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Research Article

BIOLOGICAL CHARACTERIZATION OF *NEOMYSIS INTEGER* (LEACH, 1815) FROM THE POMERANIAN BAY IN 2006–2007

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ABSTRACT
The aim of the study was to determine the biological characters typical of *Neomysis integer*, to investigate and update issues of its biology, ecology, and distribution in the southwestern Baltic Sea, and to compare biological properties of *N. integer* collected during eight study seasons in 2006–2007 in the region from Świnoujście to Darłowo. No link was established between *N. integer* size and sample collection site. The population attained sizes within the range of 2.64 to 18.84 mm. The size at which females achieved sexual maturity varied seasonally. A mean of 34 eggs was noted in the marsupium. The mean wet weight of *N. integer* was 0.011 g. Three generations were confirmed at most of the study sites.

Key words: Mysidacea, *Neomysis integer*, Pomeranian Bay, Baltic Sea.

INTRODUCTION

The genus Neomysis (Czerniawski) occurs in waters adjacent to all of the continents [Mees et al. 1994]. One of the most commonly occurring representatives of Mysidacea of the genus Neomysis in European coastal waters is *Neomysis integer* (Leach, 1815). Many aspects of this species have been investigated by Chojnacki [1991], Jensen et al. [1985], Rudstam et al. [1986], and Wiktor [1961]. Möbius was the first to observe and describe this species in the Pomerania Bay in 1873 [Jażdżewski et al. 2005]. *N. integer* is a crustacean species with an elongated, almost transparent body. Its head and most of its thorax segments are covered by a chitinized carapace, fused to the head and the proximal thorax segments. The eyes of these mysids are on stalks. The first pair of antennae is divided into two, and on the second pair there is characteristic sharp antennal scale, which is very important for the identification of this species. The abdomen comprises eight segments with biramous appendages, the first set of which function as maxillipeds. The abdomen is highly developed and ends with a narrowing, wedged tail plate with the telson and biramous appendages forming the tail fan. Statocysts, which are the primary balance organs, are located on the inner sides of the tail appendages [Żmudziński 1990]. The mean length of this species in the Pomeranian Bay is 12.5 mm [Chojnacki 1991].

N. integer is a typical euryhaline and eurythermal species [Mees et al. 1994]. It occurs at high abundance in estuarine water zones [Tattersall and Tattersall 1951, Mees et al. 1994]. It undertakes daily feeding migrations: detritus dominates its stomach contents at night indicating it feeds at the bottom, while in the daytime the dominant component is phytoplankton, which indicates this species feeds in the water column [Węsławski 1981]. *N. integer* is an omnivorous crustacean that consumes phytoplankton, zooplankton, and dead organic material [Fockedey and Mees 1999, Jerling and Wooldridge 1995, Mauchline1980, Tattersall and Tattersall 1951].

This mysid filters particles of potential food as it swims, but it can also hunt actively. It is an important link in the food chain as a consumer of secondary production, but it is also a component of food base of benthic and pelagic fish, as well as of epibenthic crustaceans [Mauchline 1980]. In the coastal waters of the Baltic sea, this species is a food component of juvenile Platichthyidae, Gobiidae, and sea trout, herring, sprats, perch, and pikeperch [Lindén et al. 2003, Mauchline 1971, Rudstam and Hannson 1990, Shvetsova et al. 1992, Szypuła et al. 1997, Węsławski 1981, Wiktor 1961].

As other mysid species do, *N. integer* females deposit eggs into the marsupium, which is formed by oostegites located on the thoracic legs on sections 2–8 of the trunk [Mauchline 1980, Mees et al. 1994]. When the young exit the marsupium they are fully formed but immature [Wittmann, 1984]. This provides them with a measure of protection from predators during development. The optimal conditions for larval development are a temperature of 15°C and a salinity range of 14–17 PSU [Fockedey et al. 2006]. The number of eggs in the marsupium and their size depends largely on the size of a female, which changes seasonally [Kinne 1955, Mees et al. 1994, Parker and West 1979].

Available literature indicates that Mysidacea are more susceptible to toxic substances than are many other studied species [Hunt et al. 2002, Morton et al. 1997, Roast et al. 1998, Verslycke et al. 2003], and as such they have been used for more than twenty years as bioindicators of environmental toxicity [Brandt et al. 1993, Emson and Crane 1994, Gaudy et al. 1991, Hunt et al. 1997, Jacobs and Grant 1974, Khan et al. 1992, Langdon et al. 1996, Lussier et al. 1985; 1999, Martin et al. 1989, McKenney 1998, Roast et al. 1999; 2001, Wildgust and Jones 1998].

The aim of the current study was to determine the biological characters typical of *Neomysis integer,* to investigate and update issues of its biology, ecology, and distribution in the southwestern Baltic Sea, and to compare the biological properties (weight, length, sex ratio, number of eggs, etc.) of *N. integer* collected during eight study seasons in 2006–2007 in the region from Świnoujście to Darłowo.

This paper includes the results of investigations of *N. integer* length and weight, the number of generations occurring annually, sex ratio, fecundity, and proximal body composition.

MATERIALS AND METHODS

Twelve sampling stations distributed along the coastal zone of the Pomeranian Bay in the southern Baltic Sea were designated for qualitative studies of *N. integer* populations. These sites were located near the mouths of the more important rivers of West Pomerania, or, in the case of the locality of Międzyzdroje, in the vicinity of marine constructions. The geographic coordinates of the locations of the sampling sites are presented in the table below (Table 1) and in Figure 1. Depending on whether or not the Lake Liwia Łuża Canal was linked with the sea, there was either just one sampling site at Niechorze or two (western and eastern).

Table 1. Geographic coordinates of the 12 sampling stations as determined with a GPS device by Garmin

Station	Geographic coordinates	
	N	E
Świnoujście west. (Ś.z.)	53°55,246’	14°16,593’
Świnoujście east. (Ś.w.)	53°55,126’	14°17,906’
Międzyzdroje (M.)	53°55,912’	14°26,662’
Dziwnów east. (D.w.)	54°01,416’	14°43,828’
Niechorze (N.)	54°06,089	15°05,973’
Mrzeżyno west. (M.z.)	54°08,792’	15°17,043’
Mrzeżyno east. (M.w.)	54°08,834’	15°17,164’
Dźwirzyno west. (Dź.z.)	54°09,546’	15°23,269’
Dźwirzyno east. (Dź.w.)	54°09,550’	15°23,291’
Kołobrzeg east. (K.w.)	54°11,238’	15°33,209’
Darłowo west. (Da.z.)	54°26,308’	15°33,213’
Darłowo east. (Da.w.)	54°26,488’	16°22,972’

The study material was collected at a depth range of 0.5 to 1 m with a drag that was constructed for this purpose (Photograph 1). The mesh bar length in the netting was 1 mm. The material collected was rinsed on a 0.5 mm mesh sieve and then preserved in 30% ethanol denatured with pyridine.

The material collected was sorted, classified into different systematic groups, and then identified to the genus, and, when possible, to the species. These tasks were performed with a Nikon C-DSS230 stereo microscope. The next stage of the study was performed on organisms from the group Mysidacea. Depending on density, the Mysidacea samples were reduced two- to fourfold using a Folsom plankton splitter [McEvan et al. 1954] to obtain a representative sub-sample of at

Figure 1. Sampling sites in the Pomeranian Bay

Photo 1. Sample collecting drag – constructed by the staff of the Department of Marine Ecology and Environmental Protection of the West Pomeranian University of Technology Szczecin

least 100 individuals. All of the caught *N. integer* specimens were identified using keys by Köhn et al. [1992] and Mańkowski [1955], in both of which the principle criterion for qualification to a particular species is the structure of the telson and scales.

The total number of *N. integer* individuals used for further study and analysis was 2894. As stated previously, the study material came from 13 sites which was collected in eight seasons in the 2006–2007 period. The precise collection dates of the samples is presented in Table 2.

The subsequent stage of the laboratory study was to take linear measurements of each specimen and to determine weight and sex. The description of the biological character of the *N. integer* specimens in the current work was done based on the following formula that was used to calculate the total length-weight dependency:

$$W = a \cdot L^b$$

where: W – weight
L – total length
a and b – coefficients characteristic of given populations presented graphically.

The measurement methodology used in the current study was that proposed by Mauchline [1971] with which *N. integer* total length is determined as the distance between the eye stalk and the posterior end of the uropods.

Individual weight (wet weight) was measured for each *N. integer* specimen in the sample to the nearest 0.00001 g on an electronic Radwag XA 110 jewelery scale after the specimens had been blotted on filter paper until all traces of wetness had been removed. Weights were measured in a closed laboratory without drafts and at a constant temperature.

In each of the samples, the eggs or embryos in the female marsupium were counted after weighing.

In order to obtain more complete information regarding the biology and properties of *N. integer* from the coastal zone of the southern Baltic Sea, the proximate composition of a pilot sample (100 grams of *N. integer* – about 10000 individuals) of the studied specimens was analyzed. This mate-

Table 2. Precise details of sampling events (for legend key see Table 1)

Station	Sampling dates in different study seasons.							
	Spring 2006 (W2006)	Summer 2006 (L2006)	Autumn 2006 (J2006)	Late autumn 2006 (PJ2006)	Winter – spring 2007 (ZW2007)	Spring 2007 (W2007)	Summer 2007 (L2007)	Autumn 2007 (J2007)
Ś.z.	12.05.	29.06.	17.09.	20.10.	07.03.	25.04.	21.06.	15.09.
Ś.w.	12.05.	29.06.	17.09.	20.10.	07.03.	25.04.	21.06.	15.09.r
M.	12.05.	29.06.	17.09.	20.10.	07.03.	25.04.	21.06.	15.09.
D.w.	12.05.	29.06.	17.09.r	20.10.	07.03.	25.04.	21.06.	15.09.
N.w.	12.05.	29.06.	17.09.	20.10.	07.03.	25.04.	21.06.	15.09.r
N.	12.05.	29.06.	17.09.	20.10.	07.03.	25.04.	21.06.	15.09.
M.z.	13.05.	28.06.	16.09.	19.10.	06.03.	24.04	20.06.	14.09.
M.w.	13.05.	28.06.	16.09.	19.10.	06.03.	24.04.	20.06.	14.09.
Dź.z.	13.05.	28.06.	16.09.	19.10.	06.03.	24.04.	20.06.	14.09.
Dź.w.	13.05.	28.06.	16.09.	19.10.	06.03.	24.04.	20.06.	14.09.
K.w.	13.05.	28.06.	16.09.	19.10.	06.03.	24.04.	20.06.	14.09.
Da.z.	13.05.	28.06.	16.09.	19.10.	06.03.	24.04.	20.06.	14.09.
Da.w.	13.05.	28.06.	16.09.	19.10.	06.03.	24.04.	20.06.	14.09.

rial was from the eastern Dźwirzyno site that was caught in the fall season of 2007. The proximate composition of *N. integer* was analyzed according to AOAC 1990 (Official Methods of Analysis, 15th Ed. Association of Official Analytical Chemists, Washington DC): water content was determined with the desiccation method; nitrogen content was determined with the Kjeldahl method; total fat content was determined with the ether extraction method. The fatty acid methyl esters were separated with gas chromatography. The percentage share of fatty acids in the tissues was determined according to AOAC 991.39 (Fatty Acids in Encapsulated Fish Oils and Fish Oil Methyl and Ethyl Esters).

RESULTS AND DISCUSSION

Origin and quantity of material

The study material was collected from areas that are typical habitats of *N. integer*: near hard substrates, such as marine constructions, boulders and smaller rocks, and sheltered areas near river mouths [Mauchline 1971, Żmudziński 1974]. The study sites were at least a few kilometers apart; however, within the areas of most sites a secondary division was made because of water flow into the sea (to the west or east, or to the left or right banks of the rivers). This choice of study sites stemmed from the desire to verify whether or not this species, which is known to be very widely distributed [Kinne 1955, Mees et al. 1994, Wiktor 1961], forms a morphological population with, for example, a distinct body build within a relatively small region (157 km of Baltic coastline). Unfortunately, the origin of the material collected on the day of catch was unknown, since the life cycle of this species is known to encompass varied migrations, including those of significant distance. It is known that environmental factors have a substantial impact on individual characters [Bremer and Vijverber 1982, Toda et al. 1984, Wiktor 1961]. It is plausible that the specimens of *N. integer* caught could have been transported by the rivers or they could have originated from the open sea, just as they could also have originated from a population that had inhabited the catch site for many generations. Indirect confirmation of this fact was the abundance of the *N. integer* specimens caught at the different sites in each of the seasons. It was easy to differentiate different stations since this species occurred only periodically, for example at Świnoujście and Dźwirzyno (Table 3). It was also significant that the highest densities of this species were observed in late fall and in early spring. In a certain sense, Mauchline [1971] confirmed these results since he observed three annual generations of *N. integer* (spring, summer, fall). He also emphasized that the continuity of one generation depends on the presence of all the generations. Consequently, in the current study, if at a given site no *N. integer* was noted in spring, or even worse, in summer, then the appearance of this species in fall was attributed exclusively to migration or inflow. In their studies of the southern Baltic Sea, Chojnacki [1991] and Pawlicka [1978] observed the occurrence of just two generations, but the general principle was the same: the spring generation should provide the individuals at a given site in the summer. Additionally, Wiktor [1961] noted that at low water temperatures, such as in late fall, these crustaceans migrate out to sea to depths of about 20 m, and then in the spring, when the water temperature increases, they return to the coastal zone. In late fall, when high densities of this species were noted, the mean water temperature was 12°C. Thus, it can be assumed that the specimens occurring in the littoral zone in early spring originate from the population occurring at a given site in late fall. Additionally, it can also be assumed that the *N. integer* specimens that were obtained for the study originate from the population of shallow waters in the littoral zone of the sea [Mauchline 1971, Węsławski 1981].

Obviously, the impact of many other factors, such as environmental conditions, feeding, lethal factors, that can affect the frequency of occurrence of *N. integer* at the study sites cannot be excluded [Chojnacki 1991, Fockedey et al. 2006, Roast et al. 1998, Roast et al. 1999, Roast et al. 2000, Roast et al. 2001a, Roast et al. 2001b, Verslycke and Jansen 2002, Verslycke et al. 2003, Verslycke et al. 2004, Wildgust and Jones 1998]. In laboratory studies, Winkler and Greve [2002] confirmed that juvenile *N. integer* specimens grow about threefold faster at temperatures of 15°C than they do at 10°C. This suggests that the nektobenthic *N. integer*, similarly to fish, can seek out better habitation conditions. During sampling for the current study, water temperature was always measured; however, no immediate dependence between water thermal conditions and the quantity of specimens caught was identified at any given sampling site. However, in late fall one of the distinct limiting factors was the strong and frequent water wavy motion in the littoral zone of the sea.

One of the factors that had an undoubtedly great impact on the occurrence of *N. integer* in the Baltic coastal zone, and about which, although it was witnessed during sampling, nothing is written, is the physical interference of humans. People were seen conducting commercial catches of this species for sale to aquarium shops, and in the summer season the presence of people and animals on the beach can disturb and effectively scare off this crustacean.

Total length and weight

The data in the literature indicates that *N. integer* specimens caught during studies performed in the Pomeranian Bay were of the following total length ranges: 7–23 mm [Wiktor 1961]; 4–19 mm [Jansen 1985]; 5–16 mm [Chojnacki 1991]. However, these authors used a different *N. integer* body segment as the measure of total length. In the current study, the smallest juvenile specimen caught was 2.64 mm; thus, it may be presumed that at this length it was possible for it to have

Table 3. Details of the abundance of *N. integer* specimens in study seasons at different sites (for legend key see Tables 1 and 2)

Station	Study seasons							
	W2006	L2006	J2006	PJ2006	ZW2007	W2007	L2007	J2007
Ś.z.	28	0	0	0	0	28	32	128
Ś.w.	11	0	0	25	51	0	66	78
M.	4	58	0	37	58	143	0	5
D.w.	69	17	1	32	77	116	0	18
N.w.	0	0	6	0	0	0	0	0
N.	0	1	0	3	13	0	0	18
M.z.	92	0	0	153	13	0	0	0
M.w.	133	0	68	5	78	38	0	0
Dź.z.	101	0	0	86	15	0	0	0
Dź.w.	71	9	5	234	261	0	0	0
K.w.	0	0	8	47	0	56	0	0
Da.z.	0	0	0	0	21	0	0	0
Da.w.	0	0	0	10	188	5	0	0

exited the marsupium. In a study in the brackish Lake Ferring, which is 100 m from the North Sea, Aaser et al. [1995] reported that juvenile stages exit the marsupium of female *N. integer* at lengths of 2-3 mm. In turn, Mees [1994] reported cohorts of individuals with a mean length of 3 mm in the months of April and May in the brackish mouth of the Westerschelde River. In the present results, the mean length of all the specimens analyzed ranges from 6.3 to 13.8 mm, while the largest specimen noted has a length of 18.84 mm. The female mean length was 9.9 mm, while that of the males was 9.2 mm. The length range of *N. integer* was, thus, similar to that reported by Wiktorowa [1961] and Jansen [1985]. Remerie et al. [2005] reported mean female lengths that are similar to the data that is the foundation of this work, i.e. 10.29 mm (Atlantic estuarine zone). Mees et al. [1994] and other authors have reported female lengths of 12 mm and male lengths of 10.5 mm, which are confirmed by the current observations of this species in the southern Baltic Sea that the mean size of females is larger than that of the males, and this is confirmed by data from other authors.

As was mentioned in the previous section, measurements were also taken of gravid females. It was confirmed that gravid females reached a mean body length range of 9.9–10.8 mm in the summer and of 10.8–12.3 mm in the fall. Along with the beginning of the winter months, it was noted that females of body lengths of about 15 mm had full marsupia. In spring, the length of the gravid females oscillated around 10.4–11.8 mm. It is plausible, thus, that the size at which females achieve sexual maturity fluctuates seasonally and is largely dependent on temperature. Summer generations achieve sexual maturity more quickly than do the others [Astthorson and Ralph 1984; Kuhlmann 1984; Mauchline 1985, Verslycke et al. 2004, Winkler and Greve 2002]. Muchline [1973] reported the mean body length of gravid females in the waters of the northeast Atlantic as 13.9 mm, which is higher than that determined in the current study (11.8 mm); this is likely linked to the higher salinity of open waters.

The mean wet weight of *N. integer* specimens in the current study is 0.011 g, which is lower than the figure reported by Orav-Kotta et al. [2009] in their studies conducted in the northern Baltic (0.016 g). Irvine et al. [1995] reported a wet weight range of 0.013 to 0.014 g. The studies by Verslycke et al. [2004] indicate that this species can attain much higher weights than those reported (mean from 0.014 g in winter to 0.027 g in spring), and this is confirmed by the results published by Mees et al. [1994]; however, significant factors in these instances might include water salinity and thermal regimes. The lightest specimen noted in the current study weighed 0.00013 g, and within this range of weight it is possible for juvenile forms of *N. integer* to exit the marsupium. The heaviest specimens in the current study weighed 0.124 g. The weight ranges of specimens from the current study were much wider than those reported in the literature. The comparison of female to male weights indicates that the latter are heavier in most instances, which is absolutely understandable since their weight is largely dependent on the weight of the marsupium.

Issue of the number of genreations

According to Winkler and Greve [2002], every *N. integer* population comprises overlapping cohorts from subsequent hatchings. It is reported in the literature that two to three mysid generations occur annually: three have been reported by Vorstman [1951], Mauchline [1971], Borghouts [1978], Parker and West [1979], Bremer and Vijverberg [1982], Mees et al. [1994], and Verslycke et al. [2004]. Two annual generations have been described in the mouths of the River Ythan by Astthorsson and Ralph [1984] and the Eider-Ring by Kinne [1955], while Kinne [1955], Wiktor [1961], Jansen [1985], Rudstam et al. [1986], Chojnacki [1991], and Aaser et al. [1995] all write about two annual generations in the coastal waters of the Baltic Sea. However, Mees et al. [1994] reports that in lower geographic zones populations of *N. integer* reproduce nearly throughout the year. Mauchline [1971] observed year-round mysid reproduction in Loch Etive, but that during winter it was not abundant. The analysis of the weight-length dependence of *Neomysis integer* in the current study leads to the observation that in many instances the graphs indicate there is more than one generation present. Two populations occurring at the same time in a single study season are visible in the population from summer 2007 at the east Świnoujście site and in winter-spring 2007 at the east Dźwirzyno site (Figures 2 and 3).

Considering the information that from the spring season *N. integer* lives for three months only [Verslycke et al. 2004], it is plausible that in one of the other annual seasons a subsequent generation, the third, appears. The weight-length

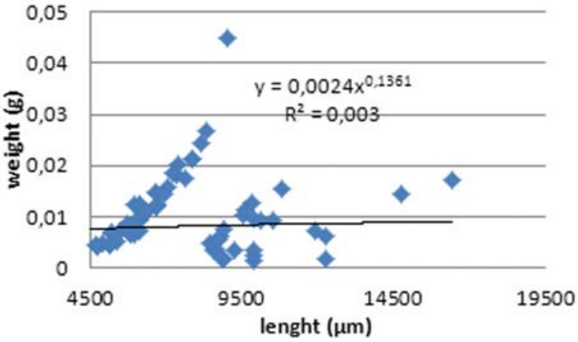

Figure 2. Weight-length dependence for the whole sample of *Neomysis integer* from the eastern Świnoujście site in the summer season 2007

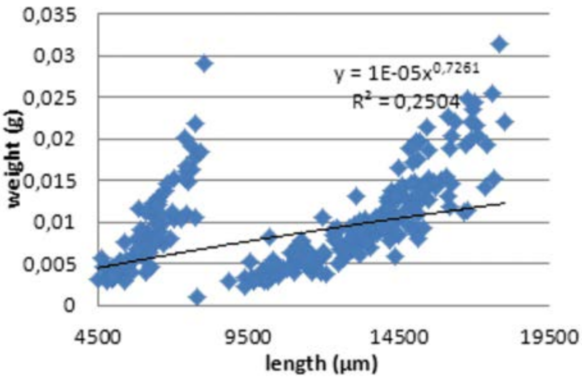

Figure 3. Weight-length dependence for the whole sample of *Neomysis integer* from the eastern Dźwirzyno site in the winter-spring season 2007

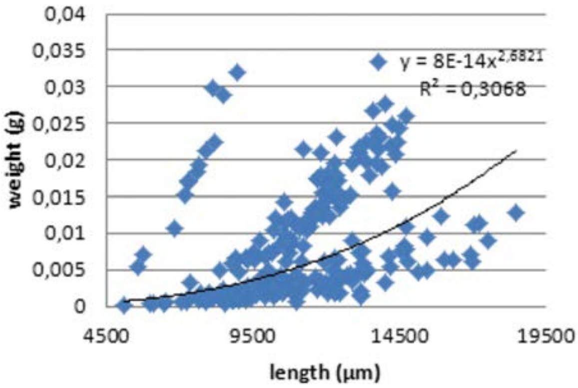

Figure 4. Weight-length dependence for the whole sample of *Neomysis integer* from the western Mrzeżyno site

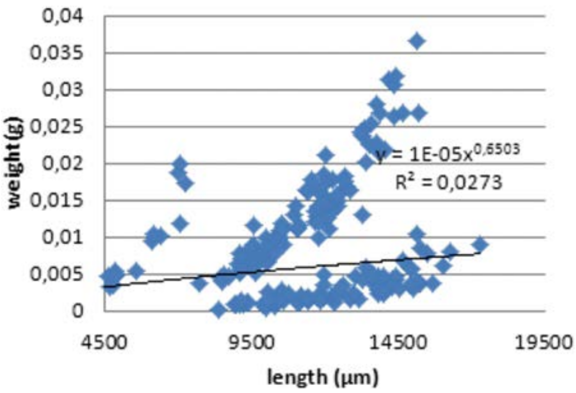

Figure 5. Weight-length dependence for the whole sample of *Neomysis integer* from the western Dźwirzyno site

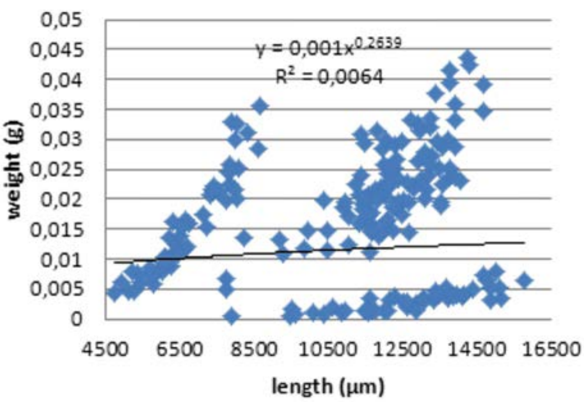

Figure 6. Weight-length dependence for the whole sample of *Neomysis integer* from the eastern Kołobrzeg site

dependence graphs of specimens from the sites at western Mrzeżyno, western Dźwirzyno, and eastern Kołobrzeg unequivocally illustrate three generations of *N. integer* (Figures 4, 5, 6). Thus, the study results presented in this paper indicate that three, not two, annual generations of *N. integer* occur in the coastal waters of the Pomeranian Bay. The increased number of annual generations as compared to that in previous studies [Kinne 1955, Wiktor 1961, Jansen 1985, Rudstam et al. 1986, Chojnacki 1991, Aaser et al. 1995] might be evidence that the environmental conditions for *N. integer* population habitation in the Pomeranian Bay have improved.

Numerical sex ratio

The sex ratio in the samples studied (Table 4) was varied: in spring the number of females was higher than the number of males (from 1.03:1 at the eastern Dźwirzyno site to 3.5:1 at the western Świnoujście site); in summer the dominance of females was even higher (sporadically 45.5:1 at the eastern Kołobrzeg site); but in fall the difference between the number of females and males decreased (1.1:1 at the eastern Mrzeżyno site). This difference began to increase again in late fall with figures of 3.9:1 at the eastern Dźwirzyno site and 23.6:1 at the western Mrzeżyno site. In the winter at the eastern Świnoujście, Międzyzdroje, and Dziwnów sites the number of males was higher than the number of females, while at the other sites the number of females was higher.

In subsequent study seasons, the predominance of females was observed again. Periods of an equalized sex ratio of 1:1 mature adult females to males is thought to be optimal for reproduction [Chojnacki 1991, Vortsman 1951]. The spring 2006 and 2007 study seasons were close to this optimum, when females were only slightly predominant over males, thus, it can be hypothesized that spring is the principal reproduction period for *N. integer* in the littoral of the southern Baltic. Węsławski [1981], however, believes that during the most intense reproduction period females significantly outnumber males, which was also reflected at several sampling sites in the present study. Grieze [1972] also reports a similar phenomenon with regard to several species of Amphipoda. The lesser number of males in the samples might also lend confirmation to the opinion that after copulation some of the males expire [Węsławski, 1981], or even that following copulation the females require more nutrition and consume the males (cannibalism among *N. integer* is described in the work of Verslycke and Janssen 2002). All of these hypotheses indicate indirectly that the periods of summer and fall in the waters of the Pomeranian Bay in the southern Baltic Sea are ones of intense reproduction. The predominance of males in the season of ZW2007 may confirm Verslycke's [2004] belief that the fall generation does not reproduce until the spring. Similar conclusions were drawn by Jansen (1985), who observed the predominance of males in the month of December. Mees et al. [1994] underscore that the at temperatures of under 10°C *N. integer* reproduction ceases.

Fecundity

A significant challenge when comparing populations of the *N. integer* is the number of embryos carried by one female [Węsławski 1981]. This number is undoubtedly dependent on the size of the female and varies seasonally [Fockedey et al. 2006]. Mauchline [1971], Pawlicka [1978], and Wiktor [1961] report that the maximum number of embryos in the marsupium is from 70 to 74, while Kinne [1955] reports the maximum to be 55 and Węsławski [1981] just 46. The results of the present study differed from the data in the literature and ranged from 14 embryos to a maximum of 44, at a mean of 34 in one marsupium. The lower number of embryos in the marsupia of female *N. integer* in the current study in comparison with the results of other authors does not necessarily indicate the lesser abundance of these organisms in the Pomeranian Bay. It might just indicate that abundance was higher. The results of the current total body length measurements of *N. integer* do not differ to a great degree from the measurement results reported by other crustacean researchers studying this species in the Pomeranian Bay and the waters of the southern Baltic coastal zone. Considering that egg size depends on female body size [Kinne, 1955, Parker and West 1979, Mees et al., 1994] and that there were fewer eggs in the crustaceans examined in the present study, one might conclude that the eggs were larger; thus there is the possibility that both embryo survival and that of the future progeny is significantly higher [Kolding and Fenchel 1981, Wehrtmann and Lopez 2003]. Mees et al. [1994] note that among females of the same size, those

Table 4. Sex ratio of *N. integer* females and males at different study sites (for legend key see Table 1 and 2)

Station	W2006	L2006	J2006	PJ2006	ZW2007	W2007	L2007	J2007
Ś.z.	1.6:1	5.2:1	–	–	–	–	–	1.2:1
Ś.w.	3.5:1	–	–	20:1	1.1:1	–	1.6:1	1.4:1
M.	1:3	2:1	–	4.8:1	1:1.11	1.1:1	–	5;0
D.w.	1.8:1	2.4:1	0:1	25;0	1:1.8	1.9:1	–	1:2.6
N.w.	–	–	2:1	–	–	–	–	–
N.	–	1:0	–	3:0	1.7:1		–	1.6:1
M.z.	3.2:1	–	–	23.6:1	1.2:1	–	–	–
M.w.	1.8:1	–	1.1:1	5:0	1.3:1	1:1.05	–	–
Dź.z.	1.15:1	–	–	16:1	2;1	–	–	–
Dź.w.	1.03:1	7:1	1.5:1	3.9:1	1.2:1	–	–	–
K.w.	–	45.5:1	8:0	11:1	–	5.9:1	–	–
Da.z.	1;2	–	–	–	2.5:1	–	–	–
Da.w.	–	–	–	9;1	2.3:1	1.5:1	–	–

which hibernate have, on average, more eggs in spring. Verslycke et al. [2004] reports, however, that the spring generation lives for only three months, and the large number of eggs in the marsupia might result in the birth of weaker specimens. In the present study the mean number of eggs in the marsupia in spring was higher than that in the summer with a mean of 36 in spring 2006 and a mean of 31 eggs in summer 2006.

The current results also confirm conclusions of other researchers regarding the growth rate of individuals in the marsupium. Fockedey et al. [2006] and Mauchline [1980] note that not all of the individuals in the marsupium are at the same stage of development. Photographs 2 and 3 illustrate the simultaneous occurrence of both *N. integer* eggs and embryos in the first stage of development.

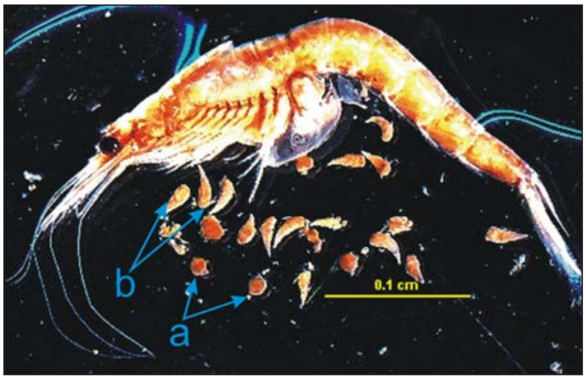

Photo 2. Marsupium contents of a female *N. integer* (a – eggs, b – embryos)

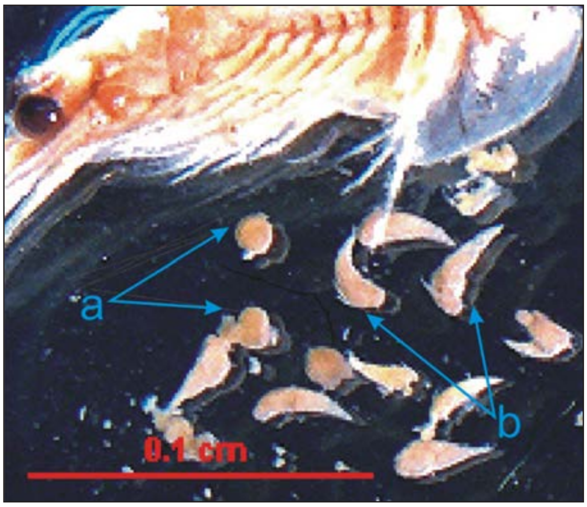

Photo 3. Marsupium contents of a female *N. integer* – close-up (a – eggs, b – embryos)

Proximate body composition of *n. integer*

The adaptations of *N. integer* to life in the estuarine zone consume a lot of energy [Verslycke and Janssen 2002]. These include this species's wide ranging tolerance of changes in salinity [Mauchline 1971], and its very efficient osmoregulation and respiration physiology [McLusky and Heard 1971, Roast et al. 1999]. This is why it is important to describe the proximate composition of *N. integer* populations. The proximate body composition of the common mysids examined in the current study is 9.34% protein, 1.22% fats, and 1.32% sugars (Table 5).

Table 5. Percentage share of the biochemical components of *N. integer*

Component	Percentage share
Water	86.28
Protein	9.34
Fat	1.22
Ash (mineral components)	1.84
Total carbohydrates	1.32

Verslycke and Janssen (2002) report a slightly different proximate composition of 7.39% protein, 3.99% fats, and 0.42% sugars. The differences in these results might have been the result of the material analysed originating from different regions and seasons, which means the specimens inhabited different environmental conditions, which included varied access to food, oxygenation, insolation, etc. While the differences in the protein fractions are not large, the fat content result from the current study is threefold lower. These results are similar to those of Ando and Nozaki [2007]; however, they assayed the fat contents in *Neomysis intermedia* [Czerniavsky, 1882]; this crustacean is a basic ingredient in the popular Japanese dish tsukudani and a southeastern Asian sauce. These authors report a 1% fat content that includes 21% palmitic acid, 12% linoleic acid, 19% EPA (eicosapentaenoic acid), and 14% DHA (docosahexaenoic acid). The results presented in Table 6 of the fatty acid composition were also similar to the results of Ando and Nozaki [2007]; however, 47.49% of the fat in *Neomysis integer* comprises polyunsaturated fatty acids. It is significant that EPA and DHA, which are Omega 3 fatty acids that are important to human health, comprised as much as 41.35% of the material originating from the Pomeranian Bay. This warrants further observation and study.

One additional question, which was not included in the current study but which occurs frequently in the literature about *N. integer*, should

Table 6. Fatty acid composition of *N. integer*

Fatty acids	Content [%]	
	Mean	SD
C14:0 (myristic)	0.98	0.05
C15:0 (pentadecanoic)	0.56	0.03
C16:0 (palmitic)	27.10	0.56
C16:1 (palmitoleic)	1.60	0.02
C17:0 (margaric)	1.41	0.04
C18:0 (stearic)	4.58	0.01
C18:1 (linoleic)	15.10	0.04
C18:2 (linoleic)	1.62	0.06
C20:3 (homo-gamma-linolenic)	1.13	0.02
C20:1 (eicosenoic)	1.20	0.01
C20:2 (eicosadienoic)	0.92	0.02
C20:4 (arachidonic)	2.46	0.00
C20:5 EPA (eicosapentaenoic)	17.13	0.13
C22:6 DHA (docosahexaenoic)	24.22	0.48
Total		
SFA (saturated fatty acids)	34.62	0.68
MUFA (monosaturated fatty acids)	17.89	0.01
PUFA (polyunsaturated fatty acids)	47.49	0.69

be posed at this juncture: what is the significance of this species as a bioindicator? This topic is omitted from studies of the biology of *N. integer* from the southern Baltic Sea, but the literature indicates that it is crucially important and common [Brandt et al. 1993, Emson and Crane 1994, Gaudy et al. 1991, Hunt et al. 1997, Jacobs and Grant 1974, Khan et al. 1992, Langdon et al. 1996, Lussier et al. 1985; 1999, Martin et al. 1989, McKenney 1998, Roast et al. 1999; 2000, Wildgust and Jones 1998]. With such a collection of wide-ranging, current data on the physiology and morphometry of this common mysid from the Pomeranian Bay, the logical undertaking would be to conduct further studies of its behavior under varied environmental conditions and its tolerance thresholds for harmful factors.

CONCLUSIONS

1. No dependencies between specimen size and collection location were noted in the material collected in 2006 and 2007 from the Pomeranian Bay.
2. In 2006 and 2007, the specimen length range of the population in the Pomeranian Bay was 2.64 to 18.84 mm. The mean length was 8.49 mm, with females at 9.9 mm, and males – 9.2 mm. The length of the smallest juvenile specimen caught was 2.64 mm, which indicates that *N. integer* exit the marsupium at this size to begin active life in the environment.
3. The size at which females achieve sexual maturity changes seasonally and is largely dependent on water temperature.
4. The mean wet weight of *N. integer* specimens from the Pomeranian Bay in 2006 and 2007 was 0.011 g, with females at 0.012 g, and males – 0.0099 g.
5. Three generations of *N. integer* were confirmed at most of the sampling sites in the coastal zone of the Pomeranian Bay in 2006 and 2007.
6. The sex ratio in the samples analyzed was fairly variable and depended on the season of the year (the ratio of females to males was 1.03:1 at the eastern Dźwirzyno site in spring 2006, while it was 45.5:1 at the eastern Kołobrzeg site in summer 2006). However, in most instances the number of females was greater than that of males. The 2006 and 2007 spring seasons were periods of sex ratio equilibrium, and as such the optimum time for reproduction.
7. The marsupia of *N. integer* contained from 14 to a maximum of 44 embryos, at an average of 34 embryos per marsupium.
8. The fat content of *N. integer* from the Pomeranian Bay was lower than that in specimens from other regions, while the fatty acids from the Omega 3 family comprised as much as 41.35% of all the fat content of the crustaceans assayed.

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