Oceanological Studies
Vol. XXIX, No. 1

Institute of Oceanography
University of Gdańsk

(77-87)
2000

Institute of Marine Sciences
University of Szczecin

Research Article

# THE SANDHOPPER (*TALITRUS SALTATOR*, MONTAGU 1808) ON THE POLISH BALTIC COAST. IS IT A VICTIM OF INCREASED TOURISM?

JAN MARCIN WĘSŁAWSKI✉, AGNIESZKA STANEK, AGNIESZKA SIEWERT, NATALIA BEER

*Institute of Oceanology, Polish Academy of Sciences*
*ul. Powstańców Warszawy 55, 81-712 Sopot, Poland*
*weslaw@iopan.gda.pl*

Key words: sandy littoral, amphipods, tourism, environmental impact assessment

## Abstract

Sandhopper occurrence and their habitat preferences were examined at 10 km intervals along 500 km of the Polish coastline in 1997. The sandy beach coastline was divided into 5 types based on physical factors. Compared to earlier data from 1950-70, sandhoppers were found in only 44% of their former sites of occurrence. In all sites examined, sandhopper density was markedly lower (an average of below 20 ind. $m^{-2}$) compared to the former data (an average of 150 ind. $m^{-2}$). The reasons for the sharp decline in sandhopper occurrence are discussed pointing at the increase of touristic activity and changes in trophic conditions as the most likely cause. Contamination alone is unlikely to affect the sandhoppers, since the most contaminated beaches at the Vistula Spit have been those with the highest sandhopper density observed recently.

## INTRODUCTION

Air breathing amphipods which feed on organic, mainly phytal debris are common inhabitants of sandy beach supralittoral all over the world (Brown and Mc Lachlan 1990). Three species (*Orchestia cavimana, Talorchestia deshayesi* and *Talitrus saltator*) were noted on the Baltic coast of Poland, however, only *T. saltator* was relatively common and abundant (Jażdżewski and Konopacka 1995). In a study performed between 1961 and 1963, *T. saltator* was found almost

everywhere along the Polish coast, inhabiting the upper 10 cm layer of wet sand just above the water line (Drzycimski and Nawodzińska 1965). Since this time, major socio-economic changes have taken place in Poland, including the increase of tourism and industrial activity followed by the increased pollution, which have directly affected the coastal environment (Korzeniewski and Neugebauer 1991). The aim of the present study was to find if these environmental and socio-economic changes had affected sandhopper occurrence.

## MATERIAL AND METHODS

Field work was performed from April to September 1996 along the entire Polish coastline (Fig. 1). Fifty sampling sites were established, roughly every 10 km, along 500 km of coastline. Sites were situated at least 1.5 km from the public entrance to the beach. Additional 15 sites covering a distance of about 15 km, were selected in the popular tourist area between Gdynia and Gdańsk. At each point several variables were measured. Physical parameters included granulometry (sand samples from the upper 5 cm of the drift line), organic matter content (estimated as the dry weight loss after combustion at 450°C after 24 h), beach width (the distance between the actual water line and the first vegetation), beach depth (the distance from the surface to groundwater table measured at 5$^{th}$ and 10$^{th}$ metre from the water line), slope of the beach (the relation of the beach width to its depth), type of the beach (dissipative, reflective, intermediate), amount of debris in the drift zone, wave height, maximal air and sea temperature.

At each sampling site sandhoppers were collected from five rows of holes (20×20×20 cm) dug at intervals of 1 m across the beach from the water line up to the dunes. The rows were dug 20 m from each other. Up to 50 holes were dug in each row resulting in 60 to 150 samples from each location, depending on the beach width. This resulted in about 6 m$^2$ of effectively checked sand in the area of

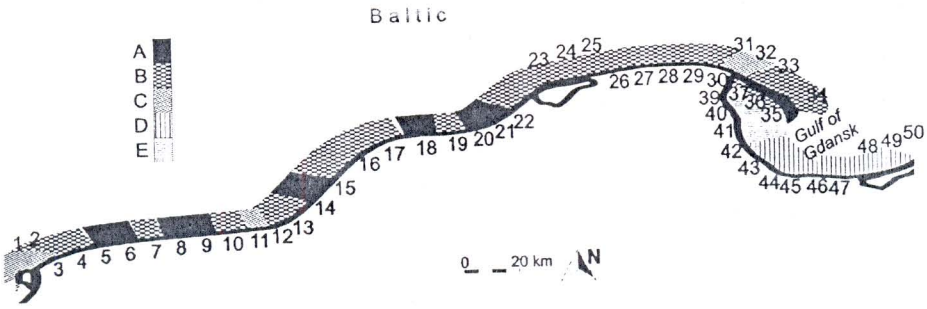



Fig. 1. Coast types in Poland, classification based on physical parameters; numbers refer to units equalled 10 km of coast line

about 30×100 m. Sandhoppers in each hole were counted and released. In the most populated areas, sandhoppers were dug from one square meter and preserved in 4% formaldehyde. These large samples were used for the estimation of sandhoppers density at each location.

Potential tourist density per each 10 km coast unit was estimated from current, local bulletins presenting the number of available hotel beds and camping sites (Panorama Turystyki 1997/1998, Polska Mapa Campingów 1997). In Sopot, where the most frequently visited beach in Poland is found, the number of tourists visiting the beach was monitored for one week in July. Every hour for 10 minutes (between 7.00 and 24.00), the number of people passing the drift line was counted. To assess human impact on the sand surface, 0.5 cm layers of rodamine colored sand were placed at depths of 5, 10, 20 and 30 cm on 0.25 $m^2$ area at the drift line. Fifty ripe *Symphoricarpus rivularis* fruit (about 0.5 cm in diameter) were placed on each coloured sand layer. Consecutive sand layers were formed again with the sand originally taken from the same depth and place. Four sites with coloured sand and fruit were prepared. The first was exposed to one step, the second to 10 steps and the third to 100 steps of a man weighing 90 kg. The fourth was the control site. Each site was examined for the depth of the coloured sand layer deformation and the percentage of crushed fruit. For the characterisation of coast types the Primer 1997 software package was used with multivariate analysis (Bray Curtis similarity and Canberra distance). Archival materials (Drzycimski and Nawodzińska 1965, Jażdżewski and Konopacka 1995) were studied to assess the former occurrence of sandhoppers. In the above cited papers, the sampling methods were described very generally and usually precise locations were not given. Wherever possible, the density data were taken, otherwise the presence or absence of sandhoppers was noted.

## RESULTS

After the analysis of environmental variables the sandy coast of Poland was divided into five categories (Fig. 1). Seventy kilometres of the eastern part of Polish coast (Vistula Spit) were grouped into one category (D) of relatively narrow, reflective and intermediate beach with a high slope and coarse sand (Fig. 1). The second group (E) consisted of sheltered, fine sand beaches of the inner Gulf of Gdańsk. Narrow fragments of stone and gravel beaches comprised the third group (C) at three sites on the open Baltic coast, while most of the open coast consisted of groups A and B - exposed, wide beaches of medium grained sand (Fig. 1). Sandhoppers were found at 20 of the 50 coast units studied. If sandhoppers occurred, their density ranged between 5 and 100 ind. $m^{-2}$ (Fig. 2). The potential number of tourists varied tenfold at different coast units (Table 1).

Table 1

The selected features of Polish Baltic coastline

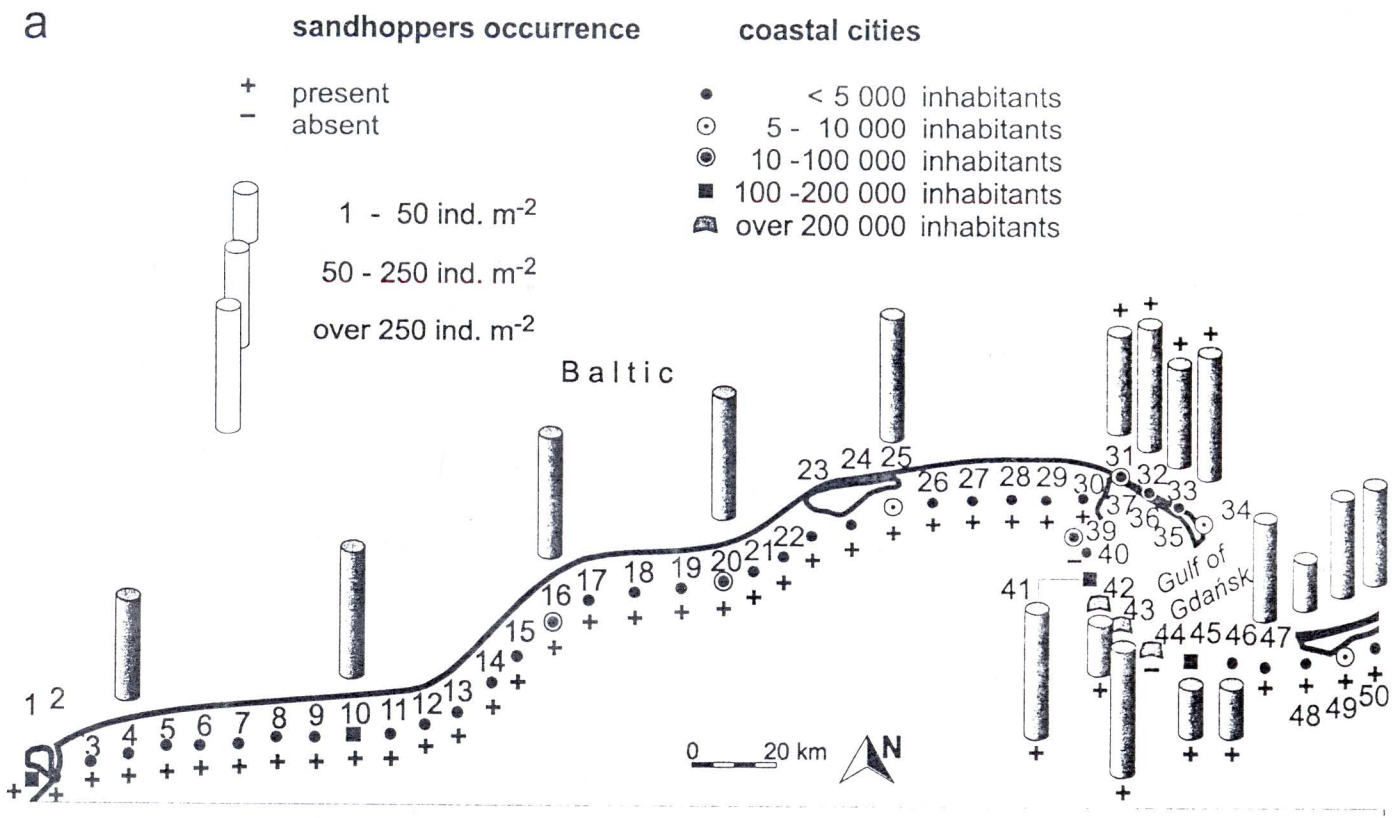
| | Location (coast unit) | beach width<br>A-below 10 m<br>B-10 to 50 m<br>C-over 50 m | beach slope<br>A-below 5%<br>B-5 to 10%<br>C-over 10% | wave exposure<br>1-low<br>2-high | mean grain size [mm] | tourist density (beds km$^{-1}$)<br>A-below 50<br>B-50 to 300<br>C-300 to 500<br>D-over 500 |
|---|---|---|---|---|---|---|
| 1 | Świnoujście | C | A | 1 | 1.0 | C |
| 2 | Międzyzdroje | B | B | 1 | 1.0 | C |
| 3 | Wisełka | B | A | 1 | 1.0 | A |
| 4 | Dziwnów | B | B | 1 | 1.0 | D |
| 5 | Pobierowo | A | C | 2 | 2.0 | C |
| 6 | Trzęsacz | B | B | 2 | 1.0 | C |
| 7 | Niechorze | B | A | 2 | 2.0 | D |
| 8 | Mrzeżyno | A | A | 2 | 2.5 | C |
| 9 | Dźwirzyno | A | A | 2 | 2.5 | C |
| 10 | Kołobrzeg | B | A | 2 | 2.0 | D |
| 11 | Ustronie Morskie | A | B | 2 | 1.5 | D |
| 12 | Sarbinowo | B | B | 1 | 1.5 | B |
| 13 | Mielno | B | B | 1 | 0.5 | C |
| 14 | Łazy | A | A | 1 | 1.0 | C |
| 15 | Dąbki | B | B | 1 | 1.0 | B |
| 16 | Darłowo | B | B | 1 | 0.5 | C |
| 17 | Wicie | B | B | 1 | 0.5 | A |
| 18 | Jarosławiec | A | C | 1 | 1.0 | C |
| 19 | Modelskie Wydmy | B | B | 1 | 2.0 | A |
| 20 | Ustka | A | B | 1 | 2.0 | C |
| 21 | Rowy | B | B | 1 | 2.0 | B |
| 22 | Smołdziński Las | B | B | 1 | 2.0 | A |
| 23 | Czołpino | B | B | 2 | 2.0 | A |
| 24 | Rąbka | B | A | 2 | 2.0 | A |
| 25 | Łeba | C | A | 2 | 2.0 | D |
| 26 | Biebrowo | B | A | 2 | 2.0 | A |
| 27 | Lubiatowo | B | A | 2 | 2.0 | A |
| 28 | Dębki | B | A | 2 | 2.0 | B |
| 29 | Karwia | B | A | 2 | 2.0 | B |
| 30 | Jastrzębia Góra | B | A | 2 | 1.5 | C |
| 31 | Władysławowo | B | A | 2 | 1.5 | C |

| | | | | | | |
|---|---|---|---|---|---|---|
| 32 | Kuźnica | C | A | 2 | 1.5 | B |
| 33 | Jastarnia | B | A | 2 | 1.5 | C |
| 34 | Hel | B | C | 2 | 1.5 | D |
| 35 | Puck Bay | A | C | 1 | 1.5 | C |
| 36 | Puck Bay | A | B | 1 | 1.5 | C |
| 37 | Puck Bay | A | B | 1 | 1.5 | C |
| 38 | Swarzewo | A | C | 1 | 1.5 | C |
| 39 | Puck | A | B | 1 | 1.0 | A |
| 40 | Mrzezino | A | B | 1 | 1.0 | B |
| 41 | Mechelinki | A | B | 1 | 1.0 | A |
| 42 | Sopot | B | B | 1 | 1.0 | D |
| 43 | Jelitkowo | B | C | 1 | 1.0 | D |
| 44 | Stogi | C | B | 1 | 1.0 | D |
| 45 | Sobieszewo | C | A | 1 | 2.5 | C |
| 46 | Jantar | C | A | 1 | 2.0 | B |
| 47 | Sztutowo | B | B | 1 | 2.0 | C |
| 48 | Kąty Rybackie | B | A | 1 | 2.0 | B |
| 49 | Krynica Morska | C | A | 1 | 2.0 | C |
| 50 | Piaski | B | C | 1 | 2.0 | A |

The most frequently visited sites were the renowned spa towns along the shore of the Gulf of Gdańsk and single spots on the open coast. Places with difficult road access, close to military areas or with poor local infrastructure were the least visited sites (Table 1). The number of people passing the drift line on the very popular beach in Sopot ranged from 600 to 3000 per day, with the heaviest concentration observed during July study in the early afternoon (Fig. 3). The experiment demonstrating the influence of human step influence on loose sand showed that 1 step disturbs the sediment in the upper 5 cm, while 100 steps disturb the sediment down to 30 cm. 20% of the white fruit were crushed in the upper 5 cm after one step, while 100 steps flattened 60% of the fruits even at the 30 cm level. The multivariate analysis of sandhopper occurrence shows no direct correlation with any of the observed physical phenomena listed in Table 1 (Fig. 4).

## DISCUSSION

The data from the only paper presenting the quantitative occurrence of sandhoppers in Poland (Drzycimski and Nawodzińska 1965) and from a number of older reports on these species occurrence cited in Jażdżewski and Konopacka (1995) compared with current results revealed a marked decline of the area


a
sandhoppers occurrence
+ present
– absent
1 - 50 ind. m-2
50 - 250 ind. m-2
over 250 ind. m-2
coastal cities
< 5 000 inhabitants
5 - 10 000 inhabitants
10 -100 000 inhabitants
100 -200 000 inhabitants
over 200 000 inhabitants
Baltic
Gulf of Gdańsk
0 20 km
N
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 39 40 41 42 43 44 45 46 47 48 49 50

b


Fig. 2. Generalised occurrence of *Talitrus saltator* along the Polish coastline:
a) data from 1950-1970 from Drzycimski and Nawodzińska (1965), Jażdżewska and Konopacka (1995)
b) current data from summer 1997

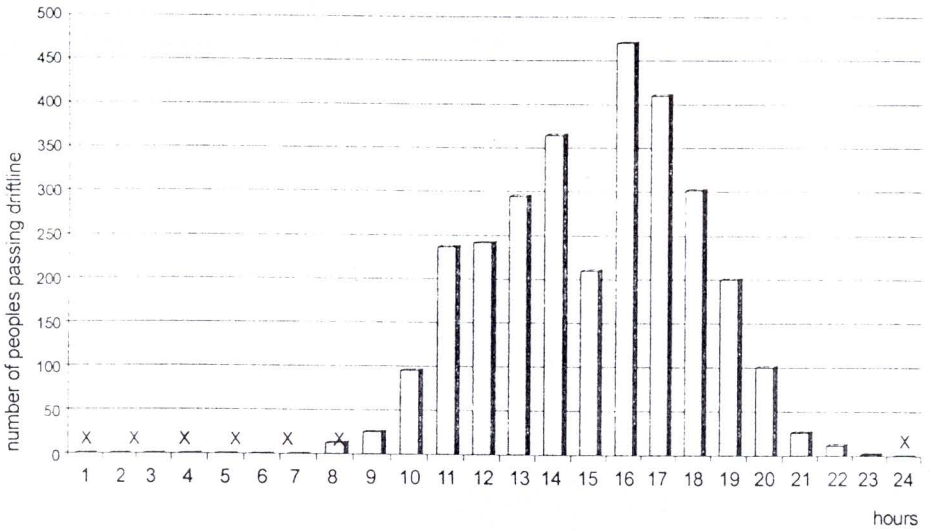



**Fig. 3.** Number of people passing daily the drift line of popular sandy beach in Sopot (mean value from 20-26th of July 1997), X - no data

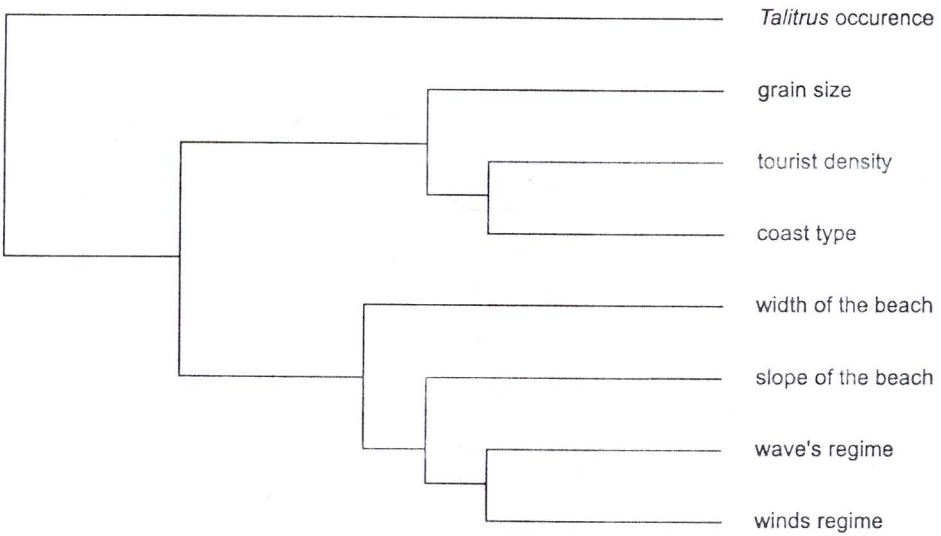



**Fig. 4.** Similarity of sandy coast variables (Bray-Curtis index) based on data presented in Table 1

inhabited by sandhoppers, as well as a distinct drop in their average density. Compared to 45 coast units where sandhoppers were found in 1950- 1970, only 20 units were found inhabited in 1997 (Fig. 2). It can not be excluded, that we missed sandhoppers in some of the selected sites, considering their patchy distribution

(Węsławski *et al.* 2000). These animals were surely absent in Gdynia-Gdańsk area (coast units 41 to 44 in Fig. 2), where very intensive sampling was performed. In the least changed region, that is the eastern part of the coast, sandhoppers remained at all sites and in similar density to that from the early 1960s. Sandhoppers have disappeared completely from the inner Gulf of Gdańsk, as well as from the most of the open coast locations. Even in the 1960s, in the heavy tourism areas from Gdynia to Gdańsk, sandhoppers were noted only in some locations (Drzycimski and Nawodzińska 1965, Skóra and Swerpel, personal communications). The eastern part of the coastline, where sandhoppers remained, is often regarded as the most polluted area due to its direct exposure to the influence of Vistula river discharge (Korzeniewski and Neugebauer 1991). Surprisingly, sandhoppers have disappeared from some areas, described as the cleanest stretches of the open Polish coast (Jóźwiak 1996). In addition to pollution, climatic changes such as storm frequency, severity of winters, the rise in sea level, changes in trophic conditions and tourist activity can be cited as reasons for the disappearance of sandhoppers. There is some evidence that climatic conditions have changed from the early 1960s to the late 1990s on the Polish coast. There are indications that during the 1960s there was a period of severe winters when the sea was frozen frequently and ice blocks were stranded on the beach (Zakrzewski 1983), a phenomenon which was surely absent from 1990 to 1997. The food of *T. saltator* is composed of algae and higher plant debris, mainly *Zostera marina* leaves (Drzycimski and Nawodzińska 1965, Lagardere 1966, Costello *et al.* 1998). The majority of seaweed meadows and a number of macroalgae species disappeared from the Polish coastal waters during the pollution crisis in the 1970s and 1980s (Pliński and Wiktor 1987, Ciszewski *et al.* 1992). Since *Zostera* was one of the species affected, the question of the scarcity or disappearance of the sandhopper food source might be raised. The increase in recreational use of beaches is apparent, however, its precise quantification is difficult. The distinct avoidance of the most populated areas by sandhoppers was shown by Drzycimski and Nawodzińska (1965), with about 1 to 2 km "sandhopper free zone" close to the coastal cities. At the beginning of the 1960s, the open coastline was regarded as a border area and thus access was limited to daytime hours only and the overall length of the restricted military area was much longer. With an estimated half million tourist beds, a two month season length (and an average holiday of two weeks), a number of 4 million visitors can be received (500000 beds × 8 weeks). Considering the number of visitors coming to Sopot, it may be concluded that 60% of the Polish coastline receives more than 100 human steps per $m^2$ daily during the peak summer season. Human trampling has been long recognised as a critical factor in many vulnerable land biota (Andersen 1995), and this approach has been recently used in a marine coastal conservation assessment (Keough and

Quin 1991, Liddle 1991, Brosnan and Crumrine 1994). Mechanical cleaning of the beaches may also be regarded as an important limiting factor for sandhoppers (Llevelyn and Zalewski 1996). Considering sporadic sandhopper occurrence (Węsławski *et al.* 2000) and their limited dispersal abilities (De-Matthaeis *et al.* 1998), a conservation option would be to concentrate tourist facilities in areas separated by relatively undisturbed stretches of coast. As was shown on the Polish coast of the Hel Peninsula, sandhoppers can occur despite a high number of tourists provided that several kilometres of less frequently visited beach exists between crowded areas.

## REFERENCES


Andersen U. V., 1995, *Resistance of Danish coastal vegetation types to human trampling,* Biol. Conserv., 71, 223-230

Brosnan D. M., Crumrine L. L., 1994, *Effects of human trampling on marine rocky shore communities,* J. Exp. Mar. Biol. Ecol., 177, 79-97

Brown A. C., McLachlan A., 1990, *Ecology of sandy shores,* Elsevier, Amsterdam, 328 pp

Ciszewski P., Ciszewski I., Kruk-Dowgiallo L., Osowiecki A., Rybicka D., Wiktor J., Wolska M., Żmudziński L., 1992, *Trends of long-term alterations of the Puck Bay ecosystem,* Stud. Mater. Oceanol., 60, 33-84

Costello M. J., McGrath D., Emblow C., 1998, *A review of the distribution of marine Talitridae (Amphipoda) in Ireland, including the results of a new survey of sandy beaches,* Proc. 4th Inter. Crustacean Congress, Amsterdam, July, 1998, 1-14

De-Matthaeis E., Davolos D., Cobolli M., 1998, *Genetic divergence between populations and species of talitrids from Aegean Islands,* J. Hered., 89, 37-43

Drzycimski I., Nawodzińska G., 1965, *Amphipoda from beaches of Polish Baltic Sea,* Przeg. Zool., 3, 267-273, (in Polish)

Jażdżewski K., Konopacka A., 1995, *Malacostraca, except terrestrial Isopoda. Polish fauna,* Muzeum i Inst. Zool. PAN, Warszawa, 165 pp, (in Polish)

Jóźwiak Z., 1996, *Littering of the Polish Baltic coastline,* PhD Thesis, University of Gdańsk, (in Polish)

[illegible] G. P., 1991, *Causality and the choice of measurements for detecting human impacts in marine environments,* Austr. J. Mar. Freshwater Res., 42, 539-554

Korzeniewski K., Neugebauer E., 1991, *Heavy metal concentrations in the Polish zone of the southern Baltic,* Mar. Pollut. Bull., 23, 687-689

Lagardere J. P., 1966, *Recherches sur la biologie et l'ecologie de la macrofaune des substrats meubles de la cote des Landes et de la cote Basque,* Bull. Cent. Etud. Rech. Sci. Biarritz, 6, 143-209

Liddle M. J., 1991, *Recreation ecology: Effects of trampling on plants and corals,* Trends Ecol. Evol., 6, 13-17

Llewellyn P., Zalewski M., 1995, *On the border between land and sea,* Wiedza i Życie,

7, (in Polish)
Panorama Turystyki - Wybrzeże, 1997/1998, anon., Gdańsk
Pliński M., Wiktor K., 1987, *Contemporary changes in coastal biocenoses of the Gdańsk Bay (Southern Baltic),* Pol. Arch. Hydrobiol., 34, 81-90
Poland - map of camping sites (Polska Mapa Campingów), 1997, anon., Gdańsk, (in Polish)
PRIMER, 1997, software package, Plymouth Marine Laboratory, UK
Węsławski J. M., Kupidura T., Żabicki M., 2000, *The sandhopper (Talitrus saltator, Montagu 1808) on Polish Baltic coast, Patterns of distribution,* Crustaceana, in print
Zakrzewski W., 1983, *Ice on the sea,* Wyd. Morskie, Gdańsk, 313 pp, (in Polish)