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THE MASS-DIMENSION RELATIONSHIPS IN THE MUSSELS *MYTILUS GALLOPROVINCIALIS* (MOLLUSCA, BIVALVIA) FROM DIFFERENT PHENOTYPICAL GROUPS IN PERIPHYTON POPULATIONS NEAR ODESSA COAST, THE NORTH-WESTERN PART OF BLACK SEA

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The Mass-Dimension Relationships in the Mussels *Mytilus galloprovincialis* (Mollusca, Bivalvia) from Different Phenotypical Groups in Periphyton Populations Near Odessa Coast, the North-Western Part of Black Sea. Govorin, I. A. — The data of the size-mass indices in the mussels *Mytilus galloprovincialis* (Lamarck, 1819) from three phenotypic groups — brown, dark violet (black) and "zebra" (brown with radial black stripes) shells in the periphyton settlements on the concrete traverses near Odessa coast, the North-western part of Black Sea (Ukraine), in March–November 2014–2015 are presented. A comparative evaluation has been made on the relationships of total mass of the mollusks, wet and dry mass of their soft body and mass of the shells on the one hand, and the size of animals (length of its shells) on the other hand, in the each of phenotypical groups from the five marine beach areas. It is shown, that in the marine areas with different degrees of isolation from the open sea by coast-protection engineering constructions, the mussels from different phenotypes have almost the same size-mass characteristics. Only the dry weight of soft animal body, which indicated to fatness of mollusk and therefore demonstrated his biological prosperity in specific hydrological conditions, can serve as a reliable criterion which can mark the shellfish habitats with different gradients of environmental factors.

Key words: mussels (Mytilidae), phenotypes, size-mass characteristics of mollusks, periphyton settlements, Odessa coast, north-western part of Black Sea, Ukraine.

Introduction

The study of polymorphism of mollusks (the variability of shape and color of shells, size-weight relationships and other morphometric features), can be an important criterion for assessing the overall diversity of shellfish populations and their response to changes in the variability environmental conditions (Protasov, Gorpinchuk, 2000; Govorin, 2009). The ability to use the phenotypic characteristics of shellfish for the comparative analysis of the structure of animal populations under different gradients of environmental factors was widely presented in the scientific literature, in particular — on the bivalve mollusk *Dreissena polymorpha* Pallas, 1771, for example (Protasov, 1998; 2002).

The most common marine bivalve mollusks in the north-western Black Sea (NWBS) are mussels *Mytilus galloprovincialis* Lamarck, 1819 (Black Sea..., 1988; Shurova, 2005, 2013). These mollusks are also one of the dominant species in biofouling on the different artificial surfaces of various coast-protected engineering structures (traverses, breakwaters) in the marine coastal areas. Only in the Odessa region of the NWBS the share of mussels in the total mass of biofouling on the concrete traverses in coastal beach areas can reach 63.0–82.0 % (Govorin et al., 2004; Govorin, Shatsillo, 2010). Based on the color of its shells, mussels can be divided into three different phenotypic groups: brown, dark violet (or black) and "zebra" (brown shells with radial black stripes) (Novac, Fuzu, 2006; Shurova, Zolotarev, 2008). These colors are genetically determined (Stolbova et al., 1996) and affected to certain differences in animal responses to environmental changes, particularly in salinity of the marine waters (Shurova 2013). Today, the results of fundamental researches on the quantitative and phenotypic distribution of the mussels *M. galloprovincialis* in the natural bottom biotopes in the NWBS are widely presented in literature (Novac, Fuzu, 2006; Shurova, Zolotarev, 2008; Shurova 2013). However, the size-mass relationships in the animals from different phenotypic groups in the biofouling settlements in this region practically not studied.

The aim of this work was to study the mass-dimension relationships in mussels *M. galloprovincialis* different phenotypes from periphyton settlements on the concrete traverses in the five beach areas with different hydrological conditions (Odessa Bay, northwestern part of Black Sea, Ukraine), for determine the possibility

to using these morphometric indices to labeling the mussels populations in the anthropogenic transformed marine coastal areas in the future.

Material and methods

Living specimens of mussels *M. galloprovincialis* were collected monthly from March to November 2014–2015 from biofouling on the concrete traverses (horizon 0.5–1.0 m) nearby Lanzheron Cape, Odessa Bay of the NWBS (46°28.091′ N; 30°45.828′ E). The mussels collected from biotopes (bt.), which were located in five marine beach areas, differed in their isolation from the open sea by coast-protection engineering constructions:

– Completely open area with free water exchange with the open sea (bt. 1);
– Semi-enclosed beach areas with breakwaters (bt. 2, 4 and 5);
– The harbor, surrounded by up-water traverses with very slow water exchange (bt. 3).

Based on the length of shells (L, mm), the collected animals were sorted to the following size groups: 10–20, 21–30, 31–40, 41–50 and 51–60 mm. From each group were taken 5–6 specimens which differed by color of its shells for further research their mass parameters: the total mass of the animal (M_1, g), the raw and dry mass of its soft body (M_2 and M_3, g) and mass of the empty shells (M_4, g).

Mollusks were divided to one or another phenotypic groups according to color of its shells: completely brown morphs (*br*), deep violet (or black) morphs with a pigment distributed uniformly on the prismatic layer of shells (*vi*) and "zebra striped" phenotype — brown shells with violet pigment presented as a radial dark lines of varying width and intensively (*ze*) (Shurova, Zolotariov, 2008; Shurova, 2013).

The data of size-mass parameters of the mussels underwent by standard statistical analysis (Statgraphics Plus 5.0). Differences between the sampling sites in the measurements made were tested by unvaried and multivariate Regression Analysis of variance (ANOVA).

Results and discussion

During the period of researches were examined 504 specimens of mussels *M. galloprovincialis*, including 224 — with completely brown shells (*br*), 235 — deep violet or black morphs (*vi*) and 45 — "zebra striped" morphs (*ze*). The length of shells (*L*) of the mollusks varied from 12.1 to 59.5 mm, the average size of the animals in each phenotypic group was 25.7 ± 9.8 (*br*), 31.5 ± 9.9 (*vi*) and 28.8 ± 9.7 mm (*ze*). The total mass of the mussel (M_1) was in the range of 0.162–15.200 g (1.972 ± 0.148, 3.240 ± 0.209 and 2.480 ± 0.482 g, respectively for each phenotypic group) (table 1).

The comparison of relations between controlled mass indices (M_1–M_4) of the mussels in five marine areas near Lanzheron Cape has shown any significant differences between animals with a different color of its shells. Only in the harbor with the strong isolation from the open sea and slow water exchange (bt. 3), mussels with "zebra striped" color shells (*ze*) was noted by very low parameters of the wet (M_2) and dry mass (M_3) of its soft body. Thus, the ratio of these indices in the total biomass of the animal (M_2 / M_1 and M_3 / M_1) in "zebra striped" mollusks amounted to 28.7 ± 1.8 % and 4.3 ± 0.5 % respectively. For comparison, these indices for the mussels brown phenotype (*br*) were 33.15 ± 1.10 % and 5.78 ± 0.27 %, and for the dark violet (black) mollusks — 31.82 ± 1.06 % and 5.23 ± 0.27 % . Furthermore, in the harbor were also observed the lowest rates of shell mass of the animals (M_4) in all of

Table 1. The size-mass characteristics of the mussels *Mytilus galloprovincialis* three different phenotypes from periphyton settlements on the concrete traverses near Lanzheron Cape (Odessa coast, north-western part of Black Sea), March–November 2014–2015

Pheno-types	*N*	Min–max values of parameters (means ± error of means)				
		L	M_1	M_2	M_3	M_4
br	224	12.1–54.2 (25.7 ± 9.8)	0.162–11.200 (1.972 ± 0.148)	0.090–9.104 (1.096 ± 0.086)	0.042–3.986 (0.601 ± 0.046)	0.006–0.726 (0.091 ± 0.007)
vi	235	12.6–59.5 (31.5 ± 9.9)	0.200–15.200 (3.240 ± 0.209)	0.100–8.740 (1.696 ± 0.110)	0.056–5.242 (1.025 ± 0.068)	0.008–0.822 (0.157 ± 0.011)
ze	45	15.4–48.5 (28.8 ± 9.7)	0.300–8.860 (2.480 ± 0.482)	0.168–5.440 (1.396 ± 0.278)	0.070–2.160 (0.766 ± 0.132)	0.012–0.288 (0.109 ± 0.018)

Note (here and in the table 2–3). Phenotypes: *br* — brown shells, *vi* — dark violet (black) shells, *ze* — brown shells with radial black stripes ("zebra"). *N* — number of specimens; *L* — length of mollusk shells, mm; M_1 — total mass of the mollusk, M_2 and M_3 — the wet and dry mass of the soft body, M_4 — mass of the empty shells, g.

Table 2. The ratio of the wet (M_2) and dry mass (M_3) of the soft body of the animals, and mass of its shells (M_4) in the total biomass of mollusk (M_1) in the different phenotypical groups of the mussels *Mytilus galloprovincialis* from the periphyton settlements near Lanzheron Cape (Odessa Coast, north-western part of Black Sea), March–November 2014–2015

Biotopes	Phenotypes	*N*	The ratio of components, %		
			M_2 / M_1	M_3 / M_1	M_4 / M_1
1	*br*	54	33.05 ± 0.73	5.67 ± 0.21	52.20 ± 0.87
	vi	49	32.56 ± 0.98	5.71 ± 0.26	51.85 ± 0.88
	ze	11	33.63 ± 2.64	5.01 ± 0.58	53.05 ± 1.41
2	*br*	42	32.72 ± 0.88	5.75 ± 0.28	56.03 ± 0.81
	vi	46	33.31 ± 0.94	5.58 ± 0.22	53.87 ± 0.86
	ze	11	36.13 ± 2.16	6.56 ± 0.59	53.26 ± 1.76
3	*br*	41	33.15 ± 1.10	5.78 ± 0.27	48.81 ± 0.86
	vi	43	31.82 ± 1.06	5.23 ± 0.27	50.27 ± 0.75
	ze	4	28.74 ± 1.83	4.31 ± 0.47	50.64 ± 2.03
4	*br*	43	31.29 ± 0.83	5.32 ± 0.24	55.06 ± 0.97
	vi	51	30.8 ± 0.65	4.95 ± 0.18	55.73 ± 0.95
	ze	9	31.39 ± 1.81	5.06 ± 0.47	52.47 ± 2.01
5	*br*	44	32.50 ± 0.70	5.35 ± 0.16	54.91 ± 1.10
	vi	46	32.80 ± 0.87	5.36 ± 0.20	54.42 ± 1.18
	ze	10	33.13 ± 1.58	5.57 ± 0.39	57.87 ± 2.86
1–5	*br*	224	34.72 ± 1.45	5.62 ± 0.12	53.84 ± 0.61
	vi	235	33.30 ± 1.12	5.37 ± 0.10	53.17 ± 0.44
	ze	45	32.27 ± 0.98	5.36 ± 0.25	53.59 ± 0.98

Note. Biotopes: 1 — completely open area with free water exchange with the open sea; 2, 4 and 5 — semi-enclosed beach areas with breakwaters; 3 — the harbor surrounded by up-water traverses with very slow water exchange.

the phenotypic groups of mussels — from 48.81 % (*br*) to 50.64 % (*ze*), while in the other four biotopes these parameters varied from 51.85 % to 56.03 % (table 2).

The analysis of the relationship between the mass indices of the animals (M_1–M_4) and the length of its shells (L) for the total data set in all five studied biotopes confirmed a strong correlation ($p < 0.01$) between these values in each of the phenotypic groups of animals. However, the comparison of the Regression Lines of depending mass indices M_1–M_3 to mollusk size (L) did not confirm any significant differences between the different colored mussels in all biotopes, except bt. 3 (the harbor). Only in the harbor were noted statistically differences between "zebra striped" mussels (*ze*) on the one hand and brown (*br*) or violet (*vi*) mollusks on the other hand, in dry mass of its soft body (M_4). The coefficient b in the equation of relation between this parameter and size of animal ($\ln M = a + b \bullet \ln L$) was only 2.59, compared with 2.77–2.80 for mussels from other phenotypes (table 3).

Table 3. The parameters of the equations ($\ln M = a + b \bullet \ln L$) of the relation between the mass indices of the mollusk (M_1–M_4) on the one hand, and the length of his shells (L) on the other hand, in the periphyton settlements of the mussels *M. galloprovincialis* near Odessa coast, north-western part of Black Sea, March–November 2014–2015

Phenotypes	Mass indices	$\ln a$	b	r	R^2	*SE*
br	M_1	–8.866	2.833	0.992	99.05	0.104
	M_2	–9.048	2.705	0.951	90.98	0.320
	M_3	–10.212	2.876	0.984	96.31	0.212
	M_4	–11.781	2.769	0.952	90.30	0.342
vi	M_1	–8.907	2.853	0.991	98.56	0.117
	M_2	–9.356	2.796	0.990	98.08	0.133
	M_3	–10.185	2.885	0.985	96.50	0.187
	M_4	–11.787	2.801	0.951	90.71	0.305
ze	M_1	–8.922	2.843	0.992	98.93	0.103
	M_2	–9.592	2.869	0.992	98.78	0.112
	M_3	–10.087	2.846	0.984	95.97	0.209
	M_4	–11.158	2.594	0.95	91.06	0.291

Note. a, b — coefficients of the equations; r — coefficient of correlation; R^2 — coefficient of determination, %; *SE* — standard error of estimation.

The final equations of the Multiple Regression Analysis linking the total mass of the mollusk (M_1) on the one hand and the linear size of animal (L), the mass of its raw soft body (M_2) and the mass of the vide shells (M_4) on the other hand, for each phenotypic groups of mussels *M. galloprovincialis* in the study marine areas of the Odessa region of the NWBS are ($p < 0.01$):

– brown specimens: $\ln M_1 = -2.9797 + 1.0951 \cdot \ln L + 0.0878 \cdot \ln M_2 + 0.5155 \cdot \ln M_4$ ($N = 225$, $R^2 = 99.19$, $SE = 0.109$);

– dark violet (black): $\ln M_1 = -2.6074 + 0.9941 \cdot \ln L + 0.1455 \cdot \ln M_2 + 0.4973 \cdot \ln M_4$ ($N = 233$, $R^2 = 99.30$, $SE = 0.090$);

– "zebra striped": $\ln M_1 = -1.6427 + 0.7153 \cdot \ln L + 0.2257 \cdot \ln M_2 + 0.5112 \cdot \ln M_4$ ($N = 45$, $R^2 = 99.41$, $SE = 0.069$).

Conclusions

In the mussels *Mytilus galloprovincialis* Lam. from various phenotypic groups, lived in the periphyton settlements in the Odessa Region of the Black Sea, any statistically significant differences between the total mass of animals, wet mass of its soft body and mass of the shells, not were found. Some of the differences between the mussels with different colored shells were observed only in the harbor which strong isolated from the open sea by coast-protected structures and slowly water exchange. In this area the dry weight of the mollusks soft body, indicated about «fatness» of the animal and his prosperity, was the lowest in "zebra striped" phenotype specimens (4.3 ± 0.5 % in the total mass of the animal), compared to mussels with brown and dark violet shells (5.4 ± 0.1 % and 5.3 ± 0.2 % correspondingly).

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