# Variations in energy and lipid content in *Mytilus edulis* from the Gulf of Gdańsk

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*Mytilus edulis*
Lipid content
Energy variations
Gulf of Gdańsk

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**Abstract**

Variations of the energy values and lipid content in the body of *Mytilus edulis* from the Gulf of Gdańsk in relation to age and wet weight of individuals in an annual cycle (February 1983 – January 1984) have been presented. The mean energy value was equivalent to 20.58 $J \cdot mg^{-1}$ dry weight and 23.26 $J \cdot mg^{-1}$ dry weight of organic matter. Mussels reach the highest energy values during a period of reproduction (April – May) and in August. After phytoplankton blooming period in autumn (October – November) individuals exhibit high energy values. The lowest ones were recorded in December. The mean lipid content was equal to 17.3%; the highest one was noted during a period of reproduction (October and November) and the lowest one in September.

## 1. Introduction

*Mytilus edulis* is a species of a wide distribution. It constitutes an essential link in the trophic chain serving as a food constituent of fish species such as cod, fluke, eelpont and plaice (Jarvekyulg, 1979). The mussel shoals act as a biofilter and make up favourable conditions of growth and existence of other organisms (Wenne, Wiktor, 1982).

The biology and ecology of *M. edulis* are relatively well known (Widdows, 1978; Widdows *et al*, 1979; Wenne, Wiktor, 1982; Cuena, Barron, Wołowicz, 1981). There is a number of papers on biochemical composition of mussels (Fraga 1954, 1956, 1958; Giese 1966, 1967, 1969; Dare, Edwards 1975; Gabbot, Bayne 1973a, b; Pieters 1978; Pieters *et al*, 1979). However, the number of works dealing with the energy values and energy processes is limited (Pieters *et al*, 1979; Risgård, Randløv 1981). There was a lack of data concerning the energy values and their changes in *M. edulis* from the Gulf of Gdańsk, so this paper aims at investigating the variations in the energy

values and lipid content in *M. edulis* of the Gulf of Gdańsk. The influence of age of *M. edulis* on the energy value and on lipid content variations has been determined in the paper taking into consideration the fact that for a given species population the energy value alters according to a development stage (age, size), season, sex, and trophic conditions (Prus, 1970). Relations between these values have also been examined. The measurements were carried out in an annual cycle.

## 2. Material and methods

The material to be examined was collected from the Gulf of Gdańsk once a month throughout February 1983 – January 1984, at a depth of 3 – 5 meters, by means of a dredge (a net mesh being 5 × 5 mm). Age was determined on the basis of annual growth. Four age groups (0 – 3) were established as well as the wet and dry body weight determined with an accuracy of 1 mg. The obtained material was dried at temperature of 55 – 60°C to constant weight, followed by combustion in a *KMB 2* type Philipson microbomb calorimeter (Klekowski, Bączkowski, 1973). 4 – 8 separate combustions were performed for each sort of material on the basis of which the average values were calculated. The mean overall energy value, the organic matter energy value, and the percentage of ash obtained from combustion of the material in the microbomb were calculated for 1 mg of dry material from each sample. A gravimetric method was employed to determine the lipid content (Dowgiałło, 1975). The lipids were extracted with a 1:1 chloroform-methanol mixture at a temperature of about 60°C. The filtrate was evaporated in a water bath. Subsequently, the lipids were reextracted from the crude preparation with a chloroform-petroleum ether mixture (1:1) and the filtrate was reevaporated in tared vessels. The lipids were determined gravimetrically.

## 3. Results

A tendency of seasonal changes in the wet weight of the consecutive groups is similar. It goes on increasing in summer and early autumn. The lowest wet weight values were noted from January to March (Fig. 1). The dry weight accounts of $11.1 \pm 5.4\%$ wet weight of a mussel (on average). A relatively high value of the standard deviation is brought about by a significant fraction of the dry weight in November ($22.6\%$) and December ($19.5\%$). The changes in dry weight throughout a year in all the age groups are similar (Fig. 1). A correlation has been revealed between the wet and dry weight in the following age groups: 1 ($R = 0.89$), 2 ($R = 0.82$), 3 ($R = 0.72$).

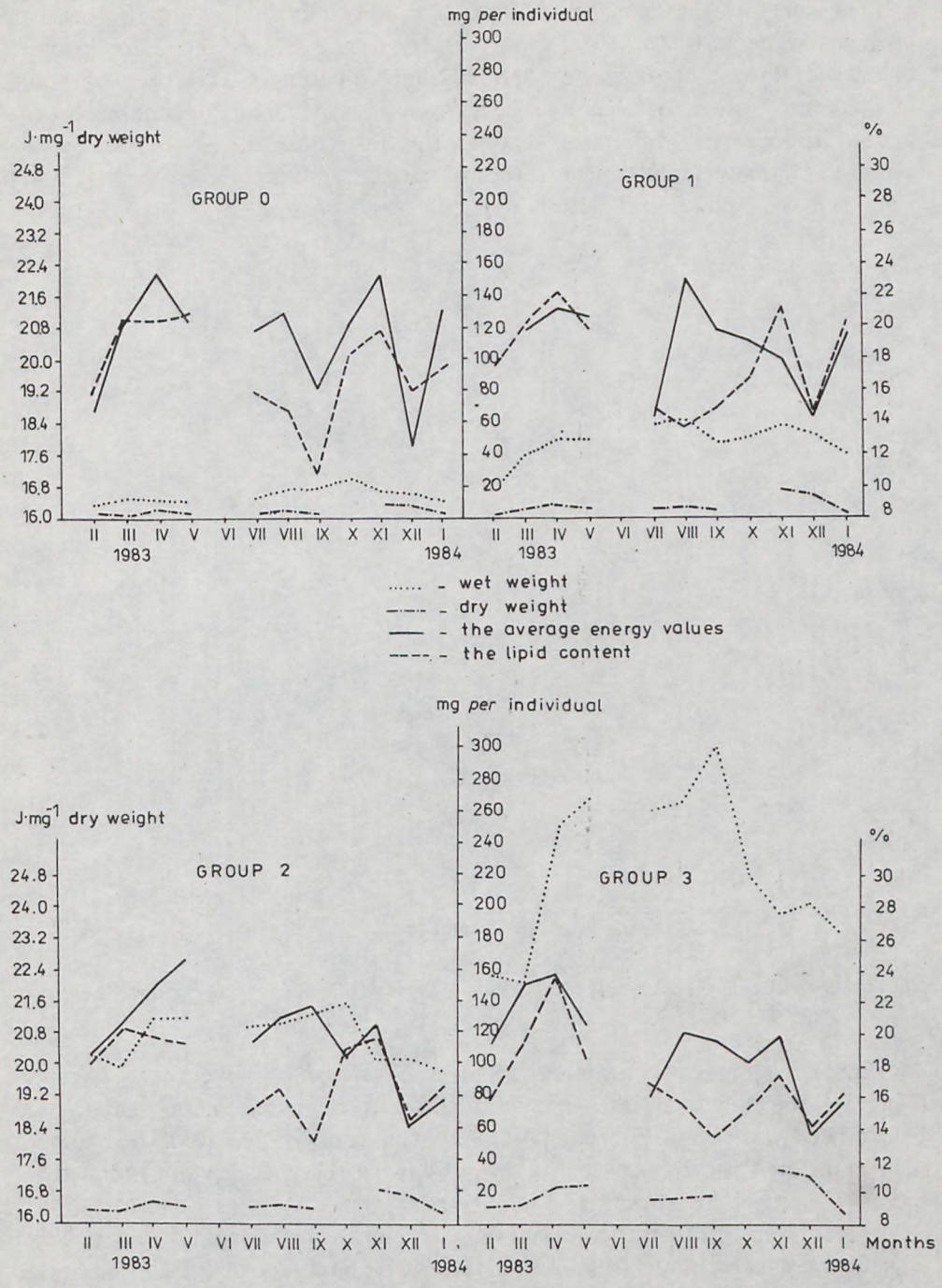


**Fig. 1.** Seasonal changes of the parameters controlled of *Mytilus edulis* in age groups

The energy values for 1 mg of the dry weight calculated on the basis of all measurements were 20.58 $J \cdot mg^{-1}$ of dry weight (total) and 23.26 $J \cdot mg^{-1}$ of dry weight (for organic compounds). Slight differences have been observed in the energy values of 1 mg of the dry weight of *M. edulis* depending on the age of individuals (differences statistically insignificant; Fig. 1) while the essential changes in the energy values of average individuals (as regards body weight) have been found within particular age groups (Fig. 2).

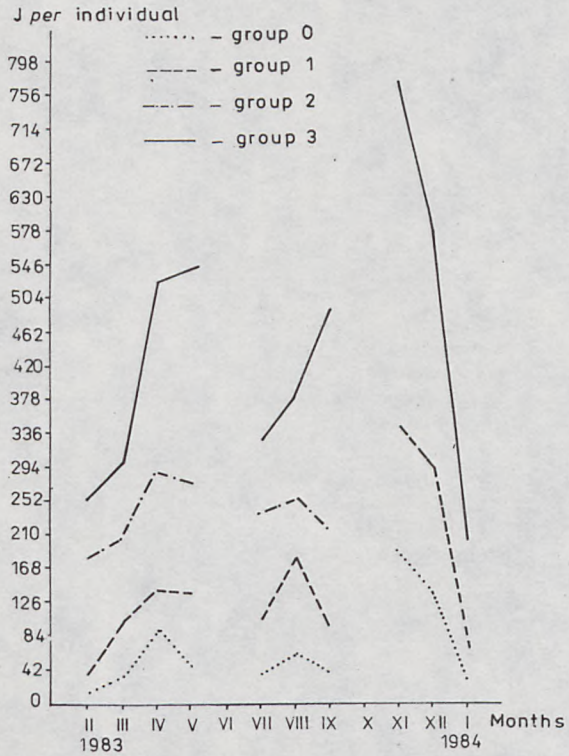


**Fig. 2.** Seasonal changes in energy values for an average individual in age groups

Seasonal changes in the energy values of *M. edulis* have been observed (Fig. 3): the lowest ones were found for the mussels being caught in December, next from February to May the energy increased, reaching a maximum in April. In consecutive months twice the energy values tended to increase, namely in August and November.

The content of mineral compounds in a mussel varied from 4.2 to 16.9%. The average percentage of ash calculated on the basis of all samples was 10.9%. Amount of the mineral residue resulting from a combustion of the material in a microbomb may be burdened with an error owing to scattering of a fraction of the material at the moment of combustion.

The amount of lipids in *M. edulis* was equal to 17.3% of dry weight. It

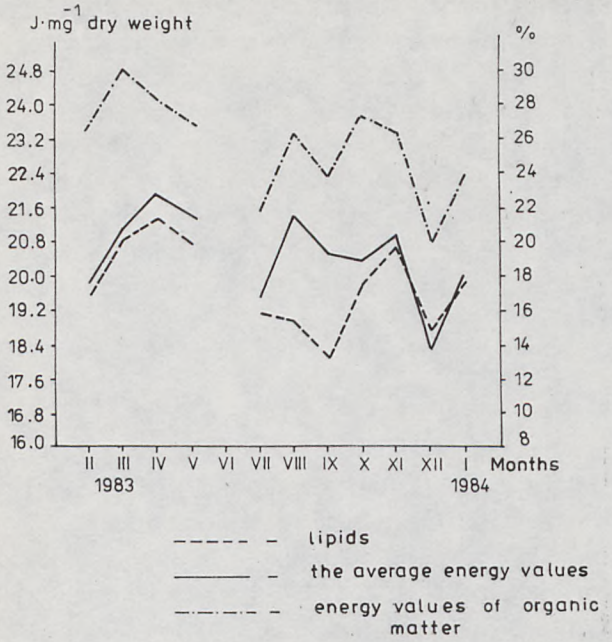


**Fig. 3.** Seasonal changes in the energy values of *Mytilus edulis*

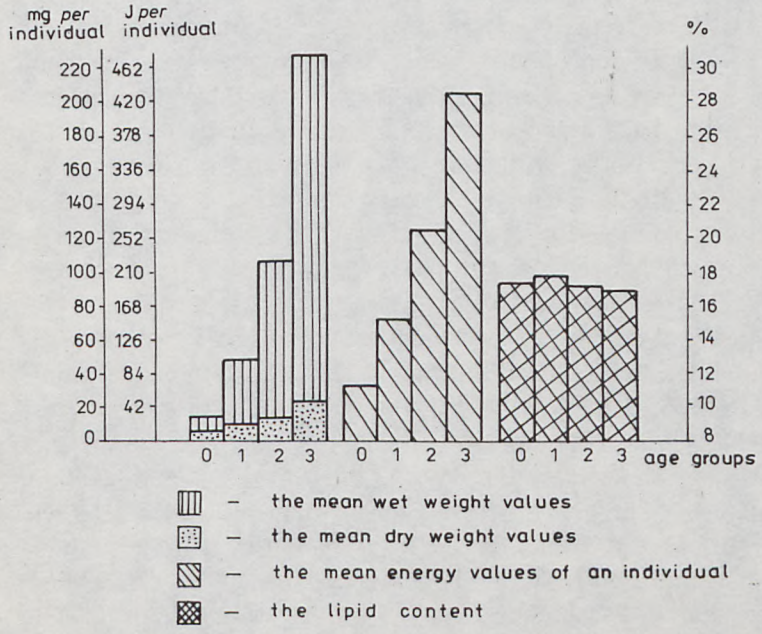


**Fig. 4.** The mean wet and dry weight values, energy values of an average individual and lipid content

was observed that in the material investigated the amount of lipids in particular age groups remained at a similar level (Fig. 4) and was characterized by the same tendency of seasonal changes (Fig. 1). An increase in the lipid content was noted in March and April – propably due to reproduction. In the course of consecutive months the percentage of lipid content decreased and reached a minimum in September (the individuals from group 1 reached a minimum in August). The second increase in the lipid content, lower than the former in spring, was observed in November. A poor correlation between energy values and lipid content was found in groups 0 ($R = 0.64$) and 3 ($R = 0.67$).

## 4. Discussion

The mean energy value of *M. edulis* from the Gulf of Gdańsk is 20.6 $J \cdot mg^{-1}$ of dry weight, whereas the mean overall energy value of *M. edulis* from the northern Baltic for the period August – October is equal 20.8 $J \cdot mg^{-1}$ of dry weight (von Bast, von Oertzen, 1976). The mean energy value for these months for a mussel from the Gulf of Gdańsk equals to 20.9 $J \cdot mg^{-1}$ of dry weight.

Risgård and Randløv (1981) on the basis of mathematical calculations have obtained the energy value of 20.5 $J \cdot mg^{-1}$ of dry weight of *M. edulis*. All these values are similar and serve as an evidence that the range of occurrence of *M. edulis* does not affect its energy values. While observing the seasonal changes, an increase in the energy values was found in spring and autumn probably owing to reproduction and rise in easily accessible food (Widdows *et al*, 1979). It was found that an increase in the energy values and lipid content in the groups 1,2, and 3 of *M. edulis* from the Gulf of Gdańsk is highest throughout a period of reproduction when a gonad is in stage III. An increase in the level of lipids in stage III may result from conversion of stored glycogen into lipid material for maturing eggs (Pieters *et al*, 1979; Zandee *et al*, 1980) whereas a rise in the energy values in August is presumably explained by an increase in the glycogen content, despite the low lipid content. It was found on the basis of biochemical analysis that glycogen is mainly accumulated during a non-reproductive cycle in summer, a gonad in stage 0 (Gabbot, 1976; Pieters, 1978). The same conclusions have been drawn from histochemical investigations of gonad tissues of *Mytilus galloprowincjalis* and *Perna perna* (Gabbot, 1976; Lunetta, 1969). Also Gabbot *et al.* reported that an accumulation of glycogen in *M. edulis* takes place in summer, after reproduction (a gonad in stage 0), chiefly in a mantle and a liver-pancreas gland while a decrease in the glycogen content to a minimum takes place in the course of gametogenesis from March to April. Also Zurrburg *et al.* (1979) report that glycogen is stored mainly after a period of reproduction.

An increase in the energy values in autumn (October, November) is connected with an accumulation of lipids. It is believed that the lipid content above the 5% of dry weight for bivalves indicates that in addition their structural role the lipids constitute an energy reserve (Giese, 1966). The role of lipids as stock compounds may be indicated by starvation experiments (Bayne, 1973; Gabbot, Bayne, 1973).

A positive correlation between glycogen and lipid contents has been found in *Ostrea edulis* and some other bivalve species, which points to a parallel energy accumulation in the form of glycogen and lipids (Walne, 1970). The accumulation cycle of glycogen in *Tellina tennis* and *Macoma balthica* from the coast of Holland is similar to that of *M. edulis*, althought some quantities of energy are stored in the form of lipids in spring and summer (Beukema, de Bruin, 1979).

Seasonal changes in lipid content in dry body weight have various forms for different species.

A cycle of changes with a maximum from March to May and a minimum from June to September has been found for *M. edulis* (Drzycimski, 1961; Lubet, 1959; Zandee *et al.*, 1980). The most pronounced seasonal changes in the lipid content have been found in gonads and a liver-pancreas gland (Takahashi, Mori, 1971; Thompson, 1977; Taylor, Venn, 1979, Zandee *et al.*, 1980).

The lipids in *M. edulis* constitute a small fraction and exhibit a distinct annual cycle exclusively in a mantle (Zurburg *et al.*, 1979). The lipid content reaches its maximum generally in spring in a period of active gametogenesis (Zurgburg *et al.*, 1979) and ranges from 6.85 to 9.82% of dry weight. The percentage of lipids of *M. edulis* was equal to 9% in summer and about 12% in spring shortly before reproduction (Pieters, 1978).

Pieters *et al.*, report (1979) that the lipid content in a mussel ranges from 9% in summer to 13–14% before reproduction in spring.

Literatura data concerning the percentage of lipid content in dry weight are, then, fundamentally compatible. The lipid content in *M. edulis* from Gulf of Gdańsk is distinctly higher than for the individuals of the same species from other regions – the mean is 17,3%. The lipid content of a mussel reported by Drzycimski (1961) for the region of Gdynia is 10.8 – 17.6%. Also in *Macoma balthica* from the Gulf of Gdańsk a high percentage of the lipid content (not reported so far) has been found – 13.24 – 36.48% (Wenne, Styczyńska-Jurewicz, 1985), including *Cardium glaucum* from Gulf of Gdańsk – 15% on average (Wołowicz, Szaniawska, 1985). This implies that the populations of bivalves from the Gulf of Gdańsk are characterized by exceptionally high energy values and lipid content.

Taking into account all the parameters being examined it cannot be equivocally stated which factor determines the energy values. Unquestionably, these are lipids during a period of reproduction. Also, following the phytoplankton bloom, they constitute a storage material whereas – after

gametogenesis – it may be glycogen. Energy values of a given individual are mostly dependent on the body weight, depending to a lesser degree upon energetical values of 1 mg of dry weight although trends in annual changes are similar in all the groups.

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## References

Bast H. D. von, Oertzen J. A. von, 1976, *Zusammenstellung von Energieäquivalenten aquatischer organismen unter besonderer Berücksichtigung der Ostsee*, Meerbiologische Beiträge aus der Sektion Biologie, Universität Rostock, 3; 295–304.

Bayne B., 1973, *Aspects of the metabolism of Mytilus edulis during starvation*, Neth. J. S. Res., 7, 399–410.

Beukema J. J., Bruin de J., 1979, *Calorific value of the soft parts of the tellinid bivalve Macoma balthica (L.) as determined by two methods*, J. Exp. Mar. Biol. Ecol., 37, 19–30.

Cuena Barron L., Wołowicz M., 1981, *A preliminary outline of the Mytilus edulis population from Gdańsk Bay*, Zesz. Nauk. Wydz. Biol. i Nauk w Ziemi Uniw. Gdańskiego, 8.

Dare P. J., Edwards D. B., 1975, *Seasonal changes in flesh weight and biochemical composition of mussels Mytilus edulis L. in the Conway estuary (N Wales)*, J. Exp. Mar. Biol. Ecol., 18, 89.

Dowgiałło A., 1975, *Chemical composition of on animals body and its food.* [In:] *Methods for ecological bioenergetics*, Eds Grodziński W., Klekowski R. Z., Duncan A., IBP Handbook, 24, Blackwell Sci. Publ., Oxford.

Drzycimski I., 1961, *Nutrition chemical composition and possibilities for utilization of the sea mussel, Mytilus edulis L., from the Southern Baltic*, Annales Biol., 18, 209–210.

Fraga F., 1954, *Average seasonal variation of chemical constituents of the mussel (Mytilus edulis)*, Rapp. P.-V. Reum. Cons. Perm. Int. Explor. Mer., 140(3), 35.

Fraga F., 1956, *Variation estacional de la composition quimica del mejillon (Mytilus edulis)*, Inv. Pesq., 4, 109-125.

Fraga F., 1958, *Seasonal variation of the composition of the mussel (Mytilus edulis)*. Part 2. *Carbohydrates*, Inv. Pesq., 11, 33–37.

Gabbott P. A., Bayne B., 1973a, *Biochemical effects of temperature and nutritive stress on Mytilus edulis Linne*, J. Mar. Biol. Assoc. U.K. 53, 2.

Gabbott P. A., Bayne B., 1973b, *Some biochemical changes in Mytilus edulis Linne induced by temperature and nutritive stress*, J. Mar. Biol. Assoc. U.K., 53.

Gabbott P. A., 1976, *Energy metabolism.* [In:] *Marine mussels, their ecology and physiology*, Ed Bayne B., Cambridge Univ. Press, Cambridge, 294–355.

Giese A. C., 1966, *Lipids in the economy of marine invertebrates*, Physiol. Rev., Vol. 46, 244–298.

Giese A. C., 1967, *Some methods for study of the biochemical constitution of marine invertebrates*, Oceanogr. Mar. Biol. Ann. Rev., Vol. 7, 159–186.

Giese A. C., 1969, *A new approach to the biochemical composition of the mollusc body*, Oceanogr. Mar. Biol. Ann. Rev., Vol. 7, 175–229.

Jarvekyulg A., 1979, *Dennaya fauna vastochnoi chasti Baltiiskogo mora. Sostav i ekologiya raspredeleniya*, izd. Balgus, Tallin.

Klekowski R. Z., Bączkowski J., 1973, *A new modification of microbomb calorimeter*, Ekol. Pol., 21(16), 231–238.

Lubet P., 1959, *Recherches sur le cycle sexual et l'emission des gametes chez les mytilides et pectinides (mollusques bivalves)*, Revive Trav. Inst. Pech. Marit., 23, 386–548.

Lunetta I. E., 1969, *Fisiologia de reproducao des mexilhos (Mytilus perna L., Mollusca, Lamellibranchiata*, Bol. Fac. Fil. Cien. Letr. Univ. S. Paulo, 324, Zoologia e Biologia Marinha, 26, 33–111.

Pieters H., 1978, *Seisoensvariaties in kondite en biochemische samenstelling van mosseln (Mytilus edulis L.) afkomstig uit de Waddenzee*, Visserij, Voorlichtingsblad voor de Nederlandse Wisserij, 31(8), 557–566.

Pieters H., Kultymans J. H., Zurburg W., Zandee D. I., 1979, *The influence of seasonal changes on energy metabolism in Mytilus edulis L.* Part 1. *Growth rate and biochemical composition in relation to environmental parametres and spawning.* [In:] *Cyclic Phenomena in Marine Plants and Animals*, Eds Naylor E., Hartnoll R. G., Pergamon Press, Oxford–New York, 285–292.

Pieters H., Kultymans J. H., Zandee D. I., Cadee G. C., 1980, *Tissue composition and reproduction of Mytilus edulis in relation to food availability*, Neth. J. S. Res., 14(3/4), 349–361.

Prus T., 1970, *Calorific value of animals as an element of bioenergetical investigations*, Pol. Arch. Hydrobiol., 17, 183–199.

Risgård A., Randløv B., 1981, *Energy budgets, growth, and filtration rates in Mytilus edulis at different algal concentrations*, Mar. Biol., 61, 227–234.

Schulte E. H., 1975, *Influence of algal concentration and temperature on the filtration rate of Mytilus edulis*, Mar. Biol., 30, 331–341.

Takahashi K., Mori K., 1971, *Seasonal variations in the metabolism of lipids and glycogen in the scallop Patinopecten yessoensis (Jay).* Part 2. *Histochemical studies*, Tohoku J. Agric. Res., 22, 134–145.

Taylor A. C., Venn T. J., 1979, *Seasonal variation in weight and biochemical composition of the tissues of the queen scallop, chlamys epercularis from the Clyde Sea area*, J. Mar. Biol. Assoc. U.K., 59, 605–621.

Thompson R. J., 1977, *Blood chemistry, biochemical composition, and the annual reproductive cycle in the giant scallop Placopecten magellanicus from South-east Newfoundland*, J. Fish. Res. Bd. Can., 34, 2104–2116.

Walne P. R., 1970, *The seasonal variation of meat and glycogen content of seven populations of oyster Ostrea edulis L. and a review of the literature*, Fishery Invest., 2, 26(3), 35.

Wenne R., Styczyńska-Jurewicz E., 1985, *Microgeographic differentiation in the condition and biochemical composition of Macoma balthica (L.) from the Gdańsk Bay (South Baltic)*, Pol. Arch. Hydrobiol., 32, 175–194.

Wenne R., Wiktor K., 1982, *Fauna denna przybrzeżnych wód Zatoki Gdańskiej*, Stud. Mater. Oceanolog. KBM PAN, 39, 138–171.

Widdows J., 1978, *Combined effects of body size, food concentration and season on the physiology of Mytilus edulis*, J. Mar. Biol. Assoc. U.K., 58(1), 109–124.

Widdows J., Fieth P., Worral C. M., 1979, *Relationships between seston available food and feeding activity in the common mussel Mytilus edulis*, Mar. Biol., Vol. 50, 195–207.

Wołowicz M., Szaniawska A., 1985, *Changes in calorific value and lipid contents of Cardium glaucum from Gdańsk Bay*, 20 European Meeting of Marine Biologists Symposium.

Zandee D. I., Kultymans J. H., Zurburg W., Pieters H., 1980, *Seasonal variations in biochemical composition of Mytilus edulis with reference to energy metabolism and gametogenesis*, Neth. J. S. Res., 14(1), 1–29.

Zurburg W., Kultymans J. H., Pieters H., Zandee D. I., 1979, *The influence of seasonal changes on energy metabolism in Mytilus edulis (L.).* Part 2. *Organ Specificity.* [In:] *Cyclic Phenomena in Marine Plants and Animals*, Ed Naylor E., Hartnoll R. G., Pergamon Press, Oxford–New York, 293–297.