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Population Structure of Haarder *Liza haematocheila* (Mugiliformes, Mugilidae) Acclimatized in the Sea of Azov Basin

O. A. Diripasko

State Enterprise Azovskii Center YugNIRO (AzYugNIRO), ul. Kommunarov 8, Berdyansk, 71118 Ukraine
e-mail: daoleg@office.gobius.com

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Abstract—As a result of the successful acclimatization in the Azov basin, haarder *Liza haematocheila* has become a commercial species and is currently among the main commercial items. Its reproduction in the new range takes place in environmental conditions strongly differing in the salinity level (3–24‰), which determined its population differentiation. The extent and structure of the phenetic diversity of *L. haematocheila* from the Sea of Azov basin was assessed and elucidated, using a phenetic approach in studies of natural populations and on the basis of studying morphological characters. Molochnyi Liman, Sivash, and marine subpopulations of *L. haematocheila* were distinguished.

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The introduction of *Liza haematocheila* to the Azov basin was initiated in 1978 (to Molochnyi Liman) and, by the late 1980s, led to the formation of a self-reproducing population in the Sea of Azov. *L. haematocheila* penetrated to the Black Sea and reached the Mediterranean Sea. Since 1992, it is included into the number of commercial species of the Azov–Black Sea basin and is currently among the main fishery objects in the Sea of Azov.

A wide adaptation flexibility of *L. haematocheila* largely promoted its successful acclimatization in the Azov basin. The formation of the population occurred under conditions considerably differing from those, which exist in the natural range (the Sea of Japan), primarily, in the main environmental parameters: temperature conditions, salinity, etc. For instance, the climate of the Sea of Japan is a monsoon climate of temperate latitudes. The summer monsoon provides high relative humidity, cloudiness, and abundant precipitation, and winter monsoon provides dry, clear weather (Gavrilov and Pushkareva, 1986). The highest temperature values of the surface water layer are observed in August: 13–14° in the north and 27° in the south, in the Korean Strait; the lowest temperatures (0 … –1.5°C) are typical of February when ice is formed in northern shallow water areas. Temperature change within the entire water area of the sea remains almost constant in all seasons and equals 13–15°C. Specific features of distribution of the surface water salinity are determined by water replacement with the neighboring sea basins, the balance between precipitation and evaporation, ice formation and ice melting, as well as by the continental discharge in coastal areas. Intraannual changes in water salinity of the Sea of Japan are within 32.9–34.6‰, although salinity may decrease to 25–30‰ at particular sites of the coastal zone (Rostov et al., 2003).

The climate of the Sea of Azov is a continental climate of temperate latitudes. It is characterized by a moderately soft short winter and a warm long summer. The highest water temperatures are recorded in July, and, in different areas of the sea, they comprise 29.3–32.8°C; the lowest temperatures (–2.4 … –0.5°C) may be observed in any winter month. The spatial water temperature distribution over the water area of the sea has a low degree of contrast because of its small size and low depths (*Hydrometeorology*…, 1991). On the whole, salinity is leading among the remaining oceanological factors determining the tendencies of development of the Sea of Azov ecosystem. The Sea of Azov salinity, because of the effects of both climatic and anthropogenic factors, is characterized by large interannual and spatial variation. The amplitude of long-term fluctuations in the Sea of Azov salinity (for the period from 1922) is 4.7‰; in Taganrog Bay, this index equals 7.5‰. Short-term periods of salinization alternate with relatively long periods of freshening (Garkopa, 2000). Water salinity has decreased to 9–11‰ up to the present time, which corresponds to its level under natural conditions of the discharge of rivers of the Sea of Azov basin.

Naturally, the differences in habitat conditions have been reflected in the specific biological features of the species. For instance, under new conditions, the rate of growth of *L. haematocheila* has increased by factors of 1.5–2.0, as compared to the native range (Sabodash and Semenenko, 1998; Tsarin et al., 1999). By the end of the feeding period, the concentration of lipids and

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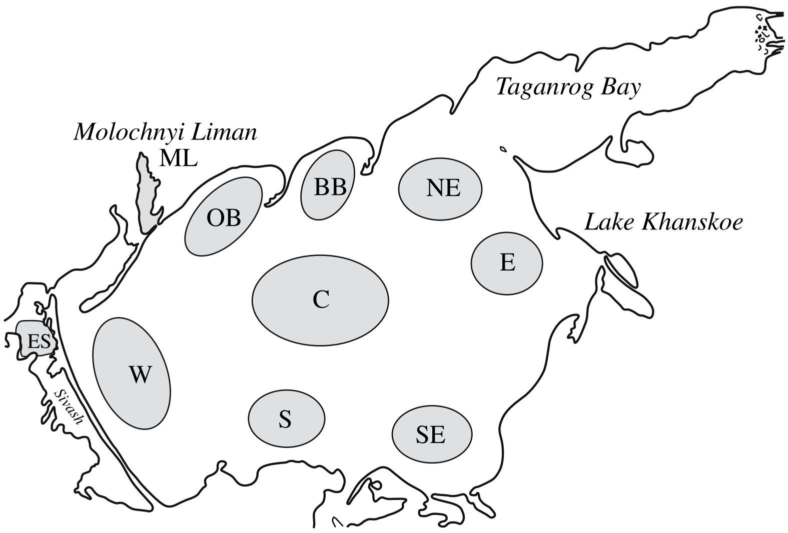

Fig. 1. The map of the Sea of Azov with designations of sampling sites for the study of morphological characters of *Liza haematocheila*. Designations of areas: NE, northeastern; E, eastern; SE, southeastern; S, southern; C, central; BB, Berdyanskii Bay; OB, Obitochnyi Bay; W, western area; ML, Molochnyi Liman; ES, Eastern Sivash.

serous proteins in the organs and tissues of *L. haematocheila* is higher by almost 50% than in fish from the Sea of Japan. The level of fat accumulation in the liver and muscles has considerably increased (Lozhichevskaya et al., 2001). The reproduction of *L. haematocheila* in the new range proceeds under environmental conditions considerably differing in salinity level: 3–7‰ in Lake Khanskoe (Yatsenko and Novikova, 2002), 9–11‰ in the water area of the sea, 11–16‰ in the northern part of Eastern Sivash, and 16–24‰ in Molochnyi Liman.

In the natural range, for instance, in Amur Bay, *L. haematocheila* spawns from mid-June to mid-July at the water temperature of 15.8–20.7°C, a salinity of 31.5–32.8‰, and at depths of 10–35 m (Mizyurkina, 1984). According to data of Kazanskii et al. (1968), *L. haematocheila* may also enter shallow lagoons for spawning (for instance, lake lagoon Tal'mi) with a salinity of 12–15‰.

It is known (Salmenkova et al., 2004) that, if a species begins to successfully reproduce in a new environment, adaptation-related changes may take place in its genetic structure. For instance, the studies of a large team of authors (Omel'chenko et al., 2004) demonstrated that, in *L. haematocheila*, at the maintenance of the initial (as in the population from the native range) level of average heterozygosity, changes in the genotypic and allele composition were revealed that are manifest at a decrease in the proportion of polymorphic loci by a factor of 1.9 and a decrease in the average number of alleles per locus by a factor of 1.5; the genetic differentiation between the samples of *L. haematocheila* from three areas of the Azov basin was also detected.

This paper concerns the study of phenetic diversity in the morphologic traits of *L. haematocheila* from the Azov basin in relation to habitat change.

MATERIAL AND METHODS

The paper is based on samples of *L. haematocheila* from different parts of the Sea of Azov and the water bodies of its basin (Fig. 1) collected in the spring–summer (prespawning) period of 2003–2005.

Twenty-nine morphometric characters and five meristic characters were studied. A total of 246 individuals of *L. haematocheila* were collected and treated to study morphometric characters; meristic characters were studied in 728 fish.

The statistical processing of the materials was performed using methods of multidimensional analysis. The Kulbach divergence was calculated (Andreev and Reshetnikov, 1977; Andreev, 1980). For meristic characters, we used the index of similarity of populations with respect to individual characters (r_{zh}) and, according to the combination of characters under consideration ($\check{r}_{zh}$), indices of intrapopulation diversity: $\tilde{\mu}$, average number of morphs in the sample and $\tilde{h}$, the proportion of rare morphs (Zhivotovskii, 1982, 1991). Significance of differences in the indices of similarity was assessed at a 1% significance level using an identity criterion (*I*). Cluster analysis (UPGMA method) was used to combine samples by levels of similarity. Factor analysis using the method of principal components was made; the elements of the method of multidimensional scaling were also employed. Comparison of the selected estimates of average values was made on the basis of Student's *t-test* (Lakin, 1980). Calculations

Table 1. Meristic characters ($M \pm m$) of haarder *Liza haematocheila* from different regions of the Azov basin

Characters	Regions of study									
	C (n = 176)	BB (n = 83)	NE (n = 57)	E (n = 77)	OB (n = 71)	S (n = 93)	ML (n = 56)	SE (n = 37)	ES (n = 50)	W (n = 28)
$1D$	4	4	4	3.97 ± 0.018	3.99 ± 0.014	4.00 ± 0.022	4	4.03 ± 0.027	4	4
$2D_1$	1.01 ± 0.008	1.02 ± 0.017	1.04 ± 0.025	1	1	0.99 ± 0.011	1	1.03 ± 0.027	1	1
$2D_2$	8.14 ± 0.036	8.07 ± 0.048	8.32 ± 0.076	8.23 ± 0.055	8.06 ± 0.053	8.22 ± 0.045	8.02 ± 0.018	8.08 ± 0.071	7.98 ± 0.053	8.04 ± 0.081
A_1	2.99 ± 0.006	2.99 ± 0.012	2.98 ± 0.018	3	2.93 ± 0.031	2.99 ± 0.011	3	2.97 ± 0.027	3	3
A_2	8.88 ± 0.026	8.92 ± 0.039	8.82 ± 0.067	8.87 ± 0.039	8.83 ± 0.049	8.83 ± 0.042	8.86 ± 0.047	8.86 ± 0.079	8.66 ± 0.079	8.93 ± 0.050

Note: $1D$, number of rays in the first dorsal fin; $2D_1$ and $2D_2$, number of unbranched and branched rays in the second dorsal fin; A_1 and A_2, number of branched and unbranched rays in anal fin. Designations of regions: C, central; BB, Berdyanskii Bay; NE, northeastern; E, eastern; OB, Obitochnyi Bay; S, southern; ML, Molochnyi Liman; S, southeastern; ES, Eastern Sivash; W, western region. $M \pm m$, mean value of a character and its error; n, number of fish studied.

were performed using the Statistica 6.0 modular software package.

RESULTS AND DISCUSSION

It is important to consider size variation in the characters under study while performing morphological analysis. To this end, preliminary special studies were performed (Diripasko and Solod, 2004), whose results showed that, for comparative analysis with respect to morphometric characters, one should use fish whose length (AC) is in the range of 35 to 55 cm since size variation is almost not manifest in this range. As for meristic characters of *L. haematocheila*, they do not change with fish growth. The samples for comparison were formed taking the latter into account.

The analysis of meristic characters was performed from data for ten samples (Table 1). As a measure of pair-to-pair similarity of samples, indices of similarity (r_{zh}) were calculated for each meristic character under comparison, and the significance of differences between them was assessed. No significant differences between the samples of *L. haematocheila* for all characters, except the number of branched rays in the second dorsal fin ($2D_2$), were revealed. Thus, in the subsequent calculations, differences in the number of rays in $2D_2$ namely determined the values of the combined index of similarity based on the combination of all characters studied ($\tilde{r}_{zh}$). The assessment of the significance of differences with respect to $\tilde{r}_{zh}$ demonstrated that differences are insignificant in most pair-to-pair comparisons of samples of *L. haematocheila* from different areas (Table 2). At the same time, according to the complex of meristic characters, *L. haematocheila* from Molochnyi Liman significantly differs from all other samples, except fish from the adjoining western part of the sea (region W) and a sample from Sivash (ES). Sivash *L. haematocheila* significantly differs only from the fish from the eastern areas of the sea: northeastern (NE) and eastern (E).

As for the intrapopulation diversity, it may be characterized by the index of the average number of morphs ($\tilde{\mu}$) that assesses the extent of phenetic diversity. According to this index, *L. haematocheila* of Molochnyi Liman is characterized by the lowest degree of phenetic diversity and differs from all other samples at $\tilde{\mu}$ = 1.193 ± 0.0449 (at the 1% significance level). In addition, according to the structure of phenetic diversity ($\tilde{h}$ = 0.148 ± 0.0320), *L. haematocheila* from Molochnyi Liman considerably differs from fish from other areas (Table 3).

Cluster analysis, performed according to indices of similarity of the samples ($\tilde{r}_{zh}$), shows that the unification of the samples of *L. haematocheila* from eight areas of the seawater areas proceeds at the similarity level 0.963. Samples from Molochnyi Liman and Eastern Sivash are combined at the level of 0.971, and the unification of two clusters takes place at $\tilde{r}_{zh}$ = 0.958 (Fig. 2).

Table 2. Values of the index of similarity $\tilde{r}_{zh}$ (above the diagonal) and the identity criterion I (below the diagonal) for the samples of *Liza haematocheila* from different areas of the Azov basin

Regions of study	Regions of study									
	C	BB	NE	E	OB	S	ML	SE	ES	W
C	–	0.997	0.993	0.994	0.991	0.990	0.982	0.992	0.986	0.995
BB	6.037	–	0.987	0.987	0.991	0.986	0.981	0.996	0.986	0.994
NE	10.591	14.572	–	0.988	0.982	0.983	0.960	0.982	0.969	0.982
E	7.348	13.308	9.171	–	0.987	0.994	0.978	0.981	0.981	0.992
OB	15.467	9.684	18.005	12.238	–	0.990	0.977	0.989	0.987	0.989
S	14.416	16.491	15.194	5.659	13.762	–	0.978	0.987	0.982	0.986
ML	24.750	18.004	38.369	24.533	18.081	24.350	–	0.974	0.984	0.987
SE	6.607	4.231	11.530	11.051	7.542	8.833	18.702	–	0.983	0.986
ES	16.581	14.967	26.714	18.964	10.418	19.663	10.756	9.626	–	0.988
W	3.586	2.710	10.854	5.833	5.237	9.013	7.026	4.916	7.357	–

Note: Designations of regions are the same as in Table 1. Significant differences according to the identity criterion (I) for the significance level 0.01 are distinguished.

Morphometric characters (Table 4) were studied in fish from six samples that represent Molochnyi Liman, Eastern Sivash, and four regions of the seawater area. As initial information for the subsequent use of statistical methods of multidimensional analysis, we made calculations of the Kulbach divergence and compiled the matrix of distances, which includes a comprehensive characteristic of reciprocal generalized distances of all samples for 29 morphometric characters.

Results of cluster analysis (Fig. 3) demonstrate that fish from sea regions (regions NE, BB, C, and E,) which at $D = 28.8$ are combined into a separate cluster, are the closest between themselves according to morphometric characters. Differences between the samples of *L. haematocheila* from Molochnyi Liman and Sivash are more considerable than between fish from sea regions. The formation of the cluster including Molochnyi Liman and Sivash fish takes place at $D \approx 47$. Clusters are combined at $D = 107$.

As a method of the most efficient placement of samples, retaining distances observed between them, we used the method of multidimensional scaling, i.e., we tried to place samples in a two-dimensional space and to verify as to how exactly the obtained configuration retains distances between the samples. The results of this procedure are presented in Fig. 4. One of the measures of assessing the quality of adjusting a model is a stress index (Borovikov and Borovikov, 1998). In our case, its value is smaller than 1×10^{-6}, which indicates a very good correlation of the matrix of initial distances with the matrix of resulting distances.

With regards to the obtained results, four samples from different regions of the seawater area (regions C, NE, E, and BB) were combined into one (designated as sample SWA–seawater area), and a factor analysis by morphometric characters of three samples of *L. haematocheila*—ML, ES, and SWA—was performed. Figure 5 shows that the samples under comparison are distinctly differentiated in the space of two principal components. The loads of eigenvectors on the

Table 3. Average number of morphs and the proportion of rare morphs of meristic characters of *Liza haematocheila* from different areas of the Azov basin

Areas of study	Average number of morphs ($\tilde{\mu}$)	Proportion of rare morphs ($\tilde{h}$)
Central	1.517 ± 0.0701	0.310 ± 0.0319
Berdyanskii Bay	1.574 ± 0.1144	0.344 ± 0.0477
Northeastern	1.634 ± 0.1161	0.257 ± 0.0528
Eastern	1.458 ± 0.0674	0.190 ± 0.0375
Obitochnyi Bay	1.609 ± 0.1071	0.268 ± 0.0487
Southern	1.624 ± 0.1295	0.375 ± 0.0498
Molochnyi Liman	1.193 ± 0.0449	0.148 ± 0.0320
Southeastern	1.740 ± 0.1999	0.331 ± 0.0769
Eastern Sivash	1.502 ± 0.0728	0.166 ± 0.0404
Western	1.354 ± 0.0814	0.154 ± 0.0509

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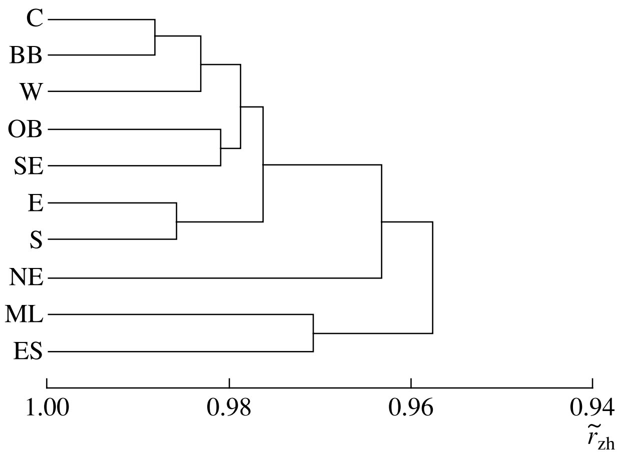

Fig. 2. Dendrogram of similarity of *Liza haematocheila* from the Azov basin by indices of similarity ($\tilde{r}_{zh}$) of meristic characters. Designations of areas are the same as in Fig. 1.

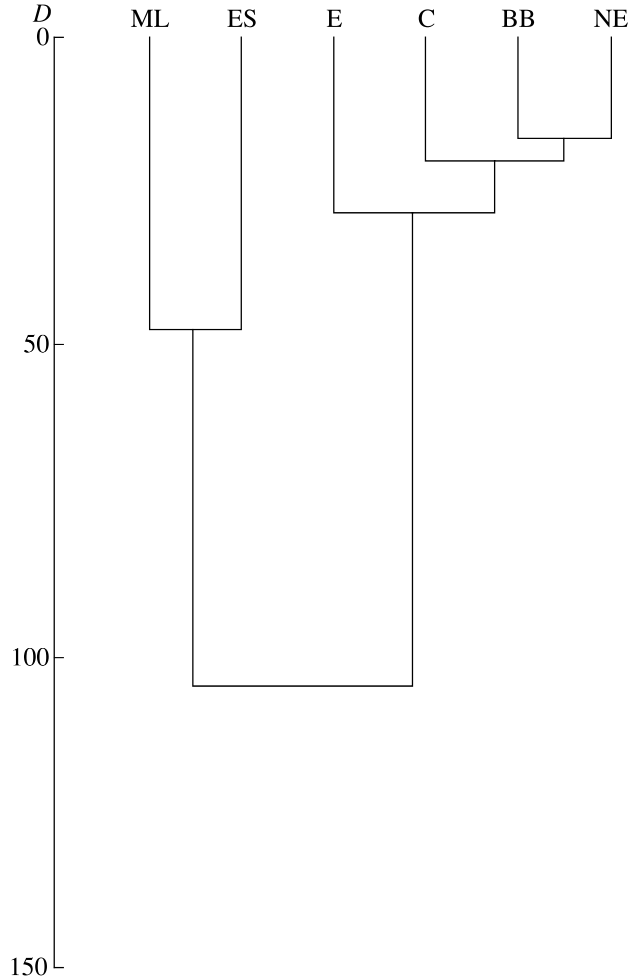

Fig. 3. Dendrogram of similarity of *Liza haematocheila* from the Azov basin by levels of divergence (*D*) of morphometric characters. Designation of areas is the same as in Fig. 1.

first and second principal components for the most "weighty" morphometric characters are listed in Table 5. The first principal component takes upon itself mainly characters specific of body proportions, while the second component takes upon itself fin parameters. On the whole, *L. haematocheila* from seawater areas is characterized by a deeper body, deeper head, and smaller anteanal and antedorsal distances (Table 4), as compared to fish from water bodies of the basin: Molochnyi Liman and Eastern Sivash. It is seen even visually (when working with the material) that the Sivash *L. haematocheila* and also, to a slightly greater degree, the Molochnyi Liman *L. haematocheila* are distinguished by a more oblong body.

If we turn to the history of the acclimatization of *L. haematocheila* in the Sea of Azov basin, we see that it is directly related to Molochnyi Liman where an experimental base was formed. Acclimatization works were performed from 1978 to 1983 by the method of stage-by-stage acclimatization (the formation of the recovery-brood stock in captivity, producing offspring by a hatchery method) rather than by direct acclimatization. After obtaining the first offspring (1984) under hatchery conditions, transportation from the Sea of Japan was stopped, and juveniles of local origin were produced (Sabodash and Semenenko, 1998). Thus, the species dispersal in the Azov basin began from Molochnyi Liman namely. As was aforementioned already, the reproduction of *L. haematocheila* in the new range proceeds at a considerably lower water salinity than in the natural range. At the same time, the range of differences in salinity in different parts of the spawning range within the Azov basin is also very wide. As many researchers report (Pryakhin and Volovik, 1997; Chesalina, 2000; P'yanova, 2002; et al.), during the adaptation of *L. haematocheila* to new habitats, the egg diameter decreased at a relative increase of the size of the adipose drop, which increases egg floatability and promotes species reproduction in water bodies with lower salinity. Hence, water salinity, at which *L. haematocheila* reproduces and develops, with rather high degree of certainty may be considered as a main factor responsible for the variation of this species under conditions of the Azov basin.

Summing up the results of the performed studies of phenetic diversity of *L. haematocheila* under conditions of the Azov basin according to the entire combination of morphologic (meristic and morphometric) characters, we arrive at the conclusion of the differentiation of the population under conditions of a new range, which is related to differences in environmental conditions in sites of reproduction and habitat, primarily, salinity.

Omel'chenko et al. (2004), based on results of the population–genetic analysis of *L. haematocheila* in the

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Table 4. Morphometric characters ($M \pm m$) of *Liza haematocheila* from different areas of the Azov basin

Characters	Areas of study					
	NE (*n* = 32)	BB (*n* = 39)	E (*n* = 38)	C (*n* = 31)	ES (*n* = 50)	ML (*n* = 56)
AC, cm	43.4 ± 0.60	44.2 ± 0.78	43.6 ± 0.87	42.9 ± 0.81	46.2 ± 0.67	41.3 ± 0.30
In % AC						
aD	43.51 ± 0.207	43.75 ± 0.252	43.44 ± 0.149	43.38 ± 0.265	45.19 ± 0.171	44.44 ± 0.144
pD	20.55 ± 0.138	20.70 ± 0.226	20.87 ± 0.150	20.70 ± 0.167	21.12 ± 0.128	20.89 ± 0.100
H	21.94 ± 0.310	22.41 ± 0.335	22.33 ± 0.312	21.38 ± 0.234	20.81 ± 0.254	18.80 ± 0.216
h	9.82 ± 0.065	9.67 ± 0.067	9.71 ± 0.072	10.17 ± 0.064	9.61 ± 0.054	9.35 ± 0.050
pl	23.29 ± 0.159	23.36 ± 0.166	23.49 ± 0.142	23.06 ± 0.131	23.60 ± 0.106	23.35 ± 0.125
aA	60.88 ± 0.331	61.74 ± 0.536	58.10 ± 0.850	61.76 ± 0.464	69.89 ± 0.248	68.64 ± 0.180
aV	34.26 ± 0.183	34.29 ± 0.137	34.03 ± 0.172	34.48 ± 0.165	34.64 ± 0.137	34.45 ± 0.163
PV	16.30 ± 0.172	16.75 ± 0.154	16.38 ± 0.131	16.29 ± 0.130	16.51 ± 0.101	15.81 ± 0.092
VA	35.11 ± 0.223	35.55 ± 0.218	36.50 ± 0.223	35.11 ± 0.278	34.84 ± 0.189	34.96 ± 0.185
lP	15.17 ± 0.117	15.08 ± 0.094	15.62 ± 0.098	15.80 ± 0.121	15.55 ± 0.073	15.65 ± 0.094
lV	13.19 ± 0.095	12.96 ± 0.100	13.65 ± 0.100	13.62 ± 0.080	13.41 ± 0.067	13.47 ± 0.075
lD1	10.65 ± 0.144	10.63 ± 0.142	11.19 ± 0.136	10.73 ± 0.172	10.36 ± 0.112	9.93 ± 0.121
hD1	12.37 ± 0.123	12.05 ± 0.110	12.59 ± 0.121	12.32 ± 0.119	13.21 ± 0.111	12.87 ± 0.123
lD2	9.46 ± 0.129	9.26 ± 0.100	8.99 ± 0.083	9.56 ± 0.103	8.90 ± 0.066	8.50 ± 0.051
hD2	12.55 ± 0.097	12.30 ± 0.094	12.74 ± 0.091	12.87 ± 0.133	12.63 ± 0.092	12.66 ± 0.073
l1–D2	18.68 ± 0.355	19.17 ± 0.174	18.49 ± 0.218	18.97 ± 0.291	19.23 ± 0.165	19.01 ± 0.190
lD1–D2	29.11 ± 0.284	29.60 ± 0.163	29.38 ± 0.173	29.27 ± 0.219	29.10 ± 0.145	28.69 ± 0.161
lA	10.37 ± 0.103	10.22 ± 0.080	10.17 ± 0.075	10.56 ± 0.089	10.18 ± 0.138	9.35 ± 0.058
hA	12.63 ± 0.121	12.41 ± 0.112	13.04 ± 0.090	12.51 ± 0.166	12.68 ± 0.066	13.01 ± 0.086
c	22.59 ± 0.117	22.53 ± 0.131	22.70 ± 0.110	22.97 ± 0.143	23.40 ± 0.092	23.37 ± 0.070
In % c						
hcz	66.92 ± 0.711	66.08 ± 0.501	66.43 ± 0.425	68.87 ± 0.533	65.47 ± 0.398	61.52 ± 0.268
ao	27.14 ± 0.313	26.78 ± 0.185	26.21 ± 0.214	27.65 ± 0.206	26.88 ± 0.128	26.91 ± 0.156
o	17.30 ± 0.227	17.49 ± 0.217	16.76 ± 0.248	17.13 ± 0.306	16.19 ± 0.153	15.93 ± 0.093
op	62.29 ± 0.257	62.07 ± 0.377	61.27 ± 0.278	63.03 ± 0.299	63.99 ± 0.157	63.24 ± 0.226
io	40.23 ± 0.425	40.83 ± 0.424	39.08 ± 0.266	39.90 ± 0.269	40.81 ± 0.201	39.35 ± 0.150
lm	27.65 ± 0.222	27.94 ± 0.199	27.80 ± 0.240	28.71 ± 0.183	28.05 ± 0.101	28.11 ± 0.113
hm	6.37 ± 0.092	6.36 ± 0.083	6.20 ± 0.072	6.40 ± 0.090	6.35 ± 0.066	6.23 ± 0.052
lmd	30.39 ± 0.272	30.67 ± 0.176	31.27 ± 0.149	30.37 ± 0.189	30.26 ± 0.170	30.58 ± 0.155
ist	33.45 ± 0.341	33.95 ± 0.271	33.29 ± 0.269	33.31 ± 0.222	33.98 ± 0.172	33.79 ± 0.139

Note: AC, body length of fish; aD, antedorsal distance; pD, postdorsal distance; aA, anteanal distance; aV, anteventral distance; PV, pectoventral distance; VA, ventroanal distance; H, body depth; h, caudal peduncle depth; pl, caudal peduncle length; lP, pectoral fin length; lV, ventral fin length; lD1 and lD2, lengths of insertions of the first and second dorsal fins; hD1 and hD2, the first and second dorsal fins depth; l1–D2, distance between dorsal fins; lD1–D2, distance between the origin of dorsal fin insertions; lA, anal fin insertion length; hA, anal fin depth; c, head length; hcz, head depth near occiput; ao, snout length; o, eye diameter; op, postorbital distance; io, forehead width; lmd, lower jaw length; lm and hm, upper jaw length and depth; ist, mouth width. Designations of areas and of the rest are the same as in Table 1.

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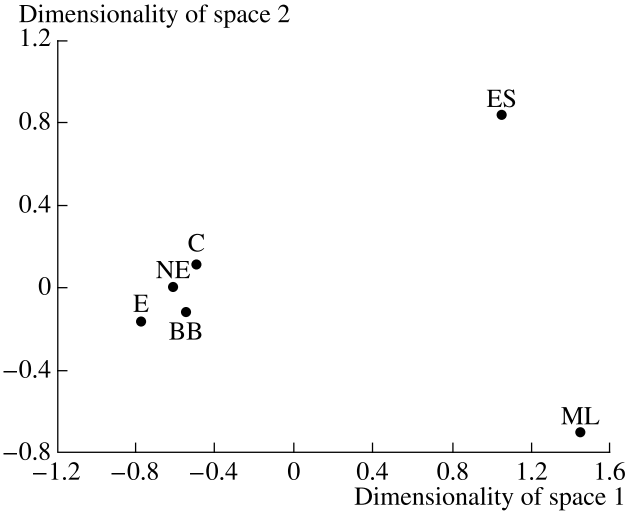

Fig. 4. Distribution of samples of *Liza haematocheila* from the Azov basin in a two-dimensional space of distances made by the method of multidimensional scaling according to a complex of morphometric characters. Designation of areas is the same as in Fig. 1.

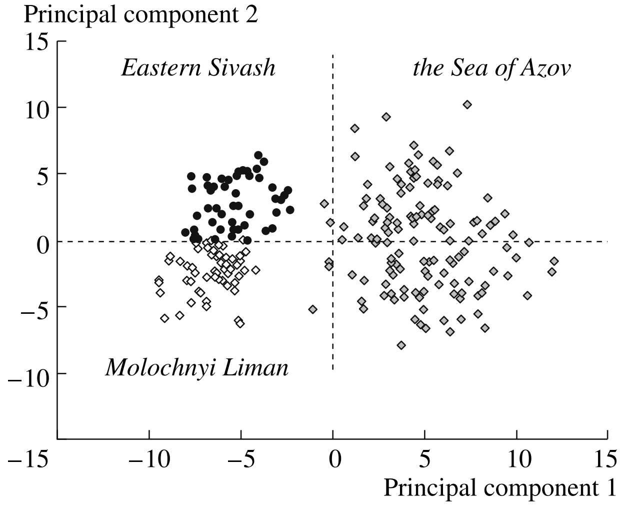

Fig. 5. Distribution of *Liza haematocheila* from different areas of the Azov basin in the space of principal components according to indices of morphometric characters.

native and new ranges, come to an analogous conclusion, i.e., that salinity level is the most probable factor of the differentiating local selection during rapid adaptation and naturalization of the acclimatized *L. haematocheila*. Within the new range, the authors separate three subpopulations of *L. haematocheila*: marine (the Sea of Azov), lacustrine (Lake Khanskoe), and Kerch (Kerchenskii Strait).

If the results of our studies and the data of the study by Omel'chenko et al. (2004) are generalized, it may be concluded that, within the Azov basin, the population of *L. haematocheila* is represented by five subpopulations: Molochnyi Liman, Sivash, marine, lacustrine, and Kerch.

Table 5. Loads of eigenvectors on principal components (loads of the ten most "weighty" indices of morphometric characters are listed)

Characters	The first principal component	Characters	The second principal component
aA	0.748	lV	0.805
hcz	−0.704	hD2	0.743
H	0.639	lP	0.731
lA	−0.623	hA	0.654
lD2	−0.591	hD1	0.376
c	0.582	h	0.372
hD1	0.504	io	−0.344
aD	0.494	op	−0.340
lD1	−0.452	lD1	0.299
h	−0.431	aA	−0.284

Note: Character designations are the same as in Table 4.

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