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Condition Index Analysis of Mussel *Mytilus Galloprovincialis* (Lamarck, 1819) from the Romanian Black Sea Coast

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Abstract

The condition index of bivalve molluscs reflects the nutritional state and metabolic response to different environmental pressures. The development of bivalves in natural environments is mediated by the interaction between environmental factors. The aim of this study is to determine the condition index of the marine bivalve *Mytilus galloprovincialis* and to establish the relationship between environmental parameters and the index values. This study was carried out between November and December 2017, at four sampling sites. The mean values of condition index varied between 4.96 g (at 2 Mai) and 9.88 g (at Midia Năvodari Port), the highest index values being recorded in port areas. From all the analyzed parameters, the condition index showed a clear relationship only with seawater temperature, chlorophyll *a* concentration and total suspended solids.

Keywords: condition index, *Mytilus galloprovincialis*, environmental parameters, Romanian Black Sea coast.

Introduction

The marine mussel *Mytilus galloprovincialis* (Lamarck, 1819) (Mollusca: Bivalvia) belongs to the Mytilidae family and shows a high adaptability and tolerance to a wide range of environmental conditions. However, the extreme values of physical factors can cause the mortality of the mussels [24].

The bivalve's development in natural environments is mediated by the interaction between environmental factors, water temperature and food

availability, in particular [3]. Other variables such as salinity [4], dissolved oxygen [8], pH [12] and sediment suspension [16] also act as limiting factors for bivalve growth. Between the biotic factors, the main factor influencing the growth, reproduction, and condition of the mussels is food availability [20]. Phytoplankton represents the main food source of the mussels and can be quantified by chlorophyll *a* concentration (as an indicator of phytoplankton biomass) [28].

The condition index of mussels reflects the nutritive status of mussels such as stored energy reserves and metabolic response to different environmental stress [29, 30, 31]. This index may also be used as a nonspecific index to assess the relation between contaminants concentrations and the mussel health [14, 31, 25].

The condition index has been used as a tool to evaluate the physiological state of mussels' health and to estimate the meat quality and yield in cultured bivalve molluscs [15, 19, 21]. The condition index can summarize the variations of physiological activity (growth, reproduction, and excretion, among others) [17]. The condition index of mussels exhibit seasonal variations, and are the results of gonad proliferation and multiplication, nutrition and stress caused by energy reserves loss [5]. Currently there are several methods used to estimate the condition index, but there is no agreement about which one is the most accurate. The total shell and soft tissue weight, internal volume, and total length are the principal parameters used in condition index equations [9, 6].

The aim of this study is to determine the condition index of the marine bivalve *Mytilus galloprovincialis* and to establish the relationship between environmental parameters and the index values.

Material and method

This study was carried out from November till December 2017, at four sampling stations (three contaminated stations – in port areas and one outside - control): Midia Năvodari Port ($44^0$20'32.76"N; $28^0$40'53.87"E), Constanţa Port ($44^0$09'39.03"N; $28^0$39'23.36"E), Mangalia Port ($43^0$48'20.98"N; $28^0$34'50.05"E) and 2 Mai ($43^0$46'44.33"N; $28^0$34'57.60"E) (Fig. 1). The sampling stations were represented using Ocean Data View [22].

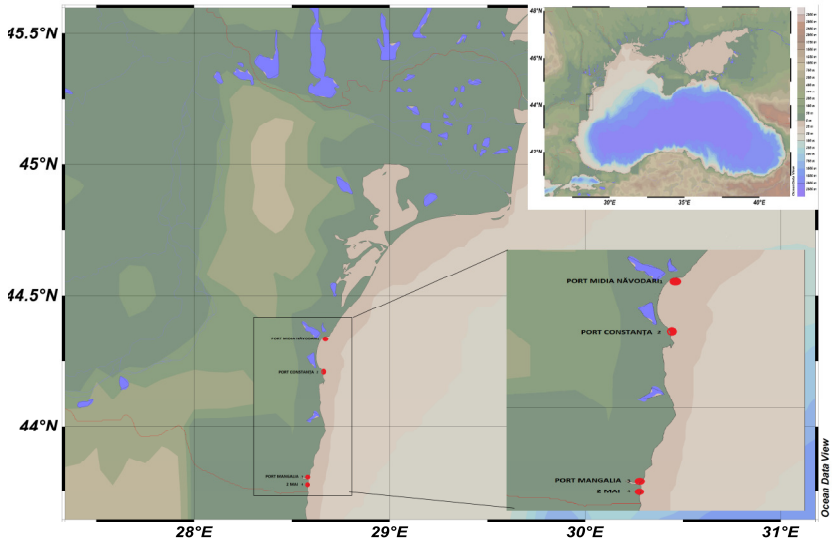

Fig. 1. Locations of sampling stations

During the sampling, *in situ* physico-chemical properties of seawater (temperature, salinity, pH, dissolved oxygen and total dissolved solids) were measured using a multiparameter sonde (HANNA HI 7698194), while water samples were taken for chlorophyll *a* and total suspended solids analysis. In the laboratory, triplicate water samples were filtered for chlorophyll *a* (3 L) and for the total suspended solids (1.5 L) onto MF-Millipore filters (pore size 0.45 µm, diameter 47 mm) using a vacuum pump (VACUUBRAND ME 4 NT).

The filters used for chlorophyll *a* were frozen until further analysis (at -20°C). The pigments were extracted with 90% acetone and measured by spectrophotometry (CECIL CE-2020 spectrophotometer), concentrations being calculated using the SCORE-UNESCO equations [27]. For the analysis of the total suspended solids, the filters were dried (at 105^0C for 3h), weighed with an electronic balance (KERN KB 3600-2N, d=0.01g) and the mean weights converted to mg/L [18].

A random number of 30 individuals of the species *Mytilus galloprovincialis* were collected from each sampling station, from 1-1.5m deep. The samples were stored in a cool box compartment after collection in the field.

In the laboratory, the individuals were cleaned of epibionts, external byssus and washed. The mussels were measured for their shell lengths (maximum anterior-posterior), shell widths (lateral dimension) and shell heights (dorsal-

ventral) with a vernier caliper (UNIOR 270A) to an accuracy of 0.02 mm. For the determination of dry meat weight, the total meat of mussels was carefully removed by de-shelling the mussel with a scalpel and the excess water was eliminated using a tissue paper. The dry meat weights and dry shell weights of the mussel were measured with an electronic balance (KERN KB 3600-2N, d=0.01g), after drying to constant weight for 24h at 105°C in a hot air oven. Prior to weighing the dry meat was kept in the desiccator for 12-14h.

The condition index (CI) was calculated based on the coefficient of dry meat weight (DMW) for each individual and the dry shell weight (DSW), multiplied by a constant of 100 [7, 6]. This index was calculated as follows:

$$CI\ (g) = (DMW/DSW)*100$$

The Kruskal Wallis Test was used to test the difference in condition index between the sampling stations. Before this we tested for homogeneity of variance using the Levene test. Correlation tests were used to determine the relationships between condition index and environmental parameters (temperature, salinity, pH, dissolved oxygen, total dissolved solids, total suspended solids and chlorophyll-a).

The statistical analysis was carried out using SPSS Statistics 20 Software.

Results and Discussions

Environmental parameters are shown in Table 1. The maximum mean temperature was recorded in Midia Năvodari Port (12.141±0.003) and the minimum at 2 Mai (9.131±0.023). The mean salinity ranged from 14.557±0.004 (at Mangalia Port) to 16.309±0.046 (at 2 Mai). Dissolved oxygen recorded high concentrations throughout the study, with a maximum mean of 9.057±0.006 (at Constanţa Port) and a minimum mean value of 8.252±0.528 (at 2 Mai).

The variations of Chlorophyll *a* concentration was similar to variations of dissolved oxygen concentrations and total suspended solids values. The highest mean value was recorded at Constanta Port (3.663±0.005) and the lowest value at 2 Mai (0.516±0.005). A Pearson's product-moment correlation was run to determine the relationship between condition index and environmental parameters (Table 2). There was a strong, positive correlation between condition index and temperature, which was statistically significant (r = 0.576, p <0.001), total dissolved solids (r = 0.315, p<0.001) and chlorophyll *a* (r = 0.269, p<0.005). Negative correlations, statistically significant were observed between condition index and salinity (r = -0.502, p<0.005), pH (r = -0.453, p<0.001) and

total dissolved solids (r = -0.429, p<0.001), and a very weak negative correlation, statistically significant with dissolved oxygen (r = -0.066, p<0.005).

Table 1. Environmental parameters (mean±standard deviation) investigated in the study

Parameters	Sampling stations			
	MDP	CTP	MGP	2MI
T (°C)	12.141±0.003	10.147±0.009	10.971±0.003	9.131±0.023
S (psu)	15.038±0.004	15.038±0.004	14.557±0.004	16.309±0.046
DO (mg/L)	8.527±0.069	9.057±0.006	8.900±0.049	8.252±0.528
pH	8.509±0.002	8.482±0.004	8.460±0.011	8.580±0.025
TDS (mg/L)	12.321±0.003	13.174±0.023	11.971±0.003	13.319±0.034
TSS (mg/L)	0.303±0.005	0.596±0.005	0.396±0.005	0.103±0.005
Chl *a* (mg/L)	1.526±0.005	3.663±0.005	2.506±0.005	0.516±0.005

Note: MDP= Midia Năvodari Port; CTP= Constanța Port; MGP= Mangalia Port; 2MI= 2 Mai. T= Temperature; S= Salinity; DO= Dissolved oxygen; TDS= Total dissolved solids; TSS= Total suspended solids; Chl *a*= Chlorophyll *a*.

The overall statistics of mussels condition index collected per sampling station are presented in Table 2. It was found that Midia Năvodari Port recorded the highest values, followed by Mangalia Port and Constanța Port. The 2 Mai station showed the lowest condition among all stations.

Table 2. Correlation matrix between condition index and environmental parameters

		CI	T	S	DO	pH	TDS	TSS	Chl *a*
CI	Pearson Correlation	1							
	Sig. (2-tailed)								
T	Pearson Correlation	0.576**	1						
	Sig. (2-tailed)	0.000							
S	Pearson Correlation	-0.502	-0.706	1					
	Sig. (2-miled)	0.000	0.000						
DO	Pearson Correlation	-0.066	-0.211*	-0.243**	1				
	Sig. (2-tailed)	0.476	0.021	0.007					
pH	Pearson Correlation	-0.453**	-0.581**	0.976**	-0.295**	1			
	Sig. (2-tailed)	0.000	0.000	0.000	0.001				
TDS	Pearson Correlation	-0.429**	-0.784**	0.774**	0.060	0.666**	1		
	Sig. (2-tailed)	0.000	0.000	0.000	0.514	0.000			
TSS	Pearson Correlation	0.315**	0.248**	-0.723**	0.448**	-0.803**	-0.122	1	
	Sig. (2-tailed)	0.000	0.006	0.000	0.000	0.000	0.183		
Chl *a*	Pearson Correlation	0.269**	0.170	-0.713**	0.491**	-0.804**	-0.115	0.993**	1
	Sig. (2-tailed)	0.003	0.064	0.000	0.000	0.000	0.212	0.000	

Note: T= Temperature (^{0}C); S= Salinity (psu); DO= Dissolved oxygen (mg/L); TDS= Total dissolved solids (mg/L); TSS= Total suspended solids (mg/L); Chl *a*= Chlorophyll *a* (mg/L). **.Correlation is significant at the 0.001 level (2-tailed); *. Correlation is significant at the 0.005 level (2-tailed).

Table 3. Summary of condition index values for sampling stations; Condition index is presented in grams (N=30). S.D.= Standard deviation; Min.= Minimum; Max.= Maximum.

Sampling stations	Mean	S.D.	Min.	Max.
MDP	9,88	2,70	6,31	18,31
CTP	7,91	2,70	4,19	14,68
MGP	8,42	2,48	5,03	14,18
2MI	4,96	1,60	2,79	12,18

Note: MDP= Midia Năvodari Port; CTP= Constanţa Port; MGP= Mangalia Port; 2MI= 2 Mai.

Kruskal-Wallis test showed that there was a statistically significant difference in condition index between the four stations ($p = 0.000 < \alpha = 0.005$; df = 3, $Chi^2 = 55.609$), with a mean rank for condition index of 86.20 for Midia Năvodari Port, 63.17 for Constanţa Port, 70.53 for Mangalia Port and 22.10 for 2 Mai.

The commercial quality and physiological state of bivalve mollusc are adequately described by the condition index, a parameter reflecting the ecophysiological conditions and the health of animals [21]. The fluctuation of the CI index is associated with the reproductive condition or environmental parameters (temperature, salinity and nutrition) of bivalves [2]. Strohmeier et al. (2008) declared that food concentration induce an increase of mussels condition index [26]. The chlorophyll *a*, an indicator of phytoplankton biomass, synchronized with the condition index during the present study. This shows that the variation of this index is related to food availability. Similar results can be found in literature [23, 10, 11]. Lachowicz (2005) declared that mussels' condition varied according to location and was linked to environmental parameters [13]. These findings are similar with the results discussed in the present study. The results of measuring the condition index in the mussel *Mytilus galloprovincialis* show that this index is higher in polluted areas (in ports). These values can be explained not only by the presence of high phytoplankton densities (and the probability of frequent phytoplanktonic blooms), but by high temperature values, too. At the reference station (2 Mai), a low condition index was recorded, caused probably by poor trophic conditions. Similar results were found by another author [1].

Conclusions

The main environmental parameters that influenced the condition index of the mussel *Mytilus galloprovincialis* at all investigated locations were temperature, total dissolved solids, chlorophyll *a*. The result of this research shows that even in the same geographical area, condition index can record different values as a result of spatial environmental differences. The highest condition index values were registered in the port areas and the lowest at the reference station, due to high phytoplankton densities and higher temperatures.

References

[1] Barille, A.L. 1996. Contribution à l'étude des potentialités conchylicoles de Pertuis Breton. Thèse de doctorat, Universirté d'Aix-Marseille II, 243 pp.
[2] Bayne, B.L., Widdows, J. and Thompson, R.J., 1976. Physiology II. In: Marine Mussels: Their Ecology and Physiology (ed. B.L. Bayne), Cambridge University Press, Cambridge, pp. 207–260.
[3] Bayne, B.L. and Newell, R.C., 1983. Physiological Energetics of Marine Molluscs. In: The Molluscs, Vol. **IV** (K.M. Wilbur Ed.), Academic Press, New York, pp. 407-515.
[4] Bernard, R.F., 1983. Physiology and the Mariculture of Some Northeastern Pacific Bivalve Molluscs. Can. Spec Publ. Fish. Aquat. Sci. **63**: 24.
[5] Çelik, M.Y., Karayücel, S., Karayücel, İ., Öztürk, R., Bora, E., 2012. Meat Yield, Condition Index, and Biochemical Composition of Mussels (*Mytilus galloprovincialis* Lamarck, 1819) in Sinop, South of the Black Sea. Journal of Aquatic Food Product Technology, **21**:3,198-205.
[6] Crosby, M.P. and Gale, D.L., 1990. A Review and Evaluation of Bivalve Condition Index Methodologies with a Suggested Standard Method. J. Shellfish Res., **9**: 233-237.
[7] Davenport, J. and Chen, X., 1987. A Comparison of Methods for the Assessment of Condition in the Mussel (*Mytilus edulis* L.). Journal of Molluscan Study, **53**: 293-297.
[8] Davis, J.C., 1975. Minimal Dissolved Oxygen Requirements of Aquatic Life with Emphasis on Canadian Species. A Review. J. Fish. Res. Bd Can. **32**: 2295-2332.
[9] Galvao, P., Longo, R., Machado Torres, J. P., Malm, O., 2015. Estimating the Potential Production of the Brown Mussel *Perna perna* (Linnaeus, 1758) Reared

in Three Tropical Bays by Different Methods of Condition Indices. Journal of Marine Biology, **2015:** 1-11.

[10] Karayücel, S. and Karayücel, İ., 1999a. Growth and Mortality of Mussels (*Mytilus edulis* L.) Reared in Lantern Nets in Loch Kishorn, Scotland. Tr. J. Vet. Anim. Sci. **23**: 397–402.

[11] Karayücel, S. and Karayücel, İ., 1999b. Growth, Production and Biomass in Raft Cultivated Blue Mussels (*Mytilus edulis* L.) in Two Scottish Sea Lochs. Isr J Aquacult-Bamidgeh **51** (1): 65-73.

[12] Kuwatam, Y. and Nishii, T., 1969. Effects of pH of Culture Water on the Growth of the Japanese Pearl Oyster. Bull. Jap. Soc. Scient. Fish. **35**: 342-350.

[13] Lachowicz, Ł. S., 2005. Population Biology of Mussels (*Aulacomya maoriana, Mytilus galloprovincialis* and *Perna canaliculus*) from Rocky Intertidal Shores in Wellington Harbour, New Zealand. PhD Thesis, Victoria University of Wellington, New Zealand, 262 pp.

[14] Lawrence, D.R. and Scott, G.I., 1982. The Determination and Use of Condition Index of Oysters. Estuaries, **2** (1): 23-27.

[15] Li, Y., Qin, J.G., Li, X., Benkendorff, K., 2009. Monthly Variations of Condition Index, Energy Reserves and Antibacterial Activity in Pacific Oysters, *Crassostrea gigas*, in Stansbury (Southern Australia). Aquaculture, **286**: 64-71.

[16] Loosanoff, V.L. and Tommers, F.D., 1948. Effect of suspended silt and other substances on the rate of feeding of oysters. Science **107**: 69-70.

[17] Lucas, A. and Beninger, P., 1985. The Use of Physiological Condition Indices in Marine Bivalve Aquaculture. Aquaculture, **44**: 187-200.

[18] Mănescu, S., Cucu, M., Diaconescu, L.M., 1978. Chimia sanitară a mediului, Ed. Medicală, Bucureşti.

[19] Mercado-Silva, N., 2005. Condition Index of the Easter Oyster, *Crassostrea virginica* (Gmelin, 1791) in Sapelo Island Georgia – Effects of Site, Position on Bed and Pea Crab Parasitism. Journal of Shellfish Research, **24 (**1): 121-126.

[20] Navarro, J.M. and Thompson R.J., 1996. Physiological Energetics of the Horse Mussel *Modiolus modiolus* in a Cold Ocean Environment. Marine Ecology Progress Series, **138**: 135-148.

[21] Orban, E., Di Lena, G., Nevigato, T., Casini, I., Marzetti, A., Caproni, R., 2002. Seasonal Changes in Meat Content, Condition Index and Chemical

Composition of Mussels (*Mytilus galloprovincialis)* Cultured in Two Different Italian Sites. Food Chemistry, **77**: 57–65.

[22] Schlitzer, R., 2009. Ocean Data View 2009, http://odv.awi.de.

[23] Seed, R., 1976. Ecology of Marine Mussels. In: B. L. Bayne (ed.), Marine Mussels: Their Ecology and Physiology. Cambridge University Press, London, pp. 13-65.

[24] Seed, R. and Suchanek, T.H., 1992. Population and Community Ecology of *Mytilus*. In The Mussel *Mytilus*: Ecology, Physiology, Genetics and Culture (ed. E.M. Gosling), Developments in Aquaculture and Fisheries Science, no. 25. Amsterdam: Elsevier Science Publ., pp. 87-169.

[25] Séguin, A., Caplat, C., Serpentini, A., Lebel, J.M., Menet-Nedelec, F., Costil, K., 2016. Metal Bioaccumulation and Physiological Condition of the Pacific Oyster (*Crassostrea gigas*) Reared in Two Shellfish Basins and a Marina in Normandy (northwest France). Marine Pollution Bulletin, **106** (1-2): 202-214.

[26] Strohmeier, T., Duinker, A., Strand, Ø., and Aure, J. 2008. Temporal and Spatial Variation in Food Availability and Meat Ratio in a Longline Mussel Farm (*Mytilus edulis*). Aquaculture **276**: 83–90.

[27] UNESCO, 1966. Determinations of photosynthetic pigments in seawater, Monographs on Oceanographic Methodology 1, Paris, France, pp: 11-18.

[28] Vasiliu, D., Boicenco, L., Gomoiu, M.T., Lazar, L., Mihailov, M.E., 2012. Temporal variation of surface chlorophyll *a* in the Romanian near-shore waters. Medit. Mar. Sci., **13** (2), 213-226.

[29] Widdows, J., 1985a. Physiological Procedures. The Effects of Stress and Pollution on Marine Animals, edited by B.L. Bayne, D.A. Brown, K. Burns, D.R., Dixon, A. Ivanovici, D.R. Livingstone, D.M. Lowe, M. N. Moore, A.R.D. Stebbing & J. Widdows. New York: Praeger Press, pp. 161-178.

[30] Widdows, J., 1985b. Physiological Responses to Pollution. Marine Pollution Bulletin **16**: 129-134.

[31] Yap, C.K., Ismail, A., Tan, S.G., 2002. Condition Index of Green-lipped Mussel *Perna viridis* (Linnaeus) as a Potential Physiological Indicator of Ecotoxicological Effects of Heavy Metals (Cd and Pb). Malaysian Applied Biology **31**(2): 37-45.