2016

Acclimatization of *Coregonus autumnalis migratorius* (Georgi, 1775) in Some Water Bodies of the Mongolian Gobi

Auyriin Dulmaa
Mongolian Academy of Sciences, adulmaa@yahoo.com

Erforsch. biol. Ress. Mongolei (Halle/Saale) 2016 (**13**): 271-279

Acclimatization of *Coregonus autumnalis migratorius* (Georgi, 1775) in some water bodies of the Mongolian Gobi

A. Dulmaa

Abstract

Introductions and subsequent acclimatization of the fish Baicalian omul (*Coregonus autumnalis migratorius natio possolskii)* was carried out in 1980, 1982, and 1986 in the previously fishless lakes of Ulaagchnii Khar, Baga, and Jaahan located in the territory of Gobi region of the Zavhan administrative aimag of Mongolia. Three million larvae of *Coregonus autumnalis migratorius natio possolskii* were received from the Bolshrechnsky fishery in Buryatya, Russia (DULMAA 1999). The density of distribution was 10-15 thousand units per hectare with an average larvae mass of 0.05 g. The relatively abundant fodder base has facilitated the high rate of growth and quick maturity (within 4 -5 years). This is related to the specific features of nutrition of Baicalian omul of different size groups. The main food for young fish were the copepods *Mixodiaptomus incrassatus, Arctodiaptomus bacillifer,* and *Cyclops abyssorum*, which build up to maximum numerical densities in July-August of each year. Fish feeding on these copepods accumulate reddish spots on their skin with a biomass of 6.99-10.1 m^3. The trophic relationship of the Baicalian omul indicate that chironomid midge larve are consumed by all age classes of fish, which also feed on amphipods, larvae of other water insects, molluscs and ostracods. Populations of fish spawn in the area of underwater spring sources. Therefore, it appears that the Baicalian omul has acclimatized well in the system of the lake Ulaagchnii Khar and has spread to all areas of the lake.

Key words: lake Ulaagchnii Khar, *Coregonus autumnalis migratorius*

Study site

The lakes of Ulaagchnii Khar, Baga, Jaahan are located in the famous “Bor-Har” sand valley of the Erdenehairhan Soum of the Zavhan aimag in western Mongolia. The lake Ulaagchnii Khar situated at 1980 m. elevation has an elongated form with two large islands in the western part. With no above-ground or riverine source, the lakes are fed mainly by direct precipitation and underwater springs. Ulaagchnii Khar is 84.5 km^2 in area and has a length and width of 36 km by 7 km, respectively, and a water volume of 1.7 km^3. The total rainwater basin size is 1,450 km^2. The maximum depth reaches 50 m with an average depth of 25 m. The lake is a closed system with no outlet and with only the small Ulaagchnii river flowing in from the north. The lake sides are low and rocky, and in several areas the mountains plunge straight into the lake, where the significant depths are found. The lake bottom consists of sand and sediment including some areas of sandy/stony bottom with aquatic vegetation. Water in the lake is fresh, with the total mineralization ranging from 200 to 542.5 mg/l of the hydrocarbonate class of the calcium group ($CaCO_3$). Each year, in late November/early December, the lake freezes with a complete cover of ice reaching a depth of 120-180 cm. The ice melts completely in late June and in summer (July-August) the water temperature of the surface reaches 15-25 °C, in 40-50 m depth it reaches only 8-12 °C. Average oxygen concentration ranges from 7.74-8.29 mg/l, with saturation up to 85.5-97.5 %. The speed of photosynthesis averages 0.10 mg O_2/l per day, with destruction of 0.06 mg O_2/l per day. The content of chlorophyll fluctuates from 0.78 to 0.47 mg/m^3. The primary production constituted 105 mg C/m^2, or 115 kcal/year (DULMAA 2004, 2005).

Thirty species of aquatic vascular plants have been recorded with up to 40 % of the lake area being covered by macrophytes (*Potamogeton lucens, P. pusilus, P. praelongus, P. natans*, *Polygonum amphibium, P. lapathifolium, Phragmites communis, Typha angustifolia, Zannichellia pedunculata, Ranunculus reptans, Batrachium mongolicum, Urticularia intermedia*). Forty two species of phytoplankton have been reported from Ulaagchnii Khar dominated by *Cyclotella comta, Oocystis submarina, Ceratium hirundinella, Dinobryon cylindricum, Anabaena lemmermanni,* and *Asterionella formosa.* The trophic conditions for the Baicalian omul in the lake Ulaagchnii Khar are defined by the biomass and concentration of organisms, such as zooplankton and benthic animals. A total of 37 species of zooplankton were found. The prevailing complex throughout the year is rotifer-copepod one, with leading species of *Arctodiaptomus bacillifer, Mixodiaptomus incrassatus, Cyclops abyssorum, Eucyclops serrulatus, Daphnia longispina, D. pulex, Bosmina longirostris, Keratella quadrata, K. cochlearis, Kellicottia longispina, Felinia longispina, Polyarthra dolichoptera, Brachionus quadridentatus, Hexarthra mira, and Asplanchna priodonta.* The zooplankton biomass (without taking into account isopods of the family Gammaridae, the population of which is sufficiently high) fluctuates in summer between a range of 6.9 to 10.1 g/m^3, in winter reaching 1.26 - 3.05 g/m^3. The seasonal production of zooplankton is estimated to be 55.92 kcal/m^2 or 7.5 g/m^2.

In the benthos, over 30 species have been identified, with domination of *Gammarus lacustris,* Chironomidae (*Chironomus plumosus, Procladius nigiventrus, Paratanytarsus* sp.), Mollusca (*Radix auricularia, R. ovata, Physa fontinalis, Sphaerium corneum, Pisidium casertanum*), Hirudinea *(Herpobdella octoculata, Helobdella stagnalis, Glossifonia heteroclita*), Trichoptera *(Agrypnia crassicornis, Limnophilus major, Oecetis ochracea*) and others. The benthos population fluctuates between 5.9 up to 11.2 thous. units/m^2, with biomass reaching 5.53-9.75 g/m^2. The area that has the highest numerical density of benthic animals is the area of sediment sands and sediment with *Chara foetida, Nitella mucronata, Fontinalis antipyretica*, where especially populated are *Gammarus lacustris*, which represents more than half of total biomass weight.

Because of the diversity and numerical density of the macro-invertebrates, the water reservoirs have favourable food conditions and places for spawning for fish. Based on these biological data, it was recommended to introduce fish by larvae of *Coregonus autumnalis migratorius natio possolskii*. In the years of 1980, 1982 and 1986 in total 3 million larvae were introduced into the lake with estimate of 10-15 thousand units per/ hectare (table 1).

Table 1: The age, size and body mass composition of *Coregonus autumnalis migratorius* from lake Ulaagchnii Khar (material examined over several years:1999, 2005-2009)

age group	n	mean of actual length (mm)		mean of actual body mass (g)		condition factor
		average	SD	average	SD	
4+	10	373.71	30.18	560.83	128.71	1.07
5+	11	432.18	53.68	737.84	180.03	0.91
6+	13	461.68	45.31	1072.55	272.01	1.09
7+	14	514.36	45.30	1373.21	326.10	1.01
8+	11	539.79	44.17	1949.59	562.90	1.24
9+	3	543.25	3.51	2458.50	404.15	1.53
10+	5	546.08	12.93	2346.50	545.15	1.44
11+	5	570.13	15.94	2385.75	510.75	1.29
12+	5	579.33	19.79	2536.67	456.05	1.30
13+	3	592.25	31.09	2945.00	767.94	1.42

The trophic conditions for the Baicalian omul in lake Ulaagchnii Khar are defined by the biomass and the concentration of organisms, such as zooplankton and zoobenthos. The reserves of zooplanktone are estimated at 72 tons. These reserves are dominated significantly by *Gammarus lacustris*, *Arctodiaptomus bacillifer* and *Mixodiaptomus incrassatus.*

Results

The Baicalian omul under conditions of the lake Ulaagchnii Khar hold on to the lake bed layers, being distributed evenly in the bays. In autumn mature fish start their spawning migration in the lake towards spring sources, where they throw out strong flow of fountain equalling to the river flow, that stimulate the omul spawning process. The spawning is carried out during late September until late October at a depth of 1.5-4.5 m, on sandy or gravel-sandy grounds.

Fig. 1: *Coregonus a.migratorius n.possolskii.*

The age structure, size and weight

The Ulaagchnii khar population of Baikalian omul has a complicated age structure with replenishment and remainder. The existence by the lake of the pot-hunter fishery has not left all local omul generations, only of 3+ to 13+ age are met (fig. 2).

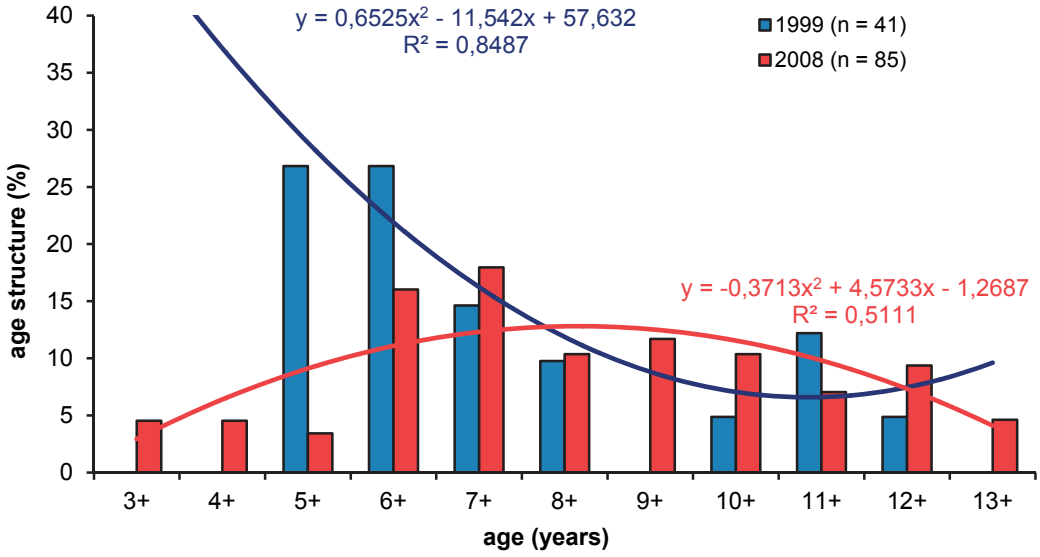

Fig. 2: Age composition of *Coregonus.a. migratorius* in fattening period of several years in the lake Ulaagvhnii Khar.

Table 2: Size and body mass of female and male *Coregonus autumnalis migratorius* of different ages in the basin of Ulaagchnii Khar

year	sex	length, body mass	age (years)										
			3+	4+	5+	6+	7+	8+	9+	10+	11+	12+	13+
1990	♀	l (mm)		390	480	520	550	600					
		bm (g)		580	800	1200	1335	2900					
	♂	l (mm)		360	363	450	550	580					
		bm (g)		550	560	800	1100	2100					
1993	♂	l (mm)		400	450	510	550	600					
		bm (g)		600	900	1200	1500	2000					
1999	♀	l (mm)		365	480	520	524	533		550	580	600	
		bm (g)		470	800	1200	1440	2900		1600	1800	2900	
	♂	l (mm)		360	363	450	550	578					
		bm (g)		550	560	800	1100	1200					
2005	♀	l (mm)		370	380	395	410						
		bm (g)		450	480	510	980						
	♂	l (mm)		330	340	360	480						
		bm (g)		570	570	840	1450						
2006	♀	l (mm)		380	474	450	570						
		bm (g)		540	817	950	1400						
	♂	l (mm)		340	470	458	550	540					
		bm (g)		490	950	1340	1160	1658					
2007	♀	l (mm)				470	517	537		561	570	587	630
		bm (g)				1200	1566	1833		2200	2366	2750	3600
	♂	l (mm)			444	468	510	534	540	551		590	
		bm (g)			700	1100	1420	1800	1928	2066		2300	
2008	♀	l (mm)				468	501	530	543	550	575	582	603
		bm (g)				1382	2125	2200	2653	2680	3200	3120	3620
	♂	l (mm)	404	437	446	474	490	520	547	526	574		
		bm (g)	680	910	1020	1420	1769	1650	2600	3000	2280		
2009	♀	l (mm)					449	475			540		
		bm (g)					880	1300			2600		
	♂	l (mm)						460				548	568
		bm (g)						1300				2000	2280

According to past research, the age structure of lake Ulaagchnii Khar omul was from 4+ up to 12+, for summer-individuals with a body length of 360-600 mm and body mass between 470 and 2900 g (DULMAA 1999). In 2007 were met summer-individuals of 5+ up to 13+ years with a body length of 444 to 630 mm and body mass between 700 and 3600 g. The individuals caught in 2008 were from

3+ to 13+ years old with a body length of 404-603 mm and a body mass of 680 to 3620 g (table 2). In general, the age structure of spawning stock of Baikalian omul of the lake Ulaagchnii Khar was 3+ - 13+ of summer-individuals, with the prevailing mass of 5+ - 8+ aged ones. The 6-7 year old females had a body length of 520-550 mm, weighted 1200-1350 g, while the same data for males were 450-550 mm and 800-1100 g**,** respectively**.** The age structure of spawning stock consists of age classes 4+ - 10+ in summer-individuals, with the main core of 5+ - 8+ aged ones. The size of the largest omul reached 650 mm length and 3520 g of mass. The sex ratio among the same age producers is close to 1:1 (fig.3).

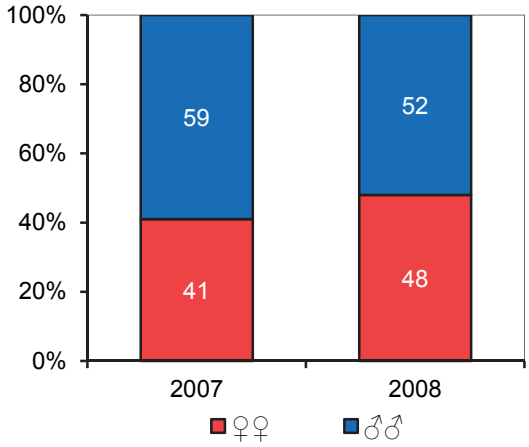

Fig. 3: Male-female-proportion of *Coregonus a. migratorius* in lake Ulaagchnii Khar in several years

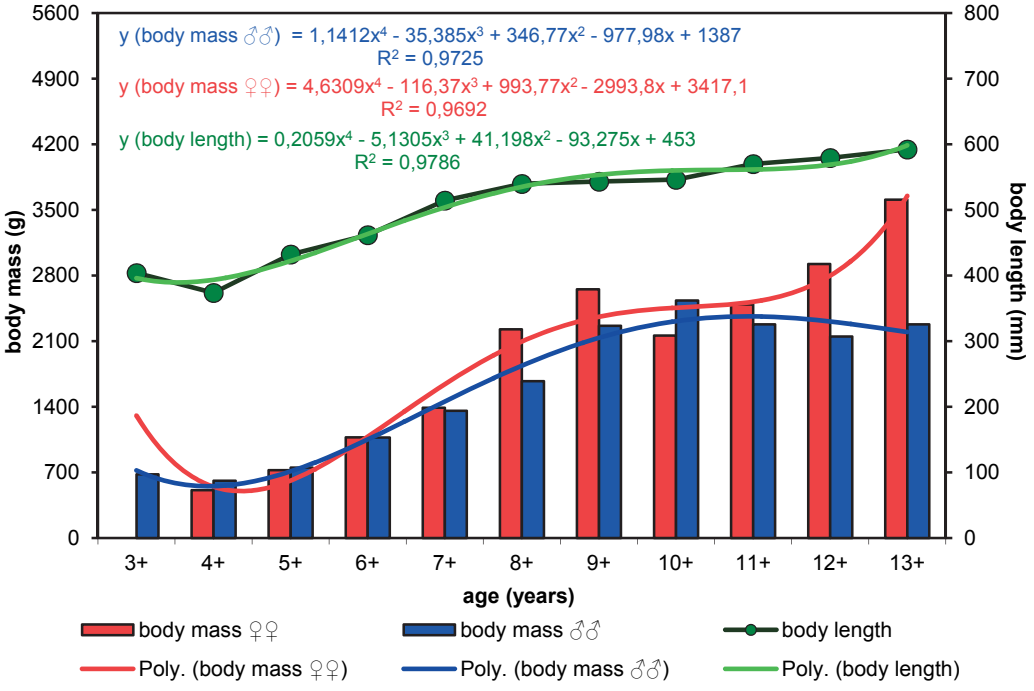

Fig. 4: Growth of body length and body mass of different age-classes of *Coregonus a. migratorius* in the lake Ulaagchnii Khar.

For comparison, in the lake Khubsugul the 6+ - 10+ age, summer females had a body length of 357-456 mm, and a body mass of 437-1122 g respectively, while summer females of *Coregonus a. migratorius* of the lake Baikal with an age of 4+ - 8+ reached 364-399 mm body length and 490-814 g body mass (DULMAA 1975, 1977a, b; TUGARINA 2002). As can be seen from above data, the acclimatization of *Coregonus autumnalis migratorius n. possolskii* in Ulaagchnii Khar is going on successfully.

Reproduction

The sexual gestation of Baikalian omul under conditions of the lake Ulaagchnii Khar is achieved by the age of 5+ - 6+. Females are larger than males. The sexual gonads of males gestate earlier than that of females. The fecundity of females of different ages differs. The largest Bakalian omul reaches a length of 610 mm, and 3960 g; the minimal length is 390 mm and 640 g body mass. The mass of female gonads ranges from 238.4 to 1120 g. The absolute fecundity reaches 55785-213000 eggs (table 3).

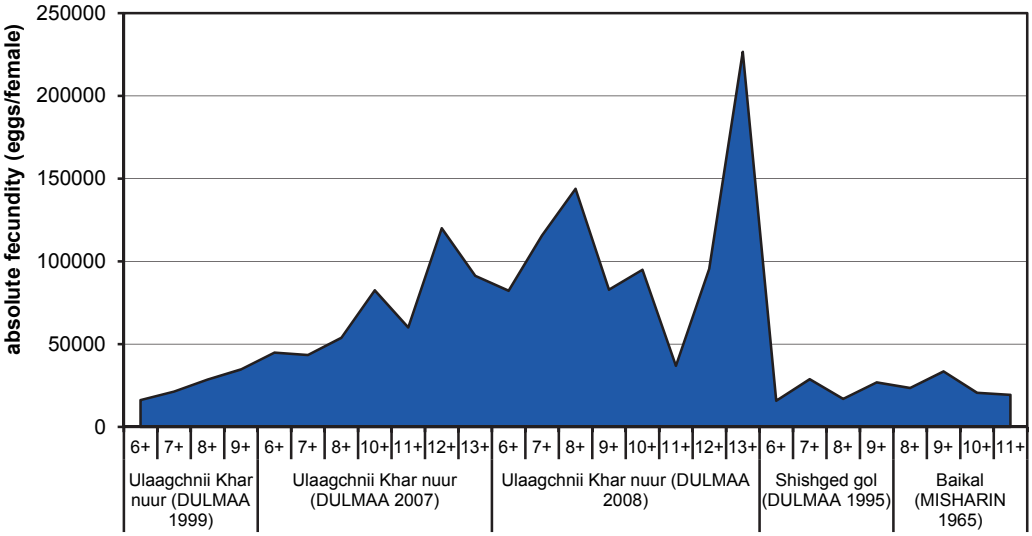

Fig. 5: Relationship between the absolute fecundity and age of *Coregonus a. migratorius* in selected water bodies of Mongolia and lake Baikal.

The diameter of ripe eggs is 1.7- 2.5 mm, and for the "natio" **p**ossolskii omul from Baikal it is 1.7-2.0 mm. The relative fecundity reaches 12.7-70.4. The year to year changes of the coefficient of maturity gonads of producers of omul in Ulaagchnii Khar are observed in different years with insignificant range. Compared with the same age group (6+, 7+, 8+) it is even similar to Shishged gol (fig. 5). The growth of sexual gonads of omul throughout summer time is sufficiently intensive. While on August 20th the omul had sexual gonads of the 3rd stage of maturity, in mid-September all caught individuals had the 4th stage of maturity of sexual gonads. The coefficient of maturity (PRAVDIN 1966) of females was 8.9-30.4 %, and the coefficient of fecundity (PRAVDIN 1966) was 9.3-45 %, respectively.

Table 3: Fecundity of *Coregonus a. migratorius* of different ages from Ulaagchnii Khar

age		6+	7+	8+	10+	11+	12+	13+
n		1	2	3	2	4	4	1
body length (mm)		410	450	469	498	515	530	550
body mass (g)		1200	1500	1833	2200	2366	2750	3600
absolute fecundity (eggs / female)	M	44880	43400	53820	72500	60196	103517	91300
	m_M		4900	4035	9000	16304	8827	
	SD		6929	6988	12727	28240	17654	
	CV		15.9	12.5	17.5	49.9	17	
	tm_M		9604	7908	17640	21956	17311	
relative fecundity ($eggs^{-1}$)	M	109.4	96.7	119	145	117	200	166
	m_M		13	8.8	17.6	32.7	17	
	SD		18.4	15.3	24.9	56.7	34	
	CV		19	12.8	17.1	48.6	16.9	
	tm_M		25.5	15.3	34.5	64	33.1	
coefficient of fecundity	M	19	15.9	5.17	15.5	24.7	13.7	21.6
	m_M		3.18	2.15	3.25	8.64	0.43	
	SD		4.49	3.72	4.6	14.9	0.87	
	CV		28.23	33.7	29.6	60.3	6.34	
	tm_M		14.1	9.68	14.8	24.6	2.24	
gonadosomatic index (%)	M	20	18.5	17.4	22.9	18.4	20.7	15.2
	m_M		2.9	2.89	20.08	4.93	1	
	SD		4.1	5	2.94	8.54	2	
	CV		22.1	28.7	12.8	46.2	9.7	
	tm_M		5.6	5.67	4.08	9.66	1.97	

M – average, m_M – error of average, SD – standard deviation, CV-coefficient variation, m_{CV}-error of coefficient variation, tm_M -confidential interval P_{005}

Fatness

The coefficient of fatness of spawning Baikalian omul males of the same age was lower than that of the females. From year to year, aspect of the coefficient of fatness of omul was almost without changes. The fatness by CLARK (1928) was high, reaching 1.2-2.5 (table 4). The indicators of fatness of Baikalian omul introduced in the lake Ulaagchnii Khar was higher than was higher than that in the mother water basin of the lakes Baikal and Huvsgul.

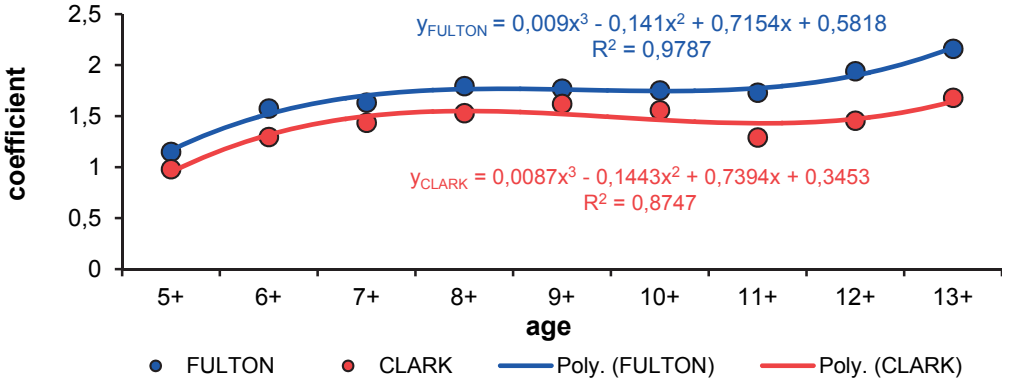

Fig. 6: Fatness of *Coregonus a. migratorius* of different ages from lake Ulaagchnii Khar (09.02.-10.04.2004).

Table 4: Coefficient of fatness of *Coregonus a.migratorius* from lake Ulaagchnii Khar (09.02-10.04.2008)

age	n	sex	by FULTON (1902)							by CLARK (1928)						
			M	± m_M	SD	CV	m_{CV}	Pt	± tm_M	M	± m_M	SD	CV	m_{CV}	Pt	± tm_M
5+	1	♂	1.15	-	-	-	-	-	-	0.98	-	-	-	-	-	-
6+	1	♀	1.74	-	-	-	-	-	-	1.16	-	-	-	-	-	-
	3	♂	1.52	0.14	0.25	16.9	6.91	9.77	0.29	1.34	0.1	0.19	14.6	5.96	8.43	0.22
7+	2	♀	1.64	0	0	0	0	0	0	1.3	0.1	0.18	14.3	7.15	11	0.25
	5	♂	1.63	0.13	0.26	15.9	5.63	7.97	0.25	1.49	0.1	0.27	18.2	6.45	9.12	0.26
8+	2	♀	1.82	0.1	0.14	1.08	4.08	5.71	0.2	1.49	0.1	0.19	13.2	6.63	9.38	0.27
	2	♂	1.77	0.01	0.02	1.36	0.68	0.96	0.03	1.57	0	0.02	1.36	0.68	0.96	0.03
9+	7	♂	1.77	0.09	0.26	14.7	3.93	5.57	0.19	1.62	0.1	0.24	14.9	3.98	5.63	0.18
10+	2	♀	0.77	0.77	1.09	14.1	70.5	99.7	1.52	0.54	0.5	1.76	141	70.5	99.7	1.06
	3	♂	1.74	0.07	0.13	7.77	3.17	4.48	0.15	1.57	0.1	0.11	7.23	2.95	4.15	0.12
11+	3	♀	1.73	0.07	0.12	7.24	2.95	4.1	0.14	1.29	0.1	0.09	7.49	3.05	4.32	0.11
12+	4	♀	2.01	0.11	0.22	11.2	3.97	5.62	0.22	1.46	0.1	0.14	9.72	3.43	4.86	0.14
	1	♂	1.66	-	-	-	-	-	-	1.44	-	-	-	-	-	-
13+	1	♀	2.16	-	-	-	-	-	-	1.68	-	-	-	-	-	-

M – average, m_M – error of average, SD – standart deviation, CV-coefficient variation, m_{CV}-error of coefficient variation, Pt-accurary indicator, ±tm_M -confidential interval P_{005}

Feeding

During breeding time, Baikalian omul feeds on both zooplankton and benthic animals. During spawning, these fish that were sampled had mostly empty stomachs. From 30 stomachs and intestine tracts of omuls caught in autumn time, the empty stomachs constituted 67.4 %. In the remaining stomachs, the food consisted of chironomid larvae that accounted 49.5 % by mass, and crustacea – 9.9 %. Probably, the Chironomidae of all age stages constitute the core food of Baikalian omul in the newly populated water reservoirs. The food base consisting mostly of Chironomidae is supplemented by amphipods. In the system of the lake Ulaagchnii Khar Baicalian omul feeds almost around the year. The nutrition consists mainly of amphipods together with Chironomidae of all age classes and larvae of other water insects, molluscs, and ostracods. The index of stomach fullness ranged between 12 to 82 ‰.

Thus, the attempt to acclimatize the Baikalian omul in the fishless and water source less basins of the Gobi area of Western Mongolia is going on successfully. The total population of Baikalian omul has reached a level with sufficient concentration producing stock and material for introduction into other water basins of Mongolia.

References

CLARK, F.N. (1928): The weight-length relationship of the California sardine (*Sardina caerulea*) at San Pedro. - Fish. Bull. U.S. **12**: 5-59.

DULMAA, A.. (1975): To studying of the *Coregonus autumnalis migratorius* (Georgi) from lake Khubsugul. –Proceedings of the Mongolian Academy of Sciences, V.**1**: 28-44.

DULMAA, A. (1977a): Hydrobiological Outline of the Mongolian lakes. - Int. Revue ges. Hydrobiol. **64** (6): 709-736.

DULMAA, A. (1977b): On biological investigations in reservoirs of the basi0n Arctic ocean of MPR. - Ulaanbaatar, 362 p.

DULMAA A. (1999): Fish and Fisheries in Mongolia. - Fish and fisheries at higher altitudes of Asia. - FAO Fisheries technical paper 385. p. 187-236.

DULMAA, A. (2004): Mongolian Fish Biodiversity and Ecology. - Proc. XIXth Int. Cong. Zool. Beijing, China: 490.

DULMAA , A. (2005): Limnology and Fish Diversity of Mongolia. - 7th Indo-Pacific Fish Conf. Taipei, Taiwan; p. 86.

FULTON, T.W. (1902): On the rate of growth of seaFishes. – Fish. Scotl. Sci. Invest Report **20** (3): 226-334.

PRAVDIN, I.F. (1966): Study guide of fishes. Moskow. p. 107-108. (in Russian).

TUGARINA, P.Y. (2002): Ecology of fishes of Lake Khubsugul and their economic potential. - Irkutsk, 209 p. (in Russian).

Address: Auyriin Dulmaa
Institute of Biology
Mongolian Academy of Sciences
Jokov avenue -77
Bayanzurkh district
Ulaanbaatar- 210351
Mongolia

E-mail: adulmaa@yahoo.com