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Energy content in relation to the population dynamics of *Mysis mixta* (Lilljeborg) from the Southern Baltic

K. Wiktor and A. Szaniawska
Institute of Oceanography, Gdańsk University,
Gdynia, Poland

Abstract

The energy content of *Mysis mixta* from the Southern Baltic in relation to its body weight was studied in June, August and October 1986, and April and May 1987. In June, immature animals (4–13 mm) and adult females (18–25 mm) dominated. The same composition was found in August, although the size had changed: the immature animals ranged from 10 to 21 mm and adult females from 21 to 30 mm. A more homogeneous population ranging from 12 to 22 mm was found in October. Males occurred in large numbers only in autumn. The dry weight was 15.04 % of the wet weight, and included 8.18 % ash. The relationship between dry weight and body length fitted the power function $W = 0.714\ L^{2.835}$. The average energy content of *M. mixta* was high: 24.748 Jmg^{-1} DW and 27.055 Jmg^{-1} AFDW. There was no significant difference in energy content between adult females and males in October, when both sexes were present. Energy content per dry weight increased with the size of the animals. *M. mixta* obtained in the study area showed similar energy content to each other.

Introduction

In the Baltic sea, *Mysis mixta* (Lilljeborg) is a common species occurring in very large numbers. It plays an important role in the flow of energy through the ecosystem by consuming phyto- and zooplankton, and detritus. It is itself eaten by a number of fish species, including cod and herring, the chief objects of commercial fisheries. *Mysis mixta* has been studied mainly in order to discover the distribution of individual animals (DEMEL and MULICKI 1959, SIUDZINSKI 1973, BOYSEN 1975, KOTTA 1980, SHESTOVA 1982) to assess their numbers and to describe its life cycle (GRABE and HATCH 1982, SALEMAA et al. 1986).

Though of a preliminary nature, the present paper aims to combine an assessment of the population dynamics of *Mysis mixta* with an estimate of the energy content of populations of this species. At the same time, an attempt is made to ascertain whether there are any differences in the energy content of *Mysis mixta* populations living in different areas of the southern Baltic.

Material and Methods

Tests were carried out in June, August and October 1986, and in April and May 1987, on samples collected at several localities in the southern Baltic (Fig. 1). Samples were taken from a depth of 60–70 m with a 5 x 5 mm mesh drag net 63 x 33 cm in size. The net was hauled for 20 minutes at a trawling speed of 2 knots. The collected material was divided into two parts. One part, selected at random and then preserved in 4 % formalin, was used to determine the composition of the population with respect to sex and size. The length of

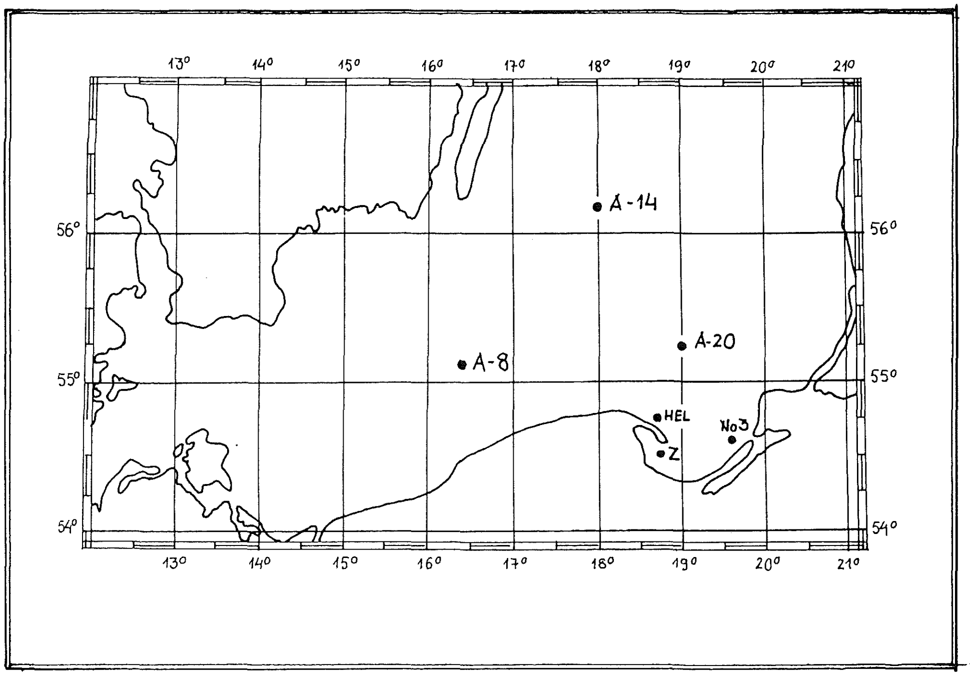

Figure 1
Location of sampling stations

individual animals was measured from the rostrum to the end of the telson, and their wet and dry weights were determined, 2358 specimens being analysed in this way. The other part was not preserved, but divided (as far as possible) into size classes at 0.5 cm intervals. The animals were sexed, then dried at 55–60°C to constant weight, and finally incinerated in a Phillipson KMB-2 calorimetric microbomb. The overall energy content (Jmg^{-1} DW) and the energy content of the organic matter (Jmg^{-1} AFDW) were determined, with the mineral content of *Mysis mixta* evaluated as the combustion residue in the microbomb.

Results

Life cycle

Towards the end of April and in May, the *Mysis mixta* population consists mostly of large females whose breeding chambers are filled with ripe embryos (0.25–0.30 mm in size) (Table 1). During this time, the young animals are released into the water. In June, small immature individuals 6–13 mm long with only partially developed secondary sexual characteristics are prevalent, making up 68.2 % (even up to 90 %) of the total population (Fig. 2). At this time, males constitute only 0.9 % of the total population. The remaining animals are females (30.9 % at Hel Station). In August, immature individuals are still dominant up to 90.6 % of population), although by then most of them have attaind a length of 15–18 mm. There are relatively fewer fully-developed females (8.3 % of the population) which probably die after reproducing. In autumn (October) the proportion of males increases to 27.5 %, but most are not yet wholly mature. There are considerable numbers of immature animals with large body size. The larger females are presumably fertilised in the autumn-winter period, and overwinter in order to be able to reproduce in the following

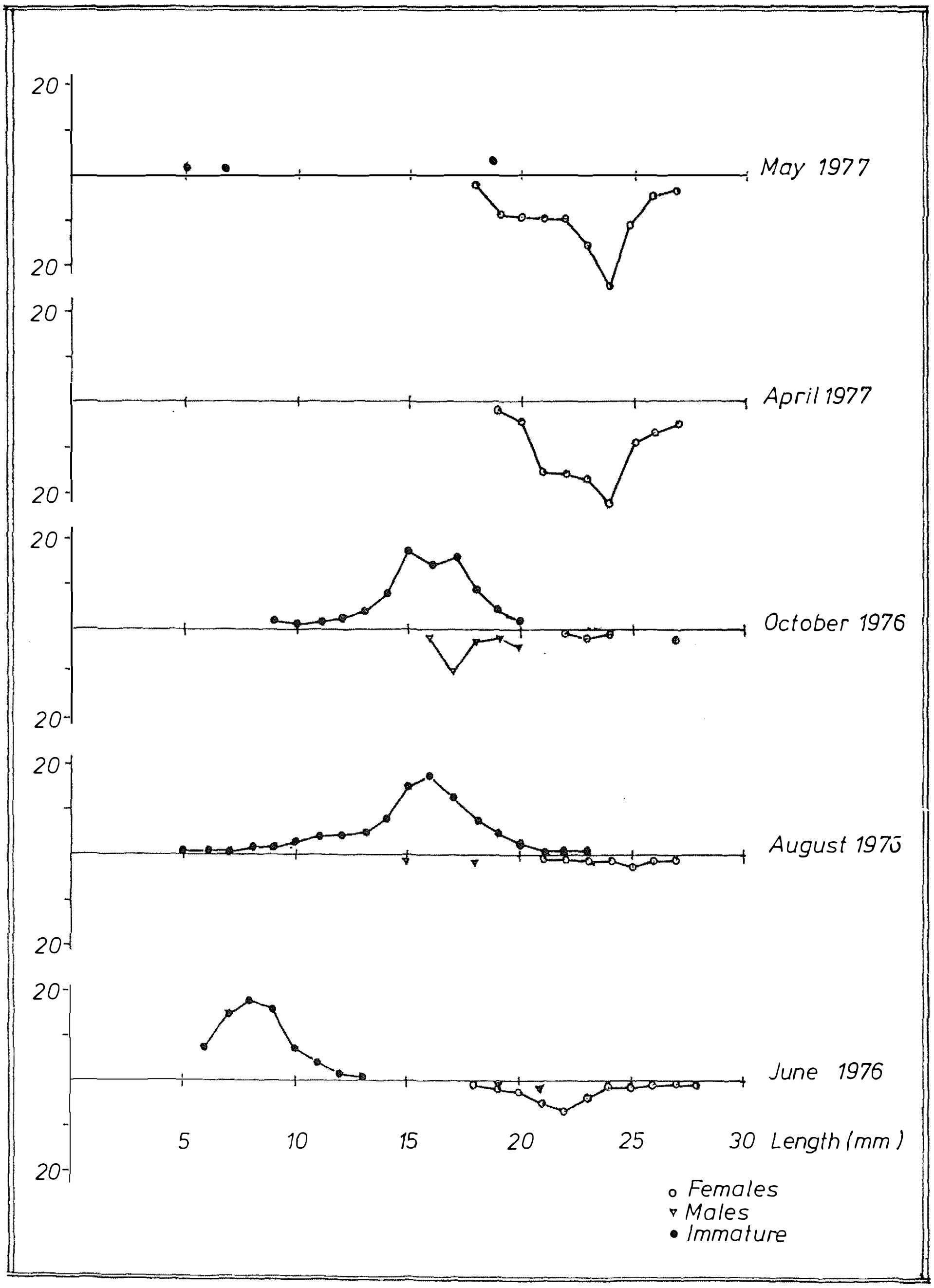

Figure 2
Life history of *Mysis mixta* from June 1986 to May 1987 (based on selected stations)

Table 1

Percentage of immature females and males of *M. mixta* at all stations

Date	No. of station	PERCENT			
		Immature	Females	Males	No. of animals
11.06	A-14	–	98.6	1.4	73
11.06	A-20	90.0	10.0	–	360
12.06	Hel	68.2	30.9	0.9	343
14.08	Hel	64.2	33.7	2.1	237
14.08	Hel	–	100.0	–	148
14.08	Hel	–	92.8	7.2	97
14.08	Hel	90.6	8.3	1.1	182
16.09	Hel	93.6	0.9	5.5	109
07.10	A-08	63.5	2.9	33.9	118
09.10	A-14	48.4	24.1	27.5	265
10.10	A-20	77.0	5.9	17.1	135
28.04	Z	–	100.0	–	41
04.05	Z	5.8	94.2	–	68
05.05	Z	6.8	93.2	–	88
06.05	3	6.4	93.6	–	94
				Total	2358

spring. The smallest ripe females were 17 mm long. They probably belong to a single generation. In individual samples, there are small deviations from the above scheme.

Wet and dry weight

A relationship exists between length and wet weight ($W = 5.0352\ L^{2.9152}$), as well as dry weight ($W = 0.7149\ L^{2.8359}$) of the individuals (Fig. 3). The average wet formalin weight of *M. mixta* is 40.4 ± 25.1 mg, whereas the dry weight is on average 15.0 ± 2.4 % of the wet weight. A very high correlation between wet and dry weight was found ($r = 0.99$). In spring, the average wet weight of an individual is low (37.0 ± 32.1 mg), because there are large numbers of *M. mixta* with small body sizes in the population. During the same period, however, large females (26–30 mm long) with full breeding chambers were found, whose wet weight was as high as 96 mg. This was the highest wet weight obtained throughout the study. In August, the average wet weight of the animals was higher (45.6 ± 24.9 mg), due to the presence in the population of a greater number of individuals longer than 10 mm. In October the wet weight of individuals was 40.0 ± 24.9 mg. In the same period, females exactly the same length as males have a slightly greater wet weight. In October, for instance, the wet weight of 20–24 mm long females was 61.9 mg, but of males the same length it was 43.7 mg.

The energy content

M. mixta is characterized by a very high energy content. The average overall energy content of the animals is 24.77 ± 2.33 Jmg^{-1} DW, and of the organic matter it is 27.11 ± 2.33 Jmg^{-1} AFDW. Mature females and males have very similar energy contents (24.07

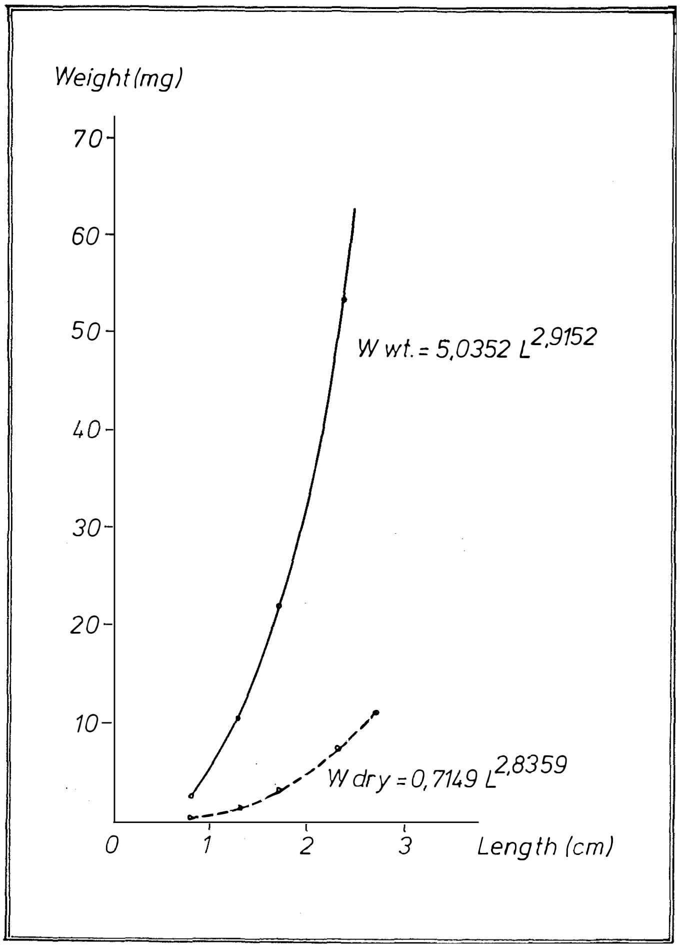

Figure 3

Relation between weight (W) and length (L) of *Mysis mixta* (all data)

Jmg^{-1} DW and 24.23 Jmg^{-1} DW, respectively, differences statistically insignificant), but the organic matter energy content differs somewhat (26.59 Jmg^{-1} AFDW and 25.89 Jmg^{-1} AFDW, respectively).

Individual size is related to energy content (Jmg^{-1}) in *M. mixta:* animals with larger body sizes have a higher energy content (Fig. 4). Immature individuals have the lowest energy content. In June, at station A 4, the energy content of individuals 6–13 mm long was 20.60 Jmg^{-1} DW, whereas in the same period that of large females over 20 mm long was 27.26 Jmg^{-1}. This situation was repeated in October, when the energy content of large females was 27.33 Jmg^{-1} DW, whereas that of immature animals 15–20 mm long was 24.07 Jmg^{-1} DW.

Very probably, the energy content varies according to the season (Fig. 4). Females caught in August (26.55 Jmg^{-1} DW) and in October (27.33 Jmg^{-1} DW) had similarly high energy

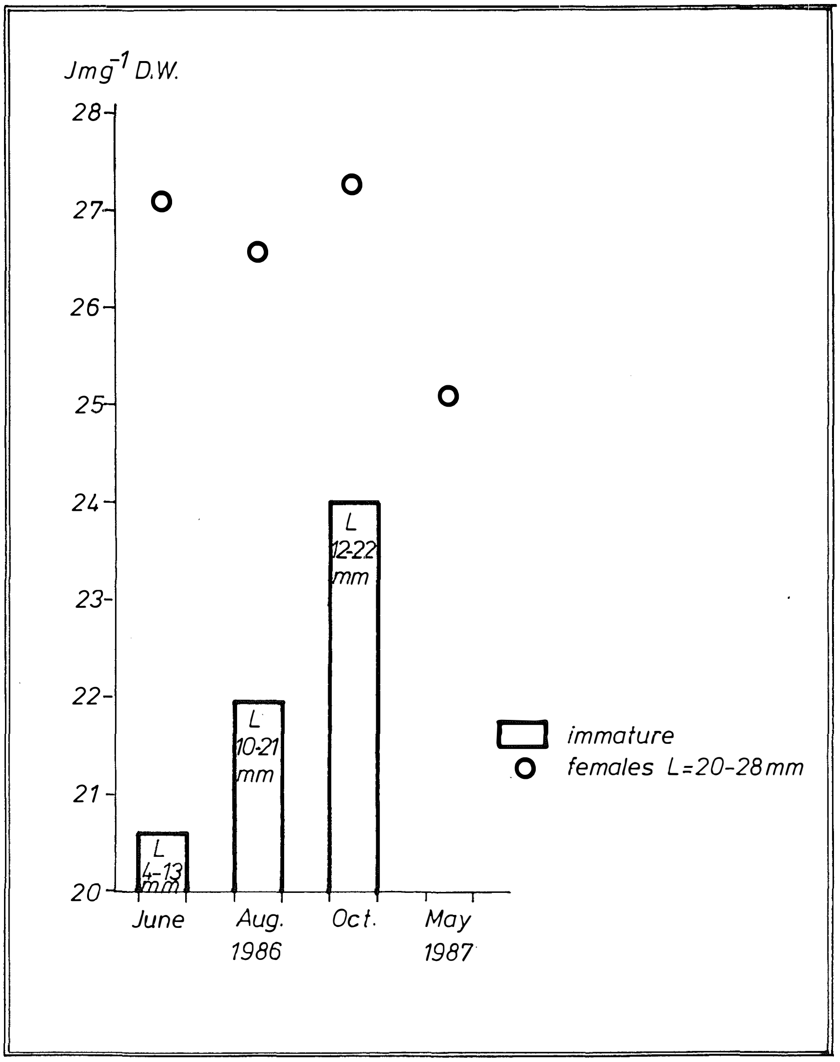

Figure 4
Changes in energy value of immature and females of *Mysis mixta*

contents, whereas females of the same size caught in the first days of May had a lower energy content (25.13 Jmg^{-1} DW).

No geographic differences in the energy content of *M. mixta* were detected.

M. mixta contains small amounts of mineral compounds (8.18 ± (SD) 1.16 %). This figure is only slightly higher (9.69 %) in young animals.

Discussion

Even though we have no material from the November – April period, our analysis of the seasonal changes in the composition of the population indicates that in the southern

Baltic *M. mixta* has one period of intense reproductive activity, which occurs in late April and May, somewhat later than off the Swedish coast (RUDSTAM et al. 1986). Nevertheless, individual females may well reproduce in the summer, as well. The absence of animals of very small size from summer (August) and autumn (October) samples could be due either to a low number of reproducing females, or to the fact that the youngest animals subsist in another, higher, layer of water. Males do not live as long as females, occurring only sporadically in the summer. They only become more numerous in the autumn. This fact also lends support to the hypothesis that reproductive activity is intense only at one time in the year. It is difficult to assess the growth rate of *M. mixta* in the study area, because of the gaps in material collection. During the first 2 months of their lives, the animals probably grow at a very rapid rate of up to 4 mm per month, which later slows considerably (Fig. 2). A similar phenomenon has been observed in *M. mixta* from the Swedish coast (RUDSTAM et al. 1986).

The dry weight found for *M. mixta* (15.04 $\pm$ 2.42 %) is very close to the figure given by RUMOHR et al. (1987) for the same species (13.3 % w.w.). These values are slightly higher than in *N. integer,* whose dry weight is only 12.8 % w.w. (RUMOHR et al. 1987).

Little data on the energy content of *M. mixta* is available. RUMOHR et al. (1987) state that individuals of this species caught in October had an energy content of 15.12 Jmg^{-1} DW; but this was measured only once, and on a small sample of animals. The energy content which we obtained for *M. mixta* was much higher (24.77 Jmg^{-1} DW): that of egg-carrying females of *M. mixta* was high as 26.59 Jmg^{-1} AFDW. *M. relicta* demonstrates similarly high values, the energy content of egg-carrying females of this species being 23.50 Jmg^{-1} AFDW (HAKALA 1979). As in *M. mixta,* the young of related species are also characterized by energy contents lower than those of the adults (HAKALA 1979). The energy content of *N. integer* is much lower: in individuals of this species caught off Sweden, it ranged from 14.97 to 13.54 Jmg^{-1} DW (RUMOHR et al. 1987). The average energy content of *N. integer* populations in the Gulf of Gdańsk is higher, 18.81 Jmg^{-1} DW (SZANIAWSKA et al. 1986), and is close to the figure given for this species (18.86 Jmg^{-1} DW) by HEALEY (1972). *N. integer* from GDR coastal waters has a slightly higher energy content: 20.77 Jmg^{-1} DW and 23.26 Jmg^{-1} AFDW (von BAST and von OERTZEN 1976). It is difficult to determine a reason for the high energy values of *M. mixta.* In the samples used to prepare this paper, there were very high contents of lipids (20.66 % d.w.) and proteins (35.12 % d.w.) in females, and 26.57 % d.w. of lipids and 27.18 % d.w. of proteins for the immature (June 1986 – unpublished data). It seems that many open water zooplankton species have high energy values, like *Calanus finmarchicus* – 7.4 cal mg^{-1} D.W. (30.98 Jmg^{-1} D.W.) (Comita and Schindler 1963). Other copepods (*Temora longicornis, Acartia longiremis, Pseudocalanus minutus elongatus*) have from 24.8 to 30.6 Jmg^{-1} D.W. (Renk 1983).

In *M. mixta,* the changes in energy content are determined not so much by the area of the southern Baltic in which the animals occur, than by the composition of their population, principally with respect to the size of the individuals and their physiological conditions. The seasonal changes in the energy content are presumably brought about by the same factors. This is understandable, seeing that the thermal conditions, which to a large extent determine seasonality in our climatic zone, remain practically unchanged during the year at the depths where *M. mixta* occurs. Nonetheless, the better trophic conditions in summer and early autumn favour the consumption of larger quantities of high-calory food, which is then used by the animals during the subsequent winter.

The mineral content of *M. mixta* (8.18 %) is low, roughly the same as that of *M. relicta* (7.5 to 10.1 %) (HAKALA 1979). *N. integer* contains rather more mineral compounds – these constitute 11.8 % of the body mass (SZANIAWSKA et al. 1986).

Because of its occurrence in large numbers in the southern Baltic, and its high energy and low mineral content, *M. mixta* appears to be a readily avalable and nutritious food for fish.

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