of organisms in the sterlet food. In some cases, at the destruction of rheophilic biocenoses, the composition of food in sterlet may resemble that one in the typical planktivores. According to Boldina (1966), in the part of the Volga River with regulated flow, pelagic cladocerans and copepods (*Acanthocyclops, Mesocyclops, Eurytemora, Bosmina, Daphnia, Leptodora*, and *Bythotrephes*) account for 52–96% of weight of content of digestive tract in sterlet.

Leeches are seldom reported as a fish food and their species composition is not given usually. At the same time, owing to their morpho-ecological properties, leeches are easily available for benthivores, epitivores, and predatory fish. These invertebrates are not poisonous, lack hard covers, move slowly, and are quite abundant. In autumn, some leeches form aggregations and migrate to riverbeds (Lukin, 1976). Leeches are readily digestible in the fish digestive tract and have quite a high nutritive value (Ugolev, 1985). The results of the present study concerning mean daily length and weight gains of sterlet underyearlings in September show that consumption of leeches provides more rapid fish weight growth at inconsiderable gain of their length compared to the period when chironomid larvae dominate the food.

Consumption of amphipods (*Corophium* in particular) observed in underyearlings in October and in age 2+ fish in June most likely relates to high abundance of these crustaceans in the lithophilous biocenoses of the Danube. It is known (Lyakhov, 1960) that *C. curvispinum* developed in huge abundance within the Volga midstream before its flow was regulated: in some places the number of this species reached 350000 ind./m^2 and their cases built a solid cover, the so-called corophiid ground. No data of the composition and abundance of amphipods, the representatives of fam. Corophiidae in the Danube are available. However, high occurrence frequency of these invertebrates in the sterlet food in some periods of observation suggests that these animals compose a considerable portion of the river's benthic fauna. The results of the studies on feeding of juvenile sterlet performed in 1951–1953 at the part of the Danube Slankamen–Beograd–Ram also favors this suggestion: at some sampling sites, *Corophium* accounted for 35–77% by number in the content of juvenile sterlet digestive tract (Jankovic, 1958).

The present study on the feeding of juvenile sterlet in the Danube River revealed high trophic plasticity and active searching ability in these fish. The larvae of chironomids and trichopterans, along with amphipods and leeches were the main preys of the studied fish. Mollusks, black gnats, oligochaetes, ostracods, cladocerans, and copepods inconsiderably enriched the feeding spectrum of juvenile sterlet.

The organisms of lithophilic and lithorheophilic biocenoses inhabiting bottom and various underwater subjects played considerable roles in the feeding of sterlet. However, it is likely that, during a certain period of time, sterlet underyearlings fed on silty littoral and sublittoral as well as among the aquatic vegetation. The patterns of seasonal dynamics of qualitative composition and domination of certain groups of organisms prove this suggestion. Furthermore, the substitution of some components of food to others only weakly influenced general intensity of the fish feeding.

The comparison of the data of the present study on the feeding spectrum of juvenile sterlet with such parameters as frequency occurrence of prey and of their relative importance in the content of digestive tract with the relevant data of the 1950s (Jankovic, 1958) revealed that, within the studied part of the Danube River, qualitative composition of macrozoobenthos did not changed considerably. The only exception is that leeches became an important component of the river bottom fauna. High intensity of feeding and fast growth rate indicate that the environmental conditions within the studied part of the river are favorable for juvenile sterlet.

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REFERENCES

Atlas presnovodnykh ryb Rossii (Atlas of Freshwater Fishes of Russia), Reshetnikova, Yu.S., Ed., Moscow: Nauka, 2002, vol. 2, 252 p.

Bartosh, N.A., Present Status of Sterlet Populations of the Kuibyshev and Nizhnekamsk Reservoirs, in *Sostoyanie popu-lyatsii sterlyadi v vodoemakh Rossii i puti ikh stabilizatsii* (Status of Populations of Sterlet in Inland Reservoirs of Russia and the Ways of Their Stabilization), Moscow: FA po Rybolovstvu, 2004, pp. 112–160.

Boldina, I.K., About Nutrition of Sterlet in the Gor'kii Reservoir, in *Tr. In-ta biologii vodokhranilishch* (Transactions of the Institute of Biology of Reservoirs), Moscow, Leningrad: Izd. AN SSSR, 1961, issues 4(7), pp. 272–280.

Boldina, I.K., Some Peculiarities of Sterlet Biology in the Kuibyshev Reservoir, in *Biologiya ryb Volzhskikh vodokhra-*

nilishch (Biology of the Volga Reservoirs), Moscow, Leningrad: Nauka, 1966, issue 10(13), pp. 119–130.

Borutskii, E.V., About Food Reserve for Fishes, in *Materialy po kormovoi baze ryb* (Materials on Food Reserve for Fishes), Moscow: AN SSSR, 1974, pp. 5–61.

Coe, B.L., Diptera Taken in Yugoslavia from May–Jule 1955 with Localities and Notes, *Bull. Muz. Hist. Natur. Pays Serbe.*, 1957, vol. 8/2, pp. 75–96.

Dubinin, V.I., Pashkin, L.M., poletaev, V.I., and Sukhoparova, A.D., Present Status of Natural Reproduction of Sturgeons in Low Pool of the Volgograd Waterwork, in *Tez. dokl. Mezhdunar. konf. Osetrovye na rubezhe XXI veka* (The International Conference Sturgeon on the Turn of XXI Century, Abstract of Papers), Astrakhan': Izd. KaspNIRKh, 2000, pp. 49–50

Filipovic, D., Benthic Macroinvertebrates of the Lower Moraca River, in *The Biota and Limnology of Lake Skadar*, Titograd: GRO Prosvet, 1981, pp. 294–299.

Filipovic, D., Benthic Macroinvertebrates of the Lower Moraca River, in *The Biota and Limnology of Lake Skadar,* Titograd: GRO Prosvet, 1981, pp. 294–299.

Karaman, G. The Zoobenthos of Lake Skadar and Its Tributary, the Moraca River, in *The Biota and Limnology of Lake Skadar*, Titograd: GRO Prosvet, 1981, pp. 221–250.

Kim, Yu.A., Present Status of Spawning Population of Sturgeon Fishes of the Ural River, in *Tez. dokl. Mezhdunar. konf. Osetrovye na rubezhe XXI veka* (The International Conference Sturgeon on the Turn of XXI Century, Abstract of Papers), Astrakhan': Izd. KaspNIRKh, 2000, pp. 60–61.

Lukin, E.I., *Fauna SSSR. Piyavki* (Fauna of USSR, Leeches), Leningrad: Nauka, 1976, 484 p.

Lyakhov, S.M., Benthos of the Volga River Close to Kuibyshev and Its Dynamics, *Trudy Inst. Biologii Vodokhranilishch AN SSSR*, 1960, issue 3(6), pp. 106–128.

Metodicheskoe posobie po izucheniyu pitaniya i pishchevykh otnoshenii ryb v estestvennykh uloviyakh (Methodological Manual for Study of Feeding and Food Relations of Fishes in Natural Conditions), Moscow: Nauka, 1974, 254 p.

Mordukhai-Bolotovskoi, F.D., Distribution of Benthos in the Rybinsk Reservoir, *Trudy Biol. St. Borok AN SSSR*, 1955, issue 2, pp. 32–88.

Nenashev, G.A., Blinov, Yu.V., Klevakin, A.A., and Minin, A.E., Status of Reserves and Perspectives of Sterlet Population Recovery in the Cheboksary Reservoir, in *Sostoyanie populyatsii sterlyadi v vodoemakh Rossii i puti ikh stabilizatsii* (Status of Sterlet Populations in Russian Reservoirs and the Ways of Their Stabilization), Moscow: FA po Rybolovstvu, 2004, pp. 193–201.

Novoselov, A.P., Sterlet of the Severnaya Dvina River Basin, in *Sostoyanie populyatsii sterlyadi v vodoemakh Rossii i puti ikh stabilizatsii* (Status of Sterlet Populations in Russian Reservoirs and the Ways of Their Stabilization), Moscow: FA po Rybolovstvu, 2004, pp. 160–173.

Opredelitel' presnovodnykh bespozvonochnykh Evropeiskoi chasti SSSR. Plankton i bentos (Determinant of Freshwater Invertebrates of European Part of USSR. Plankton and Benthos), Leningrad: Gidrometeoizdat, 1977, 511 p.

Osetrovye na rubezhe XXI veka (Sturgeon Fishes on the Turn of XXI Century), Astrakhan': Izd. KaspNIRKh, 2000, 354 p.

Pankratova, V.Ya., Distribution of Bottom Fauna in Verkhne-Volzhsk Reservoir Related with Artificial Changes of the Level, *Zool. Zhurn.*, 1940, vol. 19, issue 5, pp. 776–789.

Rozhdestvenskaya, A.D., Cultivation of Sterlet in the Ponds, in *Nekotorye voprosy osetrovogo khozyaistva Kaspiiskogo basseina* (Some Questions of Sturgeon Production in the Caspian Basin), Moscow: TsNIORKh, 1966, pp. 40–41.

Shilova, A.I., *Khironomidy Rybinskogo vodokhranilishcha* (Chironomids of the Rybinsk Reservoir), Leningrad: Nauka, 1976, 249 p.

Shmal'gauzen, I.I., Determination of General Statements and Method of Growth Study, in *Rost zhivotnykh* (Growth of Animals), Moscow, Leningrad: Biomedgiz, 1935, pp. 6–8.

The Freshwater Fishes of Europe, Lelek, A., Ed., Wiesbaden: AULA-Vert., 1987, vol. 9, 343 p.

The Freshwater Fishes of Europe. General Introduction to Fishes: Acipenseriformes, Holcik, J., Ed., Wiesbaden: AULA-Vert., 1989, vol. 1/2, 469 p.

Ugolev, A.M., *Evolyutsiya pishchevareniya i printsipy evolyutsii funktsii* (Evolution of Digestion and Principles of Evolution of Functions), Leningrad: Nauka, 1985, 544 p.

Vinberg, G.N., *Intensivnost' obmena i pishchevye potrebnosti ryb* (Intensity of Metabolism and Food Demands of Fishes), Minsk: Izd. Belorus. Univ., 1956, 253 p.

Volga i ee zhizn' (The Volga River and Its Life), Leningrad: Nauka, 1978, 350 p.

Yakovlev, S.V., Recovery of Population of Sterlet in the Don River Basin in the Area Above the Tsimlyanskaya Dumb of Hydroelectric Power Station, in *Sostoyanie populyatsii sterlyadi v vodoemakh Rossii i puti ikh stabilizatsii* (Status of Sterlet Populations in Russian Reservoirs and the Ways of Their Stabilization), Moscow: FA po Rybolovstvu, 2004, pp. 186–192.

Zadelenov, V.A., Sterlet of the Yenisei River Basin: Natural and Artificial Reproduction, in *Sostoyanie populyatsii sterlyadi v vodoemakh Rossii i puti ikh stabilizatsii* (Status of Populations of Sterlet in the Reservoirs of Russia and the Ways of Their Stabilization), Moscow: FA po Rybolovstvu, 2004, pp. 77–93.

Zhadin, V.I., Fauna of Rivers and Reservoirs, *Trudy ZIN AN SSSR*, 1940, vol. 5, issues 3–4, pp. 519–991.

Zhadin, V.I., Bottom Fauna of the Volga Close to Zhiguli and Its Possible Changes, *Trudy ZIN AN SSSR,* 1948, vol. 8, issues 3–4, pp. 413–466.

Zuev, I.P., Egortseva, Yu.A., and Rusanov, V.V., Brief Review of Present Status of Reserves and Biology of Sterlet of the Kama River Basin, in *Sostoyanie populyatsii sterlyadi v vodoemakh Rossii i puti ikh stabilizatsii* (Status of Populations of Sterlet in the Reservoirs of Russia and the Ways of Their Stabilization), Moscow: FA po Rybolovstvu, 2004, pp. 51–59.