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Morphological characteristics of the reproductive Gild of Baikal *Omul Coregonus migratorius* (Georgi) Entering the Rivers of the Posolskiy Sor Bay

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ABSTRACT

The exterior and fecundity of the reproductive gild of Baikal omul (*Coregonus migratorius, G.*) of the deep-sea morpho-ecological group (MEG) have been studied. A comparative analysis was carried out, which showed that there is an increase in linear weight indices, absolute individual fecundity. The average Smith length of producers regardless of sex and age was 367±2 mm, with an average weight of 607±11 g. Females have had a Smith length of 378±3 mm and a weight of 669±15 g, the males - 358±2 mm and 553±13 g, respectively. It is noted that some relative signs decrease with age. A significant increase in the length and weight of the fish is observed. It has been found that fecundity increases with age. The absolute fecundity was 19.903 ± 549 pcs. eggs.

Key words : *Absolute individual fecundity, Baikal omul, Comparative characteristic, Linear, Weight and meristic features, morpho-age variability, Morphological characteristic, Reproductive gild.*

Introduction

The considered Posolskiy near-bottom and deep-sea MEG is a small Baikal omul group compared to the pelagic MEG. It fattens in Lake Baikal, where it inhabits the lake at depths of up to 350 m. In autumn, it spawns in small tributaries of the Posolskiy Sor Bay with a spawning path from 3 to 20 km long (Neronov and Sokolov, 2020). It is characterized by the highest body and caudal fin height, a long head, and a small number (36-44) of coarse gill rakers compared to other morpho-ecological groups (Smirnov *et al.,* 2009).

In 2004, the author L.V. Sukhanova (2004) presented the results of a molecular phylogenetic study of Baikal omul and concluded that Baikal omul is a descendant of the whitefish ancestor inhabited lake and river water bodies at the site of modern Baikal.

The results obtained by N.G. Petukhova (2020) of a quantitative analysis of near-bottom and deep-sea MEG considered as a separate stock unit in the TISVPA and Synthesis software packages indicated that recruitment would not be able to restore the commercial stock to the biomass target within the next 5 years. The low-water period from 2014 to 2017 had a no less negative impact, which could adversely affect the spawning areas and the larva's survival by reducing the water area of the reservoir suitable for rearing—the inflow of water resources into the lake. Baikal was a record minimum during this period (Garmaev and Tsydypov, 2019).

The study aims to study the character of morphological variability of Baikal omul producers of the near-bottom morpho-ecological group, which spawns in the depressed rivers of the Posolskiy Sor Bay and their relationship with the ecological conditions of habitat.

Materials and Methods

The material was collected during research studies of the nets set in the Posolskiy Sor Bay of Lake Baikal on the migration routes of the bottom-deep-sea spawning population of the Baikal omul in the first half of September 2019-2020. A total of 116 spawners were selected, including 54 females and 62 males.

Counting, linear (with an accuracy of 1.0 mm) and weight (with an accuracy of 1.0 g) signs were studied according to the guidance of I.F. Pravdin (1966). Scales were taken from each sire to determine age and eggs were sampled to determine absolute individual fecundity (AIF).

The age of the fish was determined based on the scales according to the method that took into account the peculiarities of forming the scales sclerite pattern in the annual growth zones (Smirnov *et al.*, 2009).

Results and Discussion

The sample was represented by reproductive specimens of Baikal omul near-bottom MEG with ages ranging from 8+ to 12+ years.

The age percentage ratio of the females and males in the sample ranged from 35 to 58 % for the females, and from 42 to 65 % for the males. Sampling was random, it is not possible to judge the overall age structure of the flock.

Plastic traits. Regardless of sex and age, the average Smith length of breeding specimens was 367±2 mm; they had an average weight of 607±11g. With that, the females had a Smith length of 378±3 mm and a weight of 669±15 g, and males - 358±2 mm and 553±13 g respectively (Table 1).

By comparing the data obtained with that of 2016 (Shatalin *et al.*, 2017), there is a significant difference by age, and there is a significant increase in weight and length gain by Smith producers (Figure 2).

The highest Smith's length gain is reported for 9+ year old individuals in both females and males at 2.9 cm, whereas in 2016 the gain for 9+ year old individuals was 0.5 cm in females and 0.3 cm in males. The growth rate decreases with age and at age 12+, the Smith's length gain is close to the level from 2016 (Figure 2 (1)).

The same increase in body weight of males and females was noted, more in females at the age of 9+ (108 g) and 11+ years (70 g) and in males at 9+ - 10+ years. (Figure 2(2)).

The improvement in growth rates suggests that omul, under the anthropogenic impact of declining

Table 1. Morpho-age variability of traits

Age, years	L, MM		Lsm, MM		l, MM		W, r	
	M±m	Cv	M±m	Cv	M±m	Cv	M±m	Cv
Females								
8+	378±6.9	5.5	343.8±4.2	3.7	329.7±4.9	3.7	523.6±18.5	10.6
9+	399±3.9	3.6	372.6±3.3	3.0	353.9±3.6	3.0	632.8±21.6	11.8
10+	412±4.2	3.6	380.1±4.3	3.9	363.2±4.2	3.9	669.3±20.5	10.6
11+	426±1.6	1.2	392.5±1.4	1.1	374.5±0.9	1.1	738.8±32.7	14.0
12+	433±4.1	3.1	397.5±4.2	3.5	380.6±4.6	3.5	764.5±23.5	10.2
Ð $_{(6+ ê 9+)}$ ≥	99	99	99	99				
Males								
8+	365.5±1.9	2.1	336.4±4.3	2.7	318.6±2.5	4.3	450.9±10.6	9.7
9+	383.4±2.6	2.8	352.9±2.4	2.7	335.1±2.3	2.8	519.3±8.9	6.9
10+	399.3±2.8	2.4	366.6±2.5	2.4	349.1±2.5	2.5	601.0 ±19.5	11.3
11+	406.8±4.0	2.8	378.0±3.1	2.3	362.0±3.0	2.3	638.4±11.5	5.1
12+	414.3±3.5	2.4	387.0±4.2	3.1	368.0±3.6	2.8	701.3±15.5	6.3
Ð $_{(6+ \text{ to } 9+)}$ ≥	99	99	99	99				

Note: Median (M), median error (± m), coefficient of variation (Cv, %), L - is the absolute body length; lsm - is the median body length; l - is the body length from the top of the snout to the base of the caudal fin (commercial length), Q - is the body weight stock status, is undergoing morphological changes due to gild dilution and release of feeding area.

In 2018, it was noted that in terms of biological characteristics, there had been an overall trend over the past 30 years of increasing line-weights of omul, stabilizing and even improving growth and maturation rates amid declining stock status (Sokolov and Peterfeld, 2018).

In 2020, 4 years after introducing the fishing ban, increased linear-weight indicators and growth indicators continued.

The change in females and males' linear traits with age is directed to increased absolute body length. There was a relative difference in the fluctuation bands between females and males, which indicated that there were various linear relationships, presumably associated with sexual dimorphism.

When comparing fin sizes by age, it was observed that the relative length and height of fins decreased with age in individuals of both sexes, except for the anal and pelvic fins in males (Figure 5). It was observed that the anal and pelvic fin length curves (Figure 5(2)) at ages 11+ and 12+ changed almost equally upwards.

It was observed that the length of the upper lobe of the caudal stem is predominantly longer in females compared to the lower lobe (Figure 6). However, the caudal stem blade index in males is slightly (<1%) greater than in females.

Sexual dimorphism in omul was weakly pronounced; however, the females compared to the males featured greater body depth and girth. During the spawning period, the males had mating outfit perceptible through the sense of touch; a rather large epithelial tubercle is formed on the lateral scales.

The relative head length of the studied near-bottom MEG specimens averaged 21.6±0.09%. Without regard to age, the head indices of males and females were approximately equal.

With age, relative head length decreased in near-

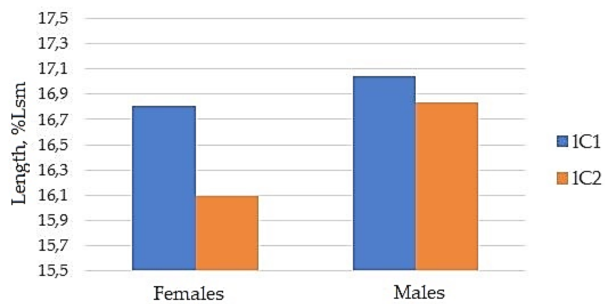


Fig. 6. Relative length of the upper (lC1) and lower (lC2) tail stem blades of females and males

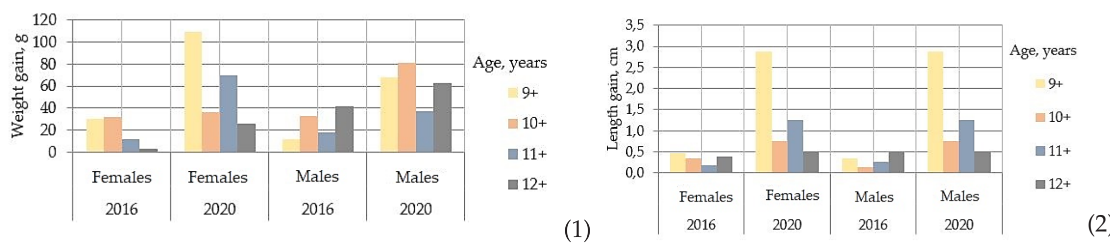
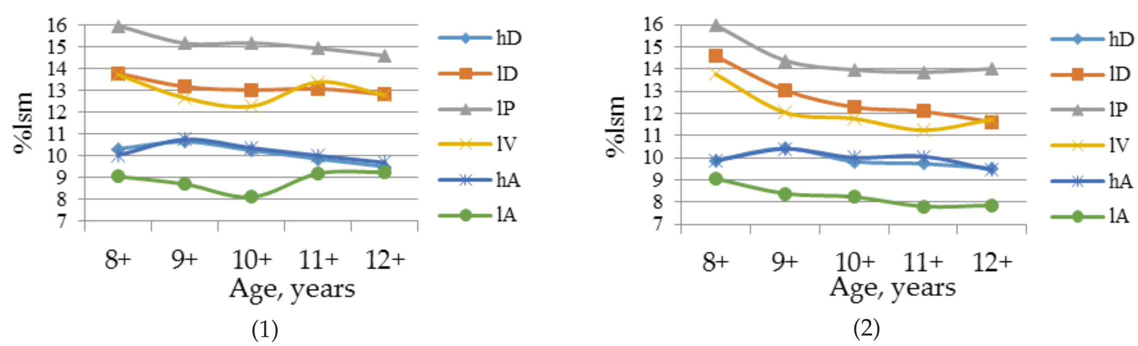


Fig. 2. Comparative Smith L cm Length gain (1) and Weight gain W (2) with males and females in 2016 and 2020



Note: hD - is the greatest height of the dorsal fin; lD - is the length of the base of the first dorsal fin; lP - is the length of the pectoral fin; lV - is the length of the ventral fin; hA - is the height of the proctal fin; lA - is the length of the base of the proctal fin

Figure 5. Change of fin length and height indices of females (1) and males (2) with age

bottom MEG from 22.2% (8+) to 20.4% (12+) and relative carcass length increased from 72.9% (8+) to 75.1% (12+), r = - 0.9 (Figure 7).

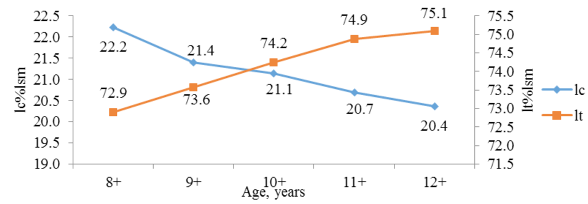


Fig. 7. Changes with age in the relative head (lc) and carcass (lt) lengths of near-bottom MEG producers

Meristic features. The number of rakers in the studied specimens of near-bottom (multirakered) omul was 40.4±1.5 units. According to the 1962-1965 data, it had been 41.42±0.22 pc. (Nikolsky, 1965). Our data's difference is insignificant and may indicate that the near-bottom and deep-sea morphological group of Baikal omul remains unaffected by feeding adaptations.

The minimum number of gills rakers on the first-gill arch was observed in 1.5% of specimens and made 36 pcs, and a maximum of 43 rakers was observed in 3% of specimens. The main percentage of specimen's distribution by the number of rakers falls on a range from 39 to 42 pcs. The highest number of specimens (47%) had 41-gill rakers, with 39% of specimens distributed among 39, 40, and 42 rakers (Figure 8).

The number of scales in the lateral line averaged

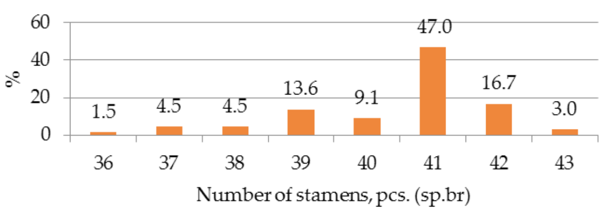


Fig. 8. Percent distribution of individuals by the number of stamens on the first-gill arch.

90±0.5 (80 to 99) pieces. The number of rows of leaves under the lateral line was 12.4±0.08 (11-14) parts, and above the lateral line, 10.8±0.08 (10-12) pieces. (Table 2).

Fecundity. The increase in AIF has a critical adaptive value aimed at increasing gild abundance (Polyakov, 1975; Moruzi, 2017).

In 2016, the AIF was 18572 eggs (Shatalin *et al.*, 2017), according to 2020 data. The AIF was 19903±549 eggs. The observed fluctuations in fecundity probably connect with the expansion of the feeding area, with a decrease in the population size.

The tendency of AIF increase was also noted in pelagic Baikal cisco MEG (Shatalin *et al.*, 2020).

The 8+-year-old individuals had an AIF of 17591±326 eggs. With age, there was an increase in fecundity of ~1644 eggs in 9+ - 10+-year-old individuals and ~4475 eggs in 11+ - 12+-year-old individuals compared to 7+-year-old individuals (Fig. 9).

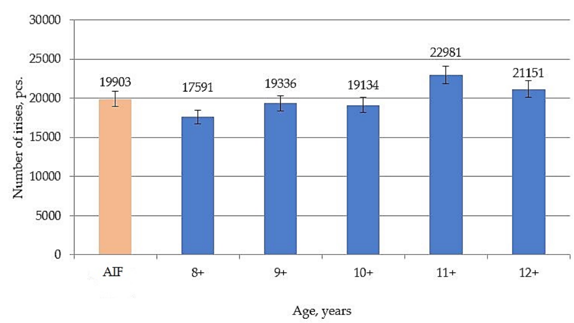


Fig. 9. Age fecundity

Results of analysis of variance in examining the strength of age's effect on fecundity showed that group averages by age differed significantly F=4.16 > F critical =2.56, P significant =0.005.

Calculation of relative individual fecundity showed that it decreased about total body weight from 33.83 units/g (8+) to 27.81 units/g (12+) (Table 3).

Table 2. Number of rows of scales and number of lateral line scales

Trait	Total			Females			Males		
	M ± m	CV	lim	M ± m	CV	lim	M ± m	CV	lim
ll_1, øò	90.3±0.49	4.4	80-99	90.2±0.61	4.3	80-98	90.6±0.49	4.4	85-99
ll_2, øò	10.8±0.08	6.1	10-12	10.9±0.09	5.5	10-12	10.8±0.15	7.1	10-12
ll_3, øò	12.4±0.08	5.5	11-14	12.3±0.10	5.3	11-14	12.5±0.14	5.7	12-14

Note: ll1 - number of scales in the lateral line; ll2 - number of scales above the lateral line; ll3 - number of scales below the lateral line

Table 3. Age fecundity of females

Age, years	W, g		Absolute fecundity, pcs.		Relative fecundity to W, pcs.	
	M±m	Cv	M±m	Cv	M±m	Cv
8+	523.6±18.5	10.6	17591±326	6	33.83±1.01	8.92
9+	632.8±21.6	11.8	19336±1122	20	30.38±1.09	12.48
10+	669.3±20.5	10.6	19134±952	17	28.48±0.93	11.33
11+	738.8±32.7	14.0	22981±1397	19	31.41±1.87	18.79
12+	764.5±23.5	10.2	21151±526	8	27.81±0.71	8.43
$P_{(8+ \text{ to } 12+)} \geq$	99	99	99			

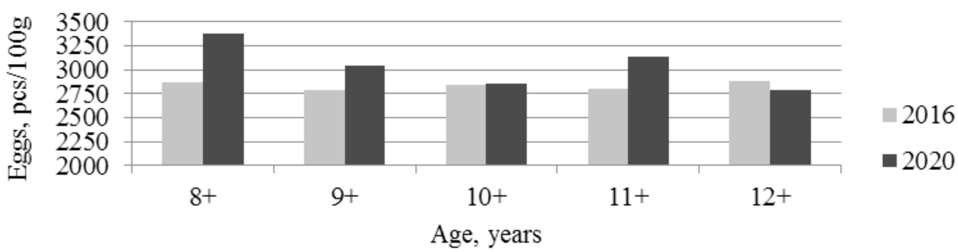


Fig. 10. Comparative analysis of relative individual fecundity

Comparative analysis of 2016 data with 2020 data showed that relative individual fecundity was higher in 2020 individuals, except for 10+ and 12+ yearlings, their numbers remained virtually unchanged (Figure 10).

Conclusions

1. There is an increase in average weight, commercial length, Smith length, most excellent body height, absolute individual fecundity (AIF). All this occurs against the background because the fish is in conditions when the number of gild decreases, and the feeding area remains the same due to changes in the food supply, the exterior of fish changes.
2. Noted that the biological characteristics in general over the past 30 years show a trend of increasing linear weight indicators of omul, stabilization, and even growth improvement and maturation hands against the background of declining stock status. In 2020, 4 years after the fishing ban, increasing line-weight and growth rates continue. This may indicate that the abundance of the near-bottom and deep-sea morpho-ecological group entering.
3. The following relative traits decrease with age: horizontal eye diameter; most excellent height of dorsal fin; pectoral-fin length; head length. There is a significant increase in the size and weight of fish. The relative carcass length also increases.
4. Sexual dimorphism in the morphometric data we obtained is weakly expressed. Females are larger than males. The mating habits of males in the spawning period are represented in the form of small bony croup.

Acknowledgements

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