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# SELECTED PROBLEMS OF THE ECOLOGY OF MOLLUSCS (*MOLLUSCA*) OF THE BRACKISH LAKE ŁEBSKO

An analysis of the distribution and abundance dynamics of the molluscs of the brackish lake Łebsko is made. Habitats with sand bottom and no vegetation, exposed to strong waves or rapid currents, are least favourable for the life of molluscs. In areas where the medium-muddy bottom is covered by abundant vegetation, the currents or waves being weak, the molluscs find the best conditions for their life. The salinity of the water is not the most important distribution-limiting factor for the freshwater molluscs found in the lake under study. A characteristic feature of the mollusc fauna of lake Łebsko is its strong seasonal and spatial variation.

In the present paper an analysis is made of the distribution and abundance dynamics of the molluscs of the brackish lake Łebsko in relation to the variation of some environmental conditions.

In bodies of brackish water fresh water is mixed with salt water of varying properties, the result being a considerable variation of ecological conditions. The fauna of these habitats is represented by eurytopic freshwater and marine organisms, and specific salt-water organisms (Remane and Schlieper 1958, Zienkiewicz 1959).

There have not been many studies on brackish water. The definition of the brackish lake and the classification of the waters with regard to salinity have undergone a distinct evolution (Redeke 1922, 1933, Välikangas 1933, Segesträle 1957, Remane and Schlieper 1958). According to the fre-

quently applied classification published by Redeke (1933) – Välikangas (1933) lake Łebsko may be counted among bodies of water of intermediate type between oligohaline and meiomesohaline brackish waters.

The ecology of the brackish-water organisms and the nature of the habitat have not hitherto been described exactly. The Polish lakes near the Baltic, as well the molluscs found in them are not an exception in this respect.

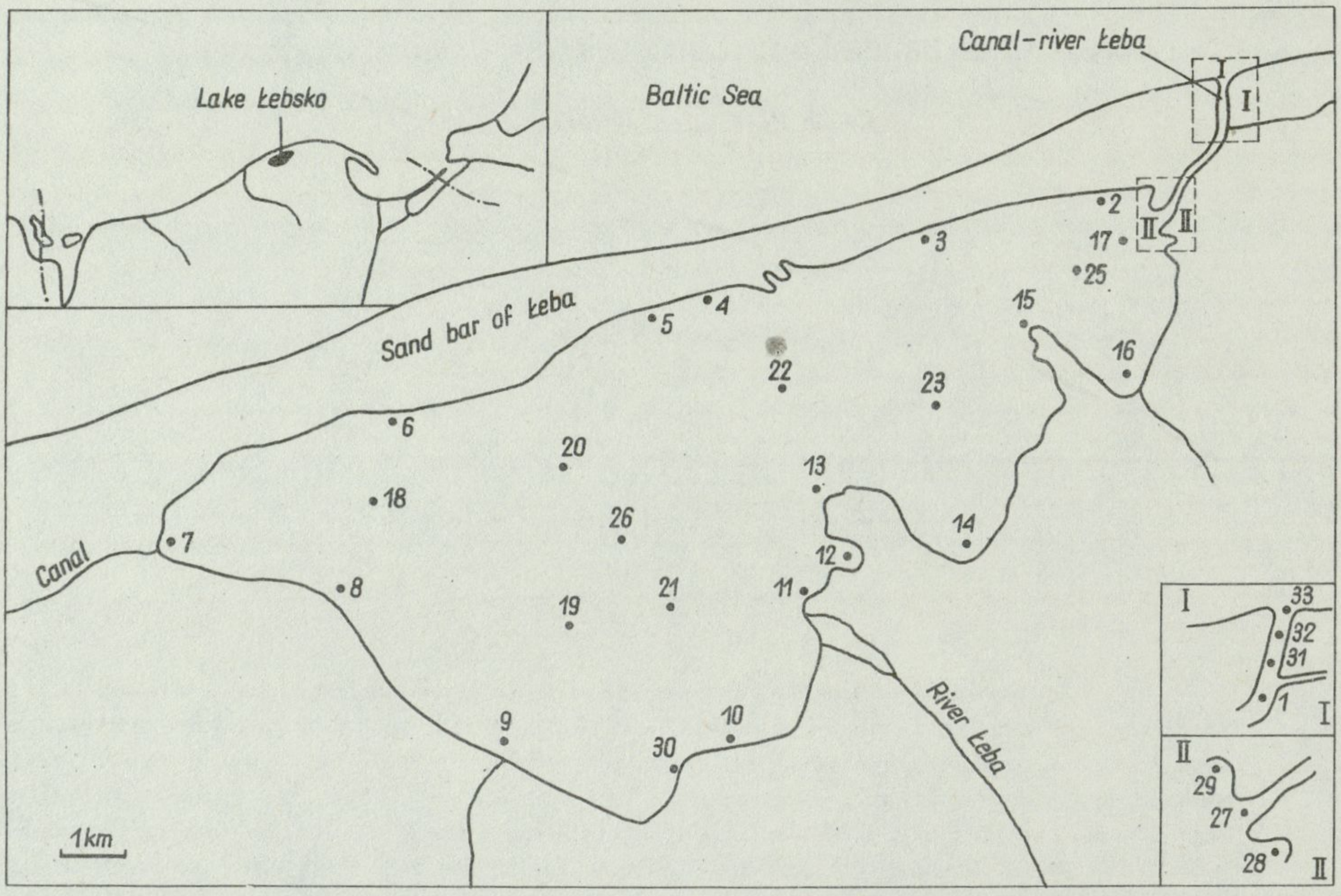


Fig. 1. Location of stations in lake Łebsko (1–33 – station numbers)

The common view is that salinity is the main selecting and modifying factor affecting the mollusc fauna in brackish waters (Demel 1951, Žadin 1952, Żmudziński 1957, Klimowicz 1958, Remane and Schlieper 1958, Wiktor 1960). Less attention has been given to the effect of other ecological factors on the distribution and abundance dynamics of the brackish-water molluscs, although the influence of these factors is often believed to be decisive.

## I. STUDY AREA AND METHOD

The research was carried out on lake Łebsko[1], a brackish lake with a surface of 7, 140 ha, maximum width – 7.6 km, maximum length – 16.4 km, average

[1]The history of lake Łebsko is discussed in Soszka's paper (in press).

depth – 1.7 m and maximum depth – 6.3 m. On its northern side the lake is separated from the Baltic by a sand bar. The river Łeba flows into the lake on its southern side. The canal-river Łeba (Fig. 1) connects lake Łebsko, on its eastern side to the sea. During westerly and north-westerly winds the mobile sand dunes on the sand bar slide into the lake in the middle portion of its northern shore. In many places over the western and southern shores of the lake marsh vegetation is found. A characteristic feature is the numerous floating islands made up of emergent vegetation. Lake Łebsko is a polymictic, strongly eutrophised body of water, characterized by strong waves and currents and considerable influxes of sea water. Most of the bottom surface of the lake is covered by mud, and its smaller proportion by sand. In the eastern part of the lake salinity sometimes exceeded the value of 5 and even 7 S‰. Among the animals found there freshwater forms prevail, but in some regions marine fauna can be seen (Tab. I).

Marine fauna (with no molluscs) observed in lake Łebsko in the years 1963–1965

Tab. I

| Species | Number of stations | Notes on distribution |
|---|---|---|
| *Cordylophora caspia* Pallas | 1, 27, 29, 31 | on *Phragmites communis* Trin. and *Myriophyllum* sp. |
| *Laomedea flexuosa* Alder | 1, 27, 31 | on *Myriophyllum* sp. |
| *Aurelia aurita* L. | 1, 27, 31 | at backward currents |
| *Spirorbis spirorbis* L. | 1, 27, 31 | on *Fucus* sp. |
| *Nereis diversicolor* O. F. Müller | 32 | on sand bottom |
| *Membranipora crustulenta* Pallas | 1, 27, 31 | on *Fucus* sp. |
| *Balanus improvisus* L. | 1–3, 27–29, 31–32 | on *Phragmites communis* Trin. |
| *Talitrus saltator* L. | 31 | on *Enteromorpha* sp. |
| *Gammarus lacusta* L. | 1, 3, 27, 29, 32 | on *Enteromorpha* sp. |
| *Neomysis vulgaris* L. | 1–5, 16–17, 27, 31–32 | in large shoals |
| *Belona acus* L. | 4 | |
| *Salmo salar* L., *Pleuronectes flesus* L., *Petromyzon marinus* L. | 2–6 | caught by fishermen |

Thirty-three stations had been selected on the lake (chiefly littoral, with depths up to about 1 m) where samples were collected in the years 1963–1966 (Fig. 1). At the stations, a great diversity of bottom, abundance of vegetation, waves, currents and salinity is seen (Tab. II). Characteristic is also the microdifferentiation of the environment at the stations considered. This differentiation most often concerns the vegetation, nature of bottom, as well as strength of waves.

The variation of the ecological factors in time is also important as well as their spatial differentiation. As a result, at some of the stations the habitats

## Description of study environments

**Water movement: a – weak, b – medium, c – strong**
**Bottom: a – sand, b – slightly muddy, c – thick mud-layer**
**Vegetation: a – absent, b – emergent, c – submergent (scarce), d – submergent (abundant)**

Tab. II

| Number of station | Water movement | | | Bottom | | | Vegetation | | | | Salinity in S‰ (from-to) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | a | b | c | a | b | c | a | b | c | d | |
| 1 | | x | | | x | | | x | | x | 0.5–6.8 |
| 2 | | x | | | x | | | x | x | | 1.1–3.4 |
| 3 | x | | | | x | | | x | | x | 0.9–2.7 |
| 4 | | x | | | x | | | x | | x | 1.1–2.5 |
| 5 | | x | | x | | | | x | x | | 1.3–2.7 |
| 6 | x | | | | | x | | x | x | | 0.5–2.3 |
| 7 | | x | | | | x | | x | | x | 0.2–1.5 |
| 8 | | x | | | x | | | x | | x | 1.3–2.7 |
| 9 | | x | | | x | | | x | x | | 0.2–2.2 |
| 10 | x | | | x | x | | | x | | x | 0.7–2.3 |
| 11 | | x | | | x | | | | x | | 0.2–2.1 |
| 12 | | x | | | | x | | x | x | | 0.9–1.8 |
| 13 | | | x | x | | | | x | x | | 1.2–2.2 |
| 14 | x | | | | | x | | x | | x | 1.3–2.9 |
| 15 | | | x | x | | | | x | x | | 1.3–3.0 |
| 16 | | x | | | x | | | x | x | | 0.9–3.2 |
| 17 | | | x | x | | | x | | | | 1.6–4.5 |
| 18 | | x | | | x | | x | | | | 1.4–2.7 |
| 19 | x | | | | | x | x | | | | 0.3–0.9 |
| 20 | | x | | | | x | x | | | | 0.9–1.8 |
| 21 | x | | | | | x | x | | | | 0.2–0.9 |
| 22 | | x | | | x | | x | | | | 1.6–2.6 |
| 23 | | x | | | x | | x | | | | 1.6–2.6 |
| 24 | x | | | | | x | x | | | | 0.9–1.8 |
| 25 | | x | | | x | | x | | | | 0.3–1.3 |
| 26 | x | | | | | x | x | | | | 0.6–1.6 |
| 27 | | | x | | x | | | x | x | | 0.3–5.6 |
| 28 | | x | | | x | | | x | x | | 1.4–4.1 |
| 29 | | x | | | x | | | x | | | 1.2–4.2 |
| 30 | x | | | | x | | | x | | x | 0.6–1.9 |
| 31 | | x | | x | | | | x | x | | 0.6–6.8 |
| 32 | | | x | x | | | x | | | | 0.6–7.9 |
| 33 | | | x | x | | | x | | | | 0.6–7.8 |

appeared to vary with the seasons and with the years. Areas once with much sediments over the bottom turned purely sandy ones, e.g. stations 3, 4 and 11. Sand sliding from dunes into the lake could clearly be seen at station 5. and at stations 8, 11 and 14 the mud layers varied considerably in thickness. During the 2-years period the proportion of marsh plants appeared to have increased considerably, e.g. at stations 8, 10 and 30. The level of the water in

the lake also showed considerable periodical variations. Likewise the winds may have caused a change in wave-strength, currents, salinity and bottom, as could be seen at stations 1, 3, 11 and 28. In some parts of the lake the bottom was very muddy, e.g. stations 7, 8, 14 and 29. When describing the stations it is necessary to take into account some chance factors such as farming activities, washing-away of shore fragments and vegetation by waves, and the like.

As indicated above, the environmental conditions of the stations reveal a considerable spatial diversity and seasonal variation, as a result of the action of various ecological factors.

Specimens of molluscs for study were collected 6 times: in the summer of 1963, in the autumn of 1964, in spring, summer and autumn in 1965, and in the winter of 1966. In 1963 specimens were collected at seven stations located in the northern portion of the lake, whereas during the remaining years – at all the stations. A total of 1335 samples was collected, 737 by a quantitative frame (0.25 $m^2$ in surface), 532 by Ekman's apparatus (250 $cm^2$ in section) and 66 by a dredge (30 cm in frame length). At each stations 5 different samples were collected each time. The material collected was put through a sieve with a mesh-size 1 × 1 mm and then preserved in 3% formalin or 70% alcohol. In addition, 187 water samples for salinity analysis were taken. Simultaneously with sample collecting observations were carried out and records made concerning waves, nature of bottom, water level, amount of vegetation and chance changes.

## II. MATERIAL

Eight mussel species and twenty-three snail species were found to occur in lake Łebsko, with a clear predominance of the freshwater species (94‰).

*Bivalvia*: *Mytilus edulis* L., *Unio tumidus* Retz., *U. pictorum* L., *Anodonta anatina* L., *Pisidium* sp., *Sphaerium* sp., *Dreissena polymorpha* Pall. and *Macoma baltica* L.

*Gastropoda*: *Theodoxus fluviatilis* L., *Viviparus viviparus* L., *Valvata piscinalis* f. *antiqua* Sow., *V. pulchella* Stud., *V. cristata* Müll., *Potamopyrgus jenkinsi* Smith., *Bithynia tentaculata* L., *Lymnaea stagnalis* L., *Radix auricularia* L., *R. limosa* L., *Galba palustris* Müll., *Physa fontinalis* L., *Acroloxus lacustris* L., *Planorbarius corneus* L., *Planorbis planorbis* L., *Anisus vortex* L., *A. septemgyratus* Bielz., *Bathyophalus contortus* L., *Gyraulus albus* Müll., *G. crista* f. *cristatus* Drap., *G. crista* f. *spinulosus* Cless., *Segmentina complanata* Drap., *S. nitida* Müll., *Succinea oblonga* Drap.

Shell fragments of two marine mussel species were found: *Mya arenaria* L. and *Cardium lamarcki* Reeve, while in the Łeba canal-river living individuals of other sea mussel were collected: *Mytilus edulis* L. and *Macoma baltica* L. In the lake three species common to the Baltic and lake Łebsko, were present: *Theodoxus fluviatilis*, *Potamopyrgus jenkinsi* and *Radix limosa*.

Range of distribution of individual mollusc species in lake Łebsko in the years 1963–1965

Tab. III

| Species | Occurrence | |
|---|---|---|
| | Number of stations | Percent |
| *Radix auricularia* | 1 | 3.0 |
| *Valvata pulchella* | 1 | 3.0 |
| *Macoma baltica* | 1 | 3.0 |
| *Sphaerium* sp. | 1 | 3.0 |
| *Unio pictorum* | 1 | 3.0 |
| *U. tumidus* | 1 | 3.0 |
| *Anisus septemgyratus* | 2 | 6.1 |
| *Gyraulus crista* f. *cristatus* | 2 | 6.1 |
| *G. crista* f. *spinulosus* | 3 | 9.1 |
| *Mytilus edulis* | 3 | 9.1 |
| *Segmentina nitida* | 4 | 12.1 |
| *S. complanata* | 5 | 15.2 |
| *Gyraulus albus* | 5 | 15.2 |
| *Potamopyrgus jenkinsi* | 5 | 15.2 |
| *Theodoxus fluviatilis* | 6 | 18.2 |
| *Valvata cristata* | 7 | 21.2 |
| *Acroloxus lacustris* | 7 | 21.2 |
| *Succinea oblonga* | 7 | 21.2 |
| *Planorbarius corneus* | 8 | 24.2 |
| *Anodonta anatina* | 8 | 24.2 |
| *Anisus vortex* | 9 | 27.3 |
| *Viviparus viviparus* | 9 | 27.3 |
| *Dreissena polymorpha* | 11 | 33.3 |
| *Valvata piscinalis* f. *antiqua* | 12 | 36.4 |
| *Bathyomphalus contortus* | 14 | 42.4 |
| *Physa fontinalis* | 15 | 45.5 |
| *Galba palustris* | 15 | 45.5 |
| *Lymnaea stagnalis* | 15 | 45.5 |
| *Planorbis planorbis* | 17 | 51.5 |
| *Bithynia tentaculata* | 18 | 54.5 |
| *Radix limosa* | 19 | 57.6 |

Individual species of molluscs in the lake varied in their range of distribution (Tab. III). The snail *Radix limosa* occurred at most of the stations under study. The range of distribution of some other snail species: *Bithynia tentaculata* and *Planorbis planorbis*, was not much smaller. On the other hand some of the species were found to occur at one station only, e.g. *Macoma baltica*, *Unio tumidus* and *U. pictorum*. The number of mollusc species varied from station to station (Fig. 2).

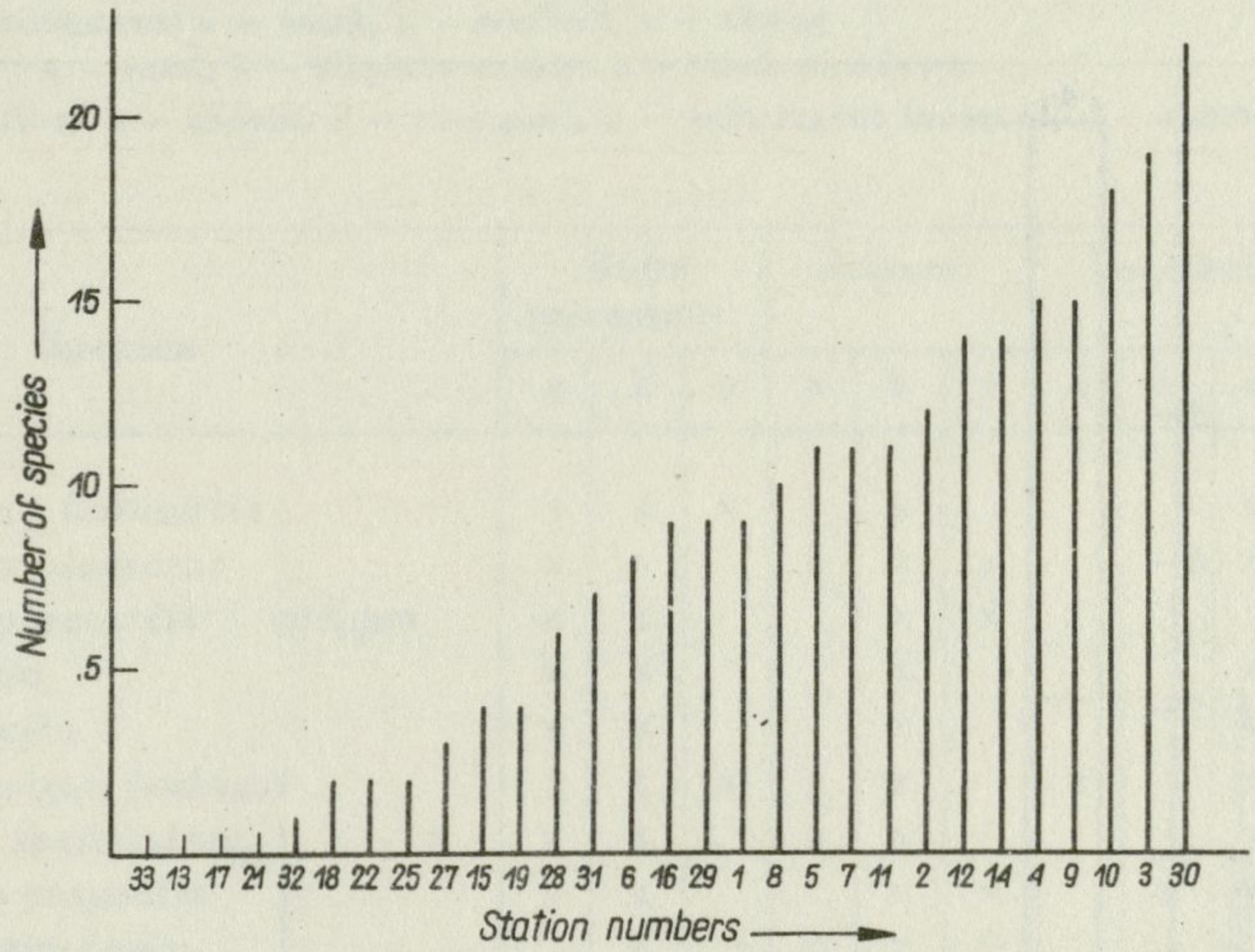


Fig. 2. Total number of mollusc species at different stations in lake Łebsko in the years 1963–1965

## III. THE EFFECT OF SOME ECOLOGICAL FACTORS ON THE MOLLUSC FAUNA

An analysis was made of the relationship between the occurrence and abundance dynamics of the molluscs in the lake littoral and the following ecological factors: waves and currents, nature of lake bottom, amount of vegetation and salinity.

### 1. The effect of waves and currents

Lake Łebsko is characterized by strong waves and currents. The stations here considered clearly vary in this respect. The strongest movement of water was observed in the canals, at river mouths and in open areas; in areas sheltered by a broad belt of emergent vegetation (e.g. stations 1, 2 and 29) the weakest water movement was recorded. A similarly weak movement of water was seen in bays protected by spits, and among piles and submerged tree branches (e.g. station 11).

An increase in the water movement appeared to be followed by a decrease of the number of species and of the size of mollusc populations (Fig. 3). A similar relationship was reported by Sandner (1953) from his study on the ecology of the leeches of lake Łebsko. In his analysis of the factors limiting the occurrence of freshwater organisms Macan (1961) also draws attention to the considerable influence of water movement, while Klimowicz (1958)

and Ökland (1964) have found that in areas with strong waves most often no molluscs are found.

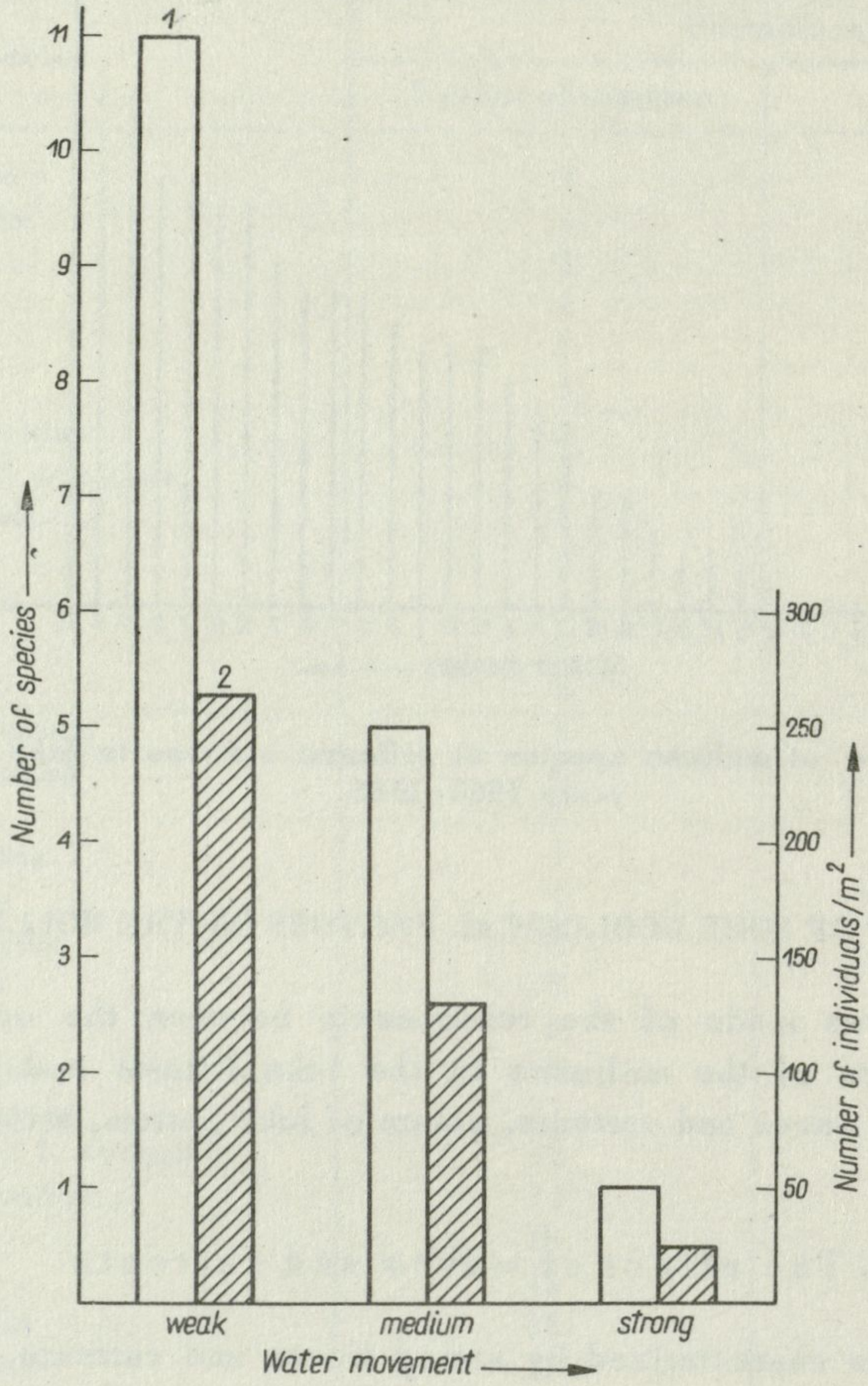


Fig. 3. Relationship between the number of species and of individuals of molluscs in lake Łebsko littoral, and the movement of water
1 – number of species, 2 – number of individuals

It has been found that three of the snail species: *Theodoxus fluviatilis*, *Radix limosa* and *Potamopyrgus jenkinsi* can live in areas with the strongest water movement (Tab. IV). Other authors (Hubendick 1947, Kaiser 1950 after Ökland 1964, Miëgel 1958, Meier-Brook 1963 and Ökland 1964) have also reported *T. fluviatilis* to be often found in regions with strong currents. Klimowicz (1958) found *Potamopyrgus jenkinsi* in habitats where the currents were strong.

In lake Łebsko in areas with a weak water movement most of the mollusc

Occurrence of molluscs in different environments of lake Łebsko during the years 1963–1965

Water movement: a – weak, b – medium, c – strong
Bottom: a – sand, b – slightly muddy, c – thick mud-layer
Vegetation: a – absent, b – emergent, c – submergent (scarce), d – submergent (abundant)

Tab. IV

| Species | Water movement | | | Bottom | | | Vegetation | | | | Salinity in S‰ (from-to) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | a | b | c | a | b | c | a | b | c | d | |
| *Theodoxus fluviatilis* | x | x | x | | x | | | | x | x | 0.2–6.6 |
| *Viviparus viviparus* | x | x | | x | x | x | | | x | | 0.2–4.2 |
| *Valvata piscinalis* f. *antiqua* | x | x | | | x | x | x | | | | 0.2–3.1 |
| *V. cristata* | x | x | | | x | | | | x | | 0.2–2.2 |
| *V. pulchella* | x | x | | | x | | | | x | | 0.2–1.5 |
| *Potamopyrgus jenkinsi* | | x | x | x | x | | x | | x | | 0.2–6.4 |
| *Bithynia tentaculata* | x | x | | x | x | | | | x | x | 0.2–6.2 |
| *Lymnaea stagnalis* | x | x | | | x | x | | x | x | x | 0.3–6.2 |
| *Radix auricularia* | | x | | x | x | | | | | x | 0.9–2.2 |
| *R. limosa* | x | x | x | x | x | x | | | x | x | 0.2–7.6 |
| *Galba palustris* | x | x | | | x | x | | | x | x | 0.2–6.6 |
| *Physa fontinalis* | x | x | | | x | | | | x | x | 0.2–4.3 |
| *Acroloxus lacustris* | x | x | | | x | | | | x | | 0.2–3.6 |
| *Planorbarius corneus* | x | x | | | x | x | | | x | x | 0.2–3.2 |
| *Planorbis planorbis* | x | x | | | x | x | | | x | x | 0.2–6.6 |
| *Anisus vortex* | x | x | | | x | | | | x | x | 0.2–2.5 |
| *A. septemgyratus* | x | x | | | x | | | | x | x | 0.2–1.7 |
| *Bathyomphalus contortus* | x | x | | | x | | | | x | x | 0.2–5.1 |
| *Gyraulus albus* | x | x | | | x | | | | x | | 0.2–1.8 |
| *G. crista* f. *cristatus* | x | x | | | x | | | | x | x | 0.2–1.4 |
| *G. crista* f. *spinulosus* | x | x | | | x | | | | x | x | 0.2–1.4 |
| *Segmentina nitida* | x | x | | | x | | | | x | x | 0.8–2.1 |
| *S. complanata* | x | x | | | x | | | | x | x | 0.8–2.2 |
| *Anodonta anatina* | x | x | | x | x | x | x | | | | 1.2–3.8 |
| *Dreissena polymorpha* | x | x | x | x | x | x | x | | | | 1.2–3.8 |
| *Unio pictorum* | x | x | | | x | | x | | | | 0.9–3.8 |
| *Pisidium* sp. | x | x | | | x | x | x | | | | 0.8–2.1 |
| *Sphaerium* sp. | x | x | | | x | x | | | | x | 1.4–2.8 |
| *Succinea oblonga* | x | x | | x | x | | | x | | | 1.3–4.3 |

species occur and some of the snail species, e.g. *Segmentina nitida*, *Gyraulus crista* and *Valvata cristata*, occur in no other environments. An unfavourable effect of waves on the molluscs, and particularly on some snail species such as *Valvata cristata*, *Gyraulus crista* and *Bathyophalus contortus*, has also been described by Ökland (1964).

Water movement affects the molluscs directly or indirectly. Its direct action is mechanical – individuals of two mussel species, *Anodonta anatina* and *Dreissena polymorpha*, were often seen being swept ashore (especially the

northern shore of the lake) by waves. The indirect action of the water movement on the molluscs is associated with its effect on other ecological factors, namely, the lake bottom and salinity. Strong waves cause a displacement of sand, which makes it difficult for the molluscs to move. Moreover, it creates adverse food conditions owing to the continuous washing-away of organic particles and of plant debris, and at the same time causing rapid variations in the salinity. Waves also make the laying of eggs difficult. Observations on the adverse effect of waves and currents on the movement and on the trophic conditions of the molluscs agree with the studies by Žadin (1927 after Klimowicz 1958) and those by Klimowicz (1958).

In the brackish lake here discussed a clear effect of the movement of water on the mollusc fauna is seen. In view of the hydrological nature of lake Łebsko the effect of the strength of water movement in it may play an important role by controlling the occurrence and the numbers of the molluscs.

## 2. The role of the lake bottom

Lake Łebsko has a strongly diversified bottom. It appears to be covered with mud in its central part and near the western and south-western shore, whereas in the eastern, south-eastern and partly in the north-eastern off-shore areas the bottom is mostly sandy.

It has been widely recognised that the distribution of the mollusc fauna, and of snails in particular, depends on the nature of the bottom (Žadin 1952, Frömming 1956).

A closer study of the role of the bottom in the distribution of the mollusc fauna has shown that these organisms avoid a sand bottom as well as a bottom that is very muddy. They find optimum conditions on a medium-muddy bottom (Fig. 4).

The nature of the bottom often depends on the force of the movement of water and its effect on the mollusc fauna is associated with the abundance of vegetation or salinity value. A sandy bottom as a rule is devoid of submergent and floating vegetation and there is little plant debris on it; the adverse effect of the bottom discussed on the mollusc fauna is probably reinforced by a high salinity. Environments of this kind probably have not enough food for the molluscs, and according to many authors food is the factor determining the occurrence of molluscs (Schermer 1951 after Ökland 1964, Frömming 1956, Dentham-Jutting 1959 after Ökland 1964).

Eight mollusc species were found to occur on sand bottom (Tab. IV). The snail *Potamopyrgus jenkinsi* was reported by Żmudziński (1957) to occur on sand bottom, while for *Bithynia tentaculata* and *Radix limosa* the sand bottom zones were probably only a place of their temporary presence.

The presence of the mussels *Anodonta anatina* and *Dreissena polymorpha* on the bottom described above was most probably the result of their being

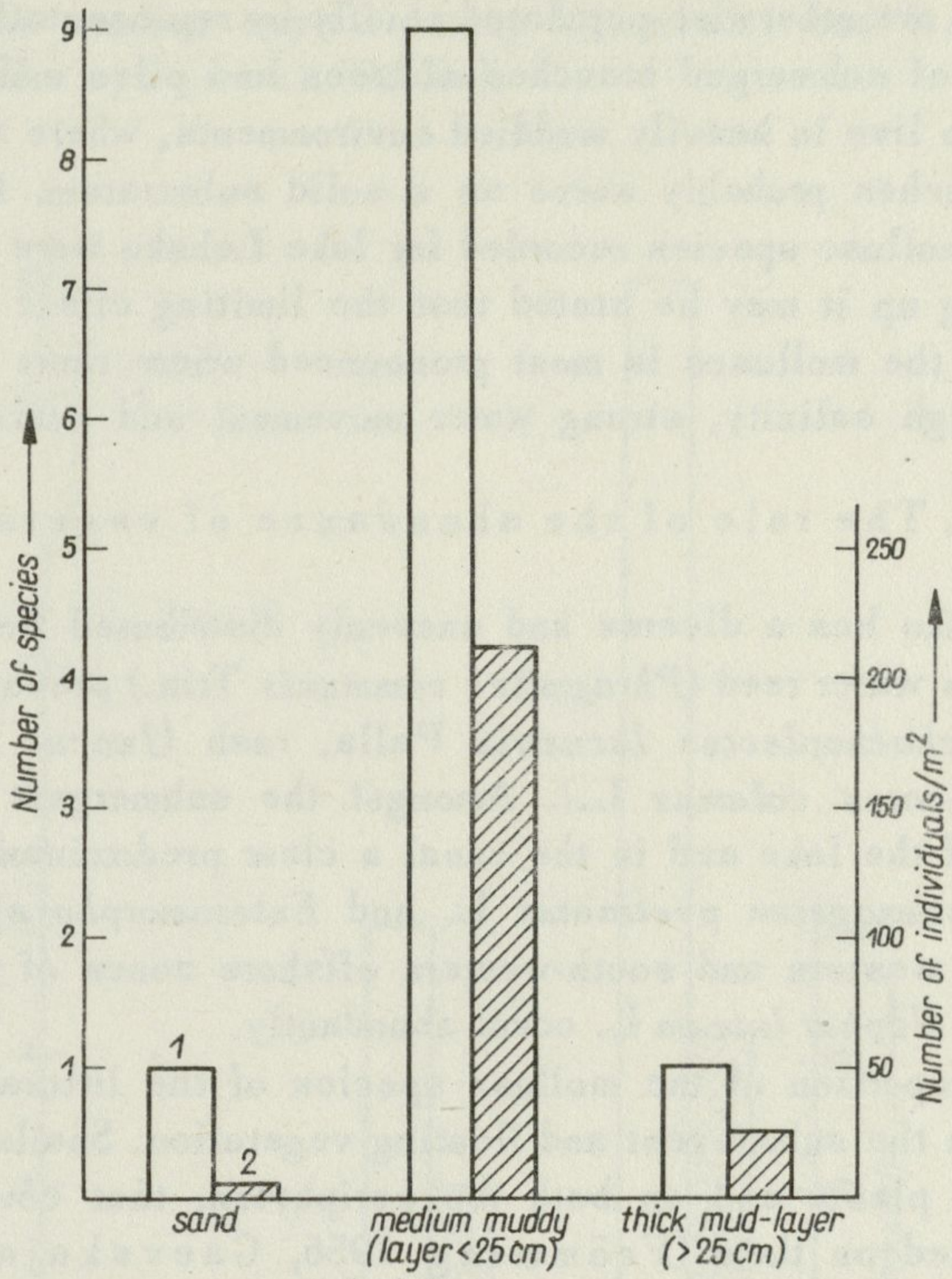


Fig. 4. Relationship between the number of species and of individuals of molluscs in lake Łebsko littoral, and the nature of lake bottom
1 – number of species, 2 – number of individuals

carried there by strong waves. However, some authors have reported the occurrence of *Dreissena polymorpha* (Żmudziński 1957, Wiktor 1960, Mikulski and Giziński 1961) and *Anodonta anatina* (Mikulski and Giziński 1961) on sand bottom.

It was observed that thick layers of mud, displaced by water motion, covered the molluscs present there. An intense mineralization going on in the bottom sediments may result in an oxygen deficiency. Klimowicz (1958) thinks that a deficiency of oxygen may become the cause of molluscs elimination. Mud particle motion makes the movement of molluscs difficult, while due to the less abundant vegetation in very muddy zones unfavourable trophic conditions are created. In those zones 11 mollusc species were found. The common *Viviparus viviparus* and representatives of the family *Planorbidae* possess a higher haemoglobin content than that found in other snails. It is probably

for this reason that they may live in areas with lower oxygen supplies. The muddy habitats are otherwise populated chiefly by representatives of *Pulmonata*. The presence of submerged branches of trees and piles makes it possible for the molluscs to live in heavily muddied environments, where there is no vegetation. The branches probably serve as a solid substratum. In medium-muddied areas all the mollusc species recorded for lake Łebsko were present (Tab. IV).

In summing up it may be stated that the limiting effect of an unfavourable substratum on the molluscs is most pronounced where there is a simultaneous action of a high salinity, strong water movement and scarcity of vegetation.

### 3. The role of the abundance of vegetation

Lake Łebsko has a diverse and unevenly distributed flora. Amongst emergent vegetation water reed (*Phragmites communis* Trin.) prevails; other abundant plants are: *Schoenoplectus lacustris* Palla, rush (*Juncus inflexus* L.) and sweet flag (*Acorus calamus* L.). Amongst the submergent vegetation in the eastern part of the lake and in the canal a clear predominance of *Potamogeton lucens* L., *Potamogeton pectinatus* L. and *Enteromorpha* sp. is seen. In the north-western, western and south-western offshore zones of the lake *Stratiotes aloides* L. and *Nuphar luteum* L. occur abundantly.

A large proportion of the mollusc species of the littoral zones is closely connected with the submergent and floating vegetation. Snails may feed directly on the higher plants and on both the periphyton, that covers them, and the debris deposited on them (Frömming 1956, Gaevskaja 1966). For some species this vegetation serves as a substratum (Stańczykowska 1960a, Mikulski and Karassowska 1960, Ökland 1964) and it checks the action of the waves (Ökland 1964).

The above findings explain the distinct relationship between the amount of vegetation and the mollusc fauna, found in lake Łebsko (Fig. 5). Some snails species occurred exclusively on plants e.g. *Acroloxus lacustris*, *Gyraulus crista* and *Valvata cristata*. The relationship between the occurrence of snails and the amount of vegetation is to some extent trophical in nature.

In areas where there is no vegetation snails occur in very small numbers (Fig. 5). In those areas also unfavourable conditions were observed with regard to food supplies, waves and nature of bottom.

The largest populations of molluscs are found in habitats with abundant vegetation. In these habitats the numbers of individuals and the number of mollusc species are almost twice as large as in the areas where vegetation is scarce. This relationship is most marked during summer. Ökland (1964) found some mollusc species (*Acroloxus lacustris*, *Valvata cristata* and *Segmentina complanata*) to be more abundant in environments rich in vegetation. A similar relationship has also been reported by Frömming (1956).

As some of the snail species live on specific plant species, the influence

of vegetation on the number of *Gastropoda* species was more pronounced. This is confirmed by the studies carried out by Mikulski and Karassowska (1960), and by Stańczykowska (1960a).

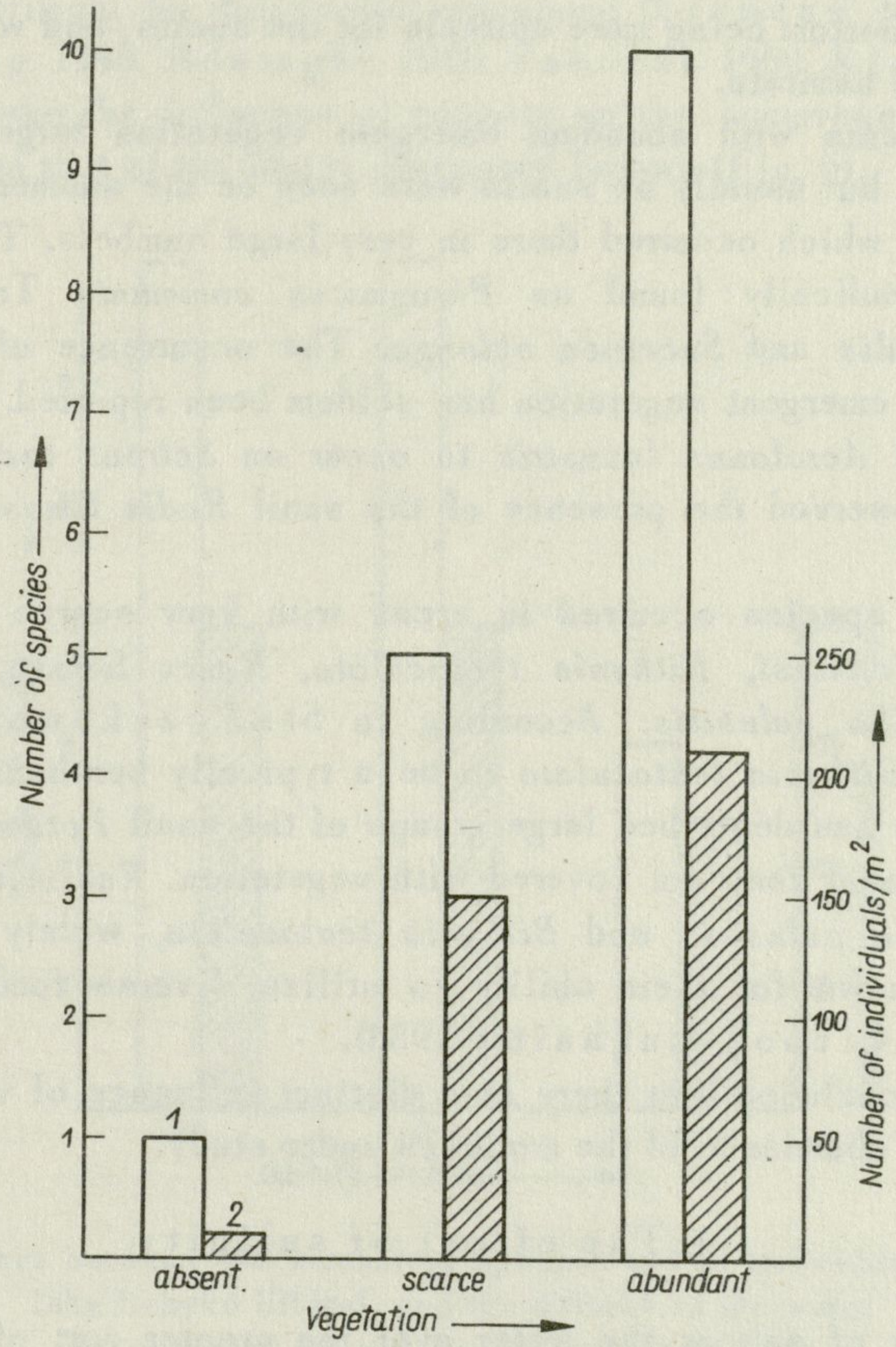


Fig. 5. Relationship between the number of species and of individuals of molluscs in lake Łebsko littoral, and the abundance of vegetation

1 – number of species, 2 – number of individuals

On submergent vegetation molluscs form larger populations and occur in large number of species than on floating vegetation (Mikulski and Karassowska 1960). In lake Łebsko the most abundant snail fauna was observed in habitats with *Stratiotes aloides* L., *Nuphar luteum* L. and *Enteromorpha* sp. This probably resulted from the fact that both *Stratiotes aloides* L. and *Nuphar luteum* L. grew in environments where currents where weak and the salinity was not very high. On plant species such as *Batrachium aquatile* L., *Myriophyllum spicatum* L., *Elodea canadensis* Rich., *Potamogeton* sp. and *Cerato-*

*phyllum demersum* L. the snail fauna appeared to be less abundant. The above results do not entirely agree with the data reported by Mikulski and Karassowska (1960) or those by Stańczykowska (1960a). These authors found abundant snail fauna on *Ceratophyllum demersum* L., *Myriophyllum spicatum* L. and *Potamogeton* sp. in freshwater habitats. This was probably connected with the bottom being more suitable for the snails, and with weak current of water in those habitats.

In environments with abundant emergent vegetation large populations of snails occurred, but usually no snails were seen on the submerged parts of the emergent plants which occurred there in very large numbers. The only species that were sporadically found on *Phragmites communis* Trin. stems were *Lymnaea stagnalis* and *Succinea oblonga*. The occurrence of snails on submerged parts of emergent vegetation has seldom been reported. Ökland (1964) found the snail *Acroloxus lacustris* to occur on *Scirpus lacustris* L , while Berg (1938) observed the presence of the snail *Radix limosa* on *Phragmites communis* Trin.

Some snail species occurred in areas with very scarce vegetation, e.g. *Potamopyrgus jenkinsi*, *Bithynia tentaculata*, *Radix limosa*, *Planorbis planorbis* and *Galba palustris*. According to Stańczykowska (1964) some authors regard *Bithynia tentaculata* to be a typically benthonic species. Klimowicz (1958) has described large groups of the snail *Potamopyrgus jenkinsi* in the offshore mud zone not covered with vegetation. *Radix limosa*, *Planorbis planorbis*, *Galba palustris* and *Bithynia tentaculata*, widely spread in lake Łebsko, are known for their ability to utilize diverse food (Žadin 1952, Schäfer 1953, Cichon-Lukanina 1958).

It may be concluded that there is a distinct influence of vegetation on the distribution and abundance of the molluscs under study.

## 4. The effect of salinity

The content of salt in the water over the greater part of lake Łebsko is much higher than that found in fresh waters. The distribution of salinity in the lake and in the Łeba river-canal varies in space and time. At stations located in areas nearest to the sea salinity appears to be the highest (Tab. II), e.g. stations 1, 2 and 33, and shows the greatest variations, for instance from 0,8 to 7.8 S‰. The lowest values of salinity and its smallest variation in time were recorded for stations situated in the southern and south-western parts of the lake, e.g. stations 8, 10 and 11. Zonation of salinity was not always observable. For some zones over lake Łebsko Sandner (1953) and Guttowa (1956) reported a higher salinity than that determined during the present research.

In his study on the distribution of freshwater molluscs in the coastal lagoon of Vistula (Zalew Wiślany) Klimowicz (1958) has found that this depends primarily on salinity. According to Remane and Schlieper (1958) for the

freshwater organisms living in brackish water the critical salinity is 3–5 S‰.

On the other hand, it has been found, both under experimental conditions and in the natural habitats, that freshwater molluscs can live in waters with a higher salinity than the maximum salinity in lake Łebsko which exceeds the salinity value critical for freshwater organisms (Gresens 1928, Schlesch 1938, Lindberg 1948, Boettger 1950, Jaeckel 1960, Klekowski 1963).

In lake Łebsko the influence of salinity on the occurrence of molluscs is less distinct than that of the above discussed factors (Fig. 6).

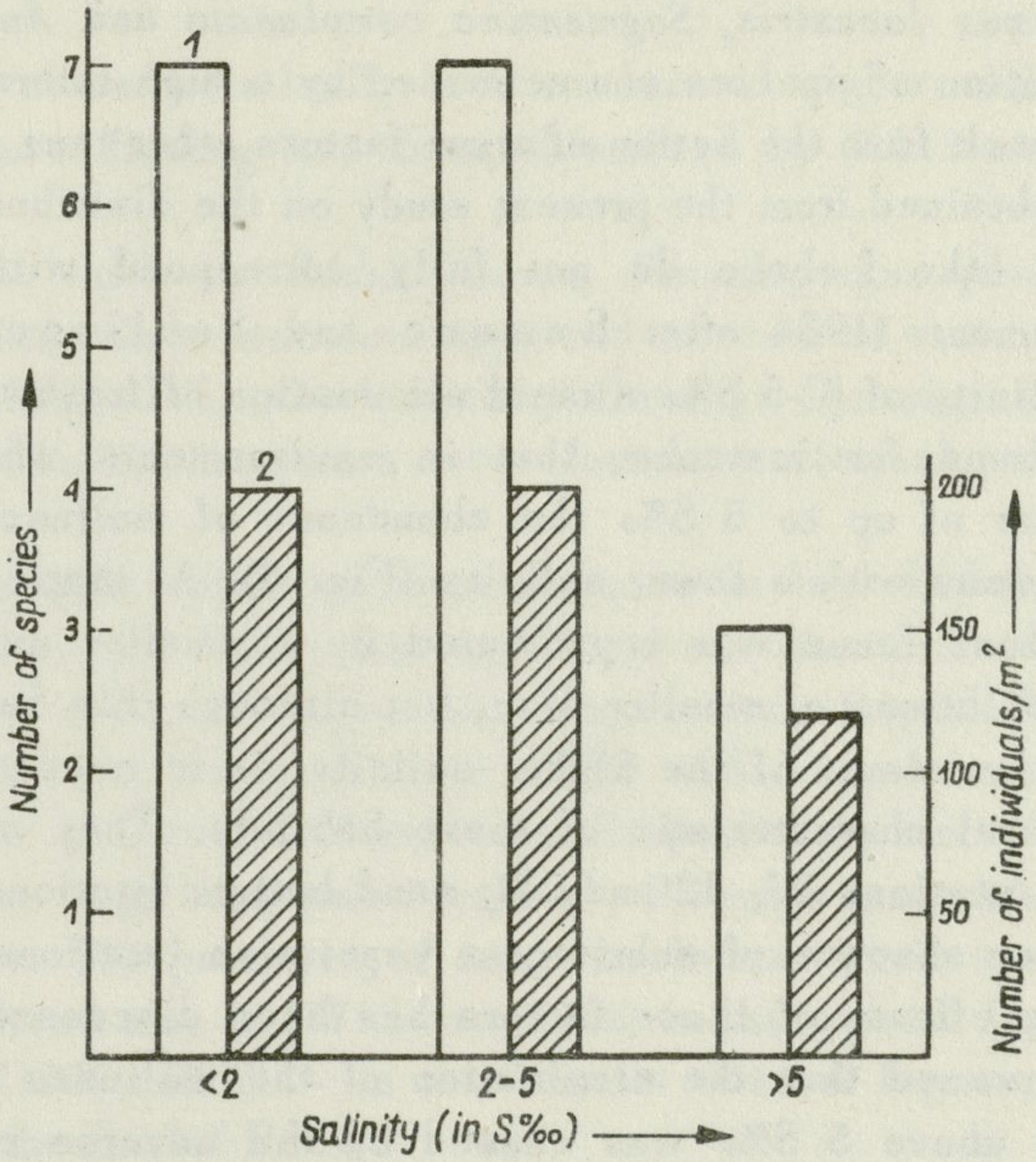


Fig. 6. Relationship between the number of species and of individuals of molluscs in lake Łebsko littoral, and the salinity of the water
1 – number of species, 2 – number of individuals

In certain cases the following factors may have a stronger eliminating effect than that of salinity: fast flow water, unsuitable substratum, absence of submergent or floating vegetation. Molluscs were, for instance, found to be absent nearly from the whole part of the Łeba river-canal before the Łeba harbour, whereas at station 1, where the salinity was higher, 7 freshwater mollusc species occurred.

Likewise, data from other environments with high salinity values (e.g. stations 2, 28, 29 and 31) support the supposition that ecological factors other than salinity play an important role. In areas exposed to waves or strong currents, and with a diversified bottom and vegetation the mollusc fauna clearly varied in respect of both the number of species and the number of

individuals. In this case the important factor was not salinity but the amount of vegetation and the nature of the bottom. In environments with no shelter to check waves, and with a sand bottom or one that was heavily muddied and devoid of vegetation molluscs were very rare, while in the nearby habitats (at a distance of no more than 10 m), with the same salinity, they appeared to be represented by from 5 to 8 snail species (e.g. areas close to stations 1, 2, 28 and 29). Moreover, the distribution of individual freshwater mollusc species in the zones with different salinity over lake Łebsko does not always correspond with their tolerance of salinity (e.g. *Theodoxus fluviatilis*, *Viviparus viviparus*, *Acroloxus lacustris*, *Segmentina complanata* and *Anodonta anatina*). A limited distribution of species characterized by a high tolerance with regard to salinity may result from the action of some factors other than salinity.

The results obtained from the present study on the distribution of molluscs in the brackish lake Łebsko do not fully correspond with the statement published by Remane (1934 after Remane and Schlieper 1958) that in waters with a salinity of 3–5 S‰ a rapid elimination of freshwater fauna takes place. It was found for instance, that in environments where the salinity attained the value of up to 5 S‰ the abundance of molluscs was not much smaller than in areas with a lower salinity (Fig. 6). At stations with a higher salinity the mollusc fauna was represented by a smaller number of species forming there populations of smaller size, but although this had no doubt been to some extent the result of the higher salinity, it is necessary to take into account the general characteristic of these habitats. They are characterized by strong waves (stations 27, 32 and 33), sand bottom (stations 31, 32 and 33) and by scarcity or absence of submergent vegetation (stations 27, 31, 32 and 33). The adverse effects of these factors has been discussed above. It may, therefore, be presumed that the elimination of the molluscs at stations with a salinity value above 5 S‰ was caused by the adverse conditions of the environment in general. The knowledge of the tolerance of molluscs with regard to salinity and its variations would make it easier to find the ultimate explanation of the above problem.

In the Łeba river-canal two marine mussel species were found: *Mytilus edulis*, and *Macoma baltica*. The entrance of marine mussels to environments with rather a low salinity has often been reported (Demel 1951, Žadin 1952, Mulicki 1957, Żmudziński 1957, 1967, Klimowicz 1958, Wiktor 1960, 1962, Hunter-Russel 1961, Jażdżewski 1962). It seems that in the case here considered the mussels had been carried over to the Łeba river-canal.

In the literature there are reports describing the dwarfing phenomenon among both the marine molluscs living in freshened zones (Žadin 1952, Zienkiewicz 1959, Demel 1962) and the freshwater molluscs found in brackish waters (Raabe 1956, Klimowicz 1958). Dwarfed individuals of *Radix limosa* were found in the Łeba river-canal. It should be considered that the cause of

this process is also the ecologically unfavourable conditions in general, and not only, as generally assumed, the high salinity. A similar view has been published by Raabe (1956). The above assumption is supported also by the occurrence of dwarfed individuals of *Planorbis planorbis* in areas with a low salinity (near station 6).

Fragments of shells of the marine mussels *Mya arenaria* and *Cardium lamarcki* were also found in lake Łebsko (over a large area). These had no doubt been carried over from the sea to the lake. Klimowicz (1958) also observed *Cardium lamarcki* shells being carried to the Vistula coastal lagoon from the sea.

Mussels are characteristically less tolerant of higher salinity than are the snails. The above finding has been described by Klimowicz (1958) and Wiktor (1960).

Snail species such as *Radix limosa*, *Potamopyrgus jenkinsi*, *Theodoxus fluviatilis* and *Bithynia tentaculata* appeared to occur at stations with a salinity above 5.5 S‰ (Tab. IV), whereas the following: *Gyraulus albus*, *Segmentina complanata* and *Valvata cristata* were found at stations where the salinity was low.

Some of the snail species known to occur in lake Łebsko are also found in the Baltic. They are: *Radix limosa*, *Theodoxus fluviatilis* and *Potamopyrgus jenkinsi* (Demel 1927, 1935, Bursa, Wojtusiak K. and Wojtusiak R. J. 1947, Żmudziński 1961). Žadin (1952) and Zienkiewicz (1959) have also reported the occurrence of some snail species in more freshened regions of the Baltic sea (e.g. *Viviparus viviparus*, *Bithynia tentaculata*, *Planorbis* sp. and *Lymnaeidae*). The presence of some freshwater snail species in brackish waters was observed also by: Wiktor (1962) in the coastal lagoon of Szczecin, Żmudziński (1957, 1967) – in the Vistula coastal lagoon, and Jażdżewski (1962) – in the Bay of Puck.

Although many authors have found that salinity plays a significant role in the distribution of the freshwater fauna (Remane 1934 after Remane and Schlieper 1958, Sandner 1953, Guttowa 1956, Tasjunas 1959, Macan 1961, Hartog 1963, Kinne 1964a, 1964b), in lake Łebsko in many cases salinity was not the most important factor eliminating freshwater mollusc fauna. It may be presumed that in this lake the elimination and the abundance dynamics of the molluscs are shaped by several factors; the action of the particular factors may vary.

## IV. QUANTITATIVE AND QUALITATIVE VARIATIONS OF THE MOLLUSC FAUNA

A strongly marked regularity of the mollusc fauna in lake Łebsko is its quantitative and qualitative variation in time and space (Fig. 7 and 8). The cause of this variability is first of all the complex interaction of many variable ecological factors, and sometimes also the action of some chance factors.

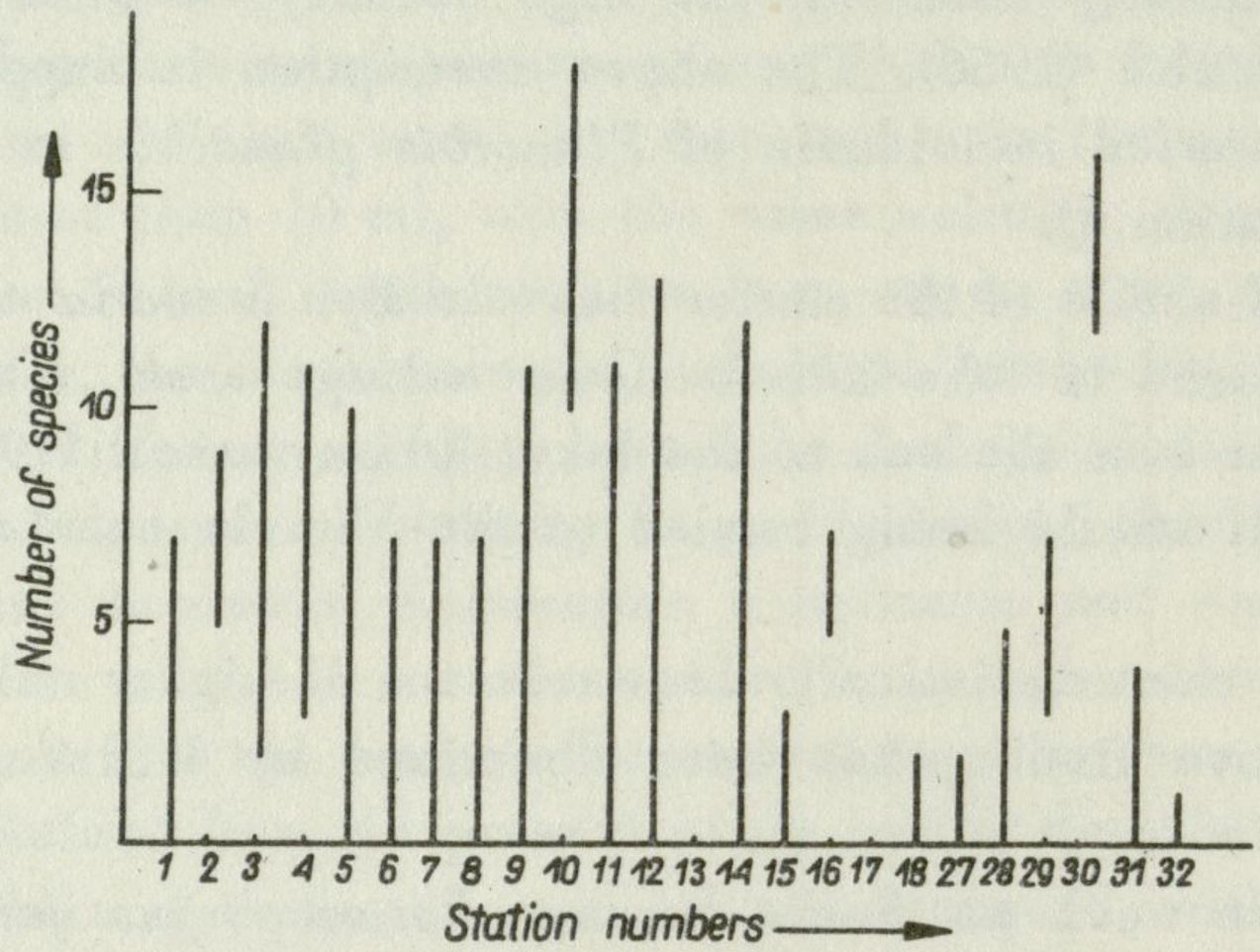


Fig. 7. Range of variation of the number of mollusc species at different stations in lake Łebsko littoral in the years 1963–1965

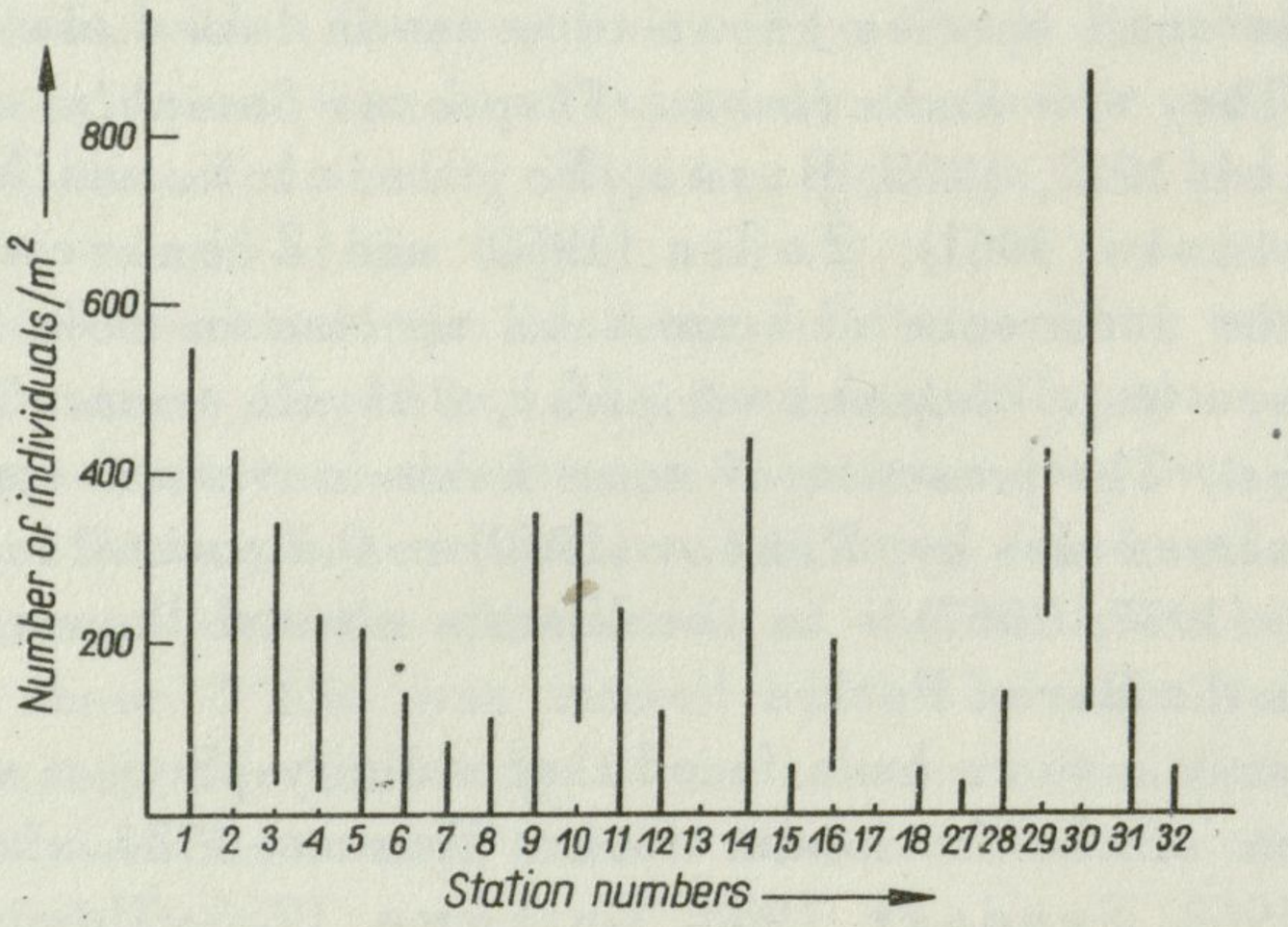


Fig. 8. Range of variation of the number of mollusc individuals at different stations in lake Łebsko littoral in the years 1963–1965

At some stations the variations in the number of species came up to 12 species (stations 12 and 14) (Fig. 7). Variations in the number of individuals were also considerable (Fig. 8).

A considerable variation in time too was evident (Fig. 9 and 10). The largest numbers of species and of individuals in populations were recorded during summer, and the lowest in winter. At individual stations the species varied with the seasons. The number of species and of individuals also varied from year to year.

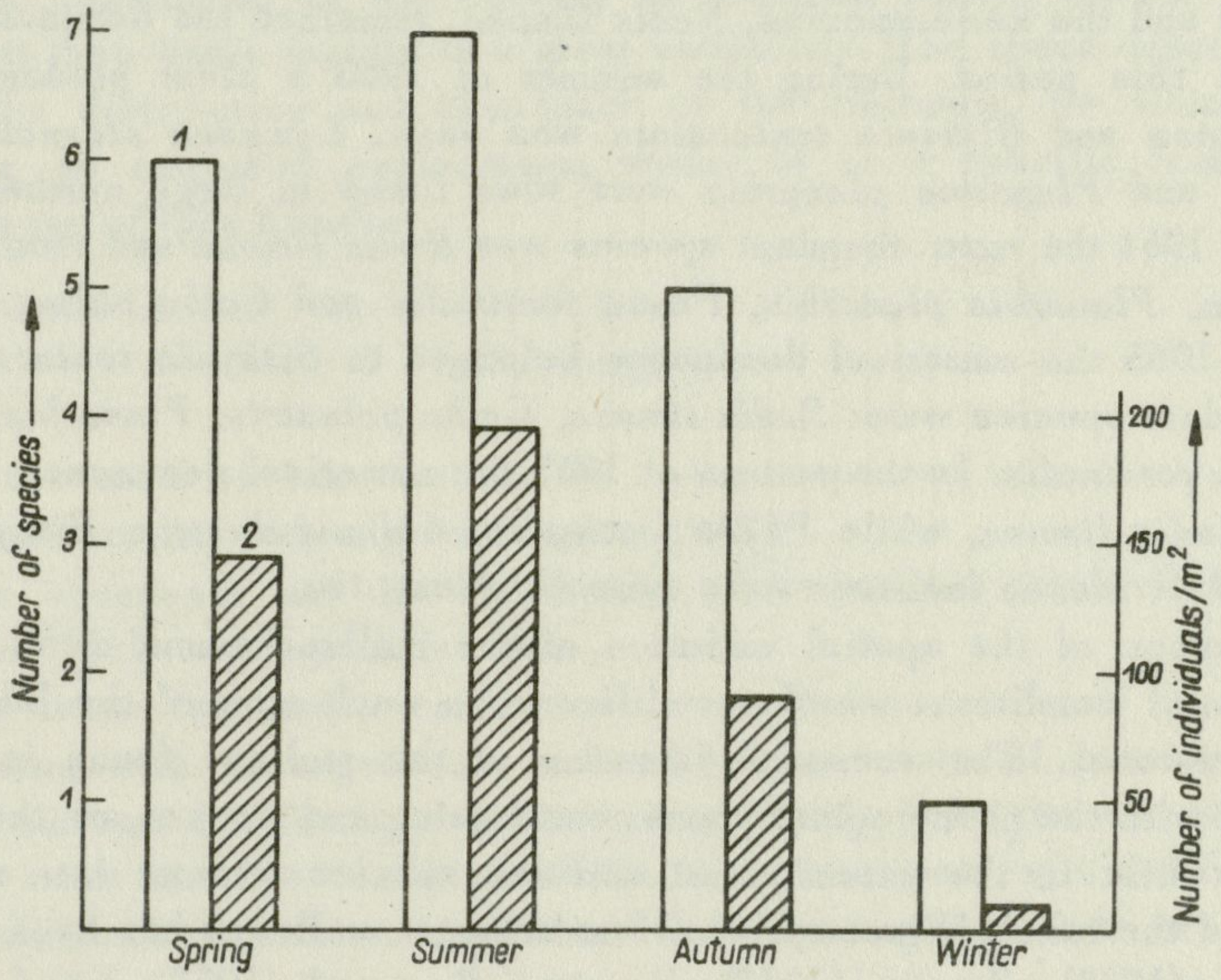


Fig. 9. Seasonal variation of the number of species and of individuals of molluscs in lake Łebsko littoral in 1965
1 – number of species, 2 – number of individuals

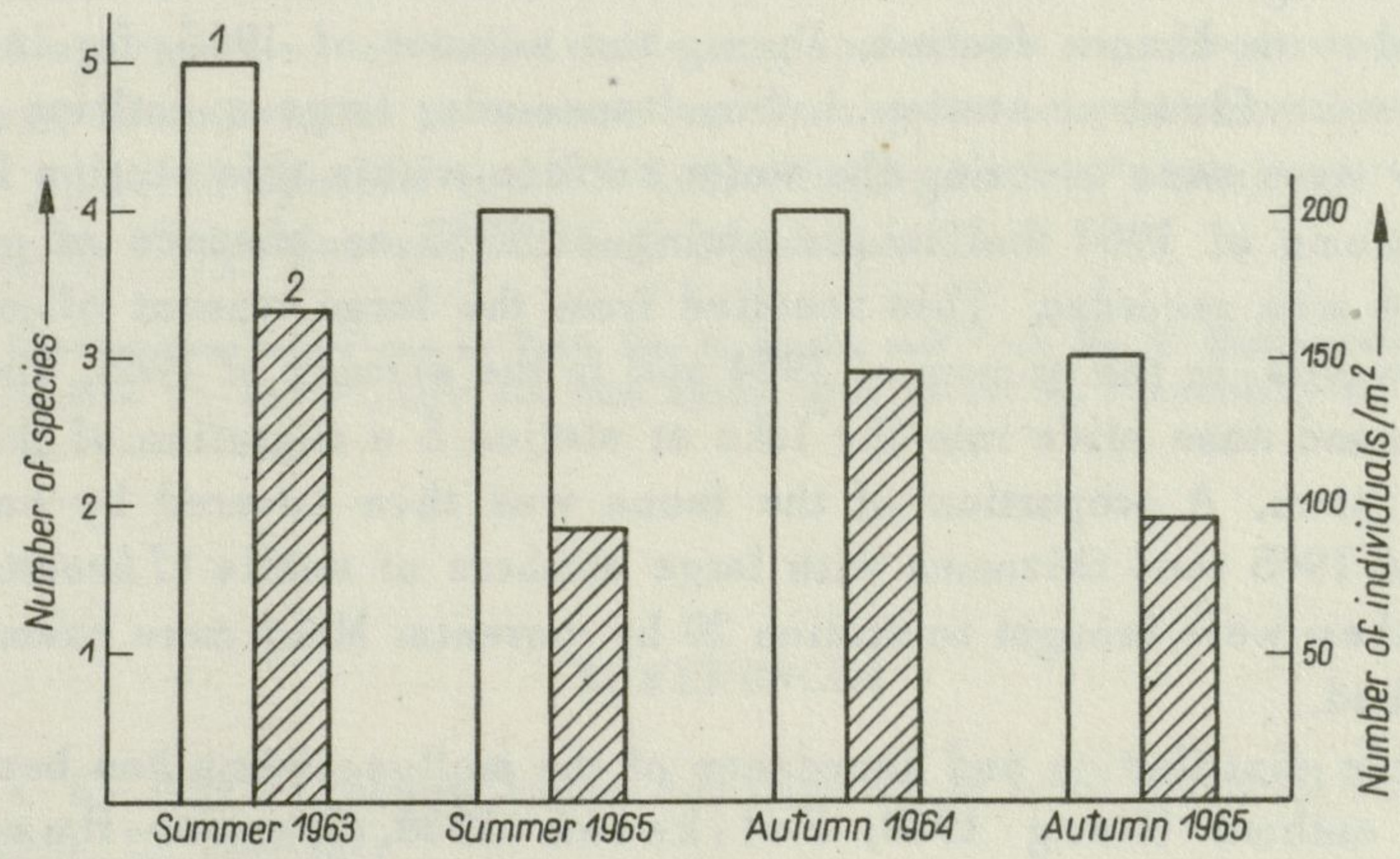


Fig. 10. A comparison of the number of species and of individuals of molluscs during the same seasons of different study years in lake Łebsko
1 – number of species, 2 – number of individuals

Moreover, during the 3 year period the particular stations varied from year to year with regard to dominant species. An exception was station 1 and 11 where one and the same species, *Radix limosa*, remained the dominant species throughout this period. During the summer of 1963 a clear predominance of *Radix limosa* and *Bithynia tentaculata* was seen. *Lymnaea stagnalis*, *Physa fontinalis* and *Planorbis planorbis* were also found in large numbers. In the autumn of 1964 the most abundant species was *Radix limosa* and then: *Bithynia tentaculata*, *Planorbis planorbis*, *Physa fontinalis* and *Galba palustris*. In the spring of 1965 the numerical dominance belonged to *Bithynia tentaculata*. The less abundant species were: *Radix limosa*, *Galba palustris*, *Planorbis planorbis* and *Physa fontinalis*. In the autumn of 1965 the numerical dominance was taken over by *Radix limosa*, while *Physa fontinalis*, *Galba palustris*, *Bithynia tentaculata* and *Acroloxus lacustris* were quite abundant, too.

The cause of the spatial variation of the mollusc fauna must lie in the environmental conditions which are different in each area of the lake and the Łeba river-canal. The seasonal variation of the mollusc fauna is no doubt connected with the phenological phenomena (spring and summer are the breeding seasons, while in the autumn most mollusc species migrate into the deeper portions of the lake). Migratory behaviour amongst molluscs has been described by: Berg (1938), Žadin (1952), Hunter-Russel (1953), Stańczykowska (1959, 1960b) and Drozdowski (1961), among others.

A characteristic feature of lake Łebsko is the strong action of the winds. Winds cause rapid changes in salinity, in bottom and also a dislodgement of shore fragments, vegetation, tree branches, rhizomes, piles and the like. The irregular changes in the distribution and abundance of the molluscs are often associated with chance factors. During the summer of 1965, for instance, no molluscs were found at station 1. Simultaneously, large quantities of oil and lubricants were seen covering the water surface within this station for 7 days. In the autumn of 1964 and in the spring of 1965 an absence of molluscs at station 14 was recorded. This resulted from the large amount of mud brought there by waves. In the autumn of 1964 and in the summer of 1965, simultaneous with the sand dune slide into the lake at station 5 a migration of the molluscs could be seen. A proportion of the fauna was then covered by sand. In the summer of 1965 reed rhizomes with large numbers of snails (*Theodoxus fluviatilis*) on them were brought to station 29 by currents. Many more examples could be described.

Variable distribution and abundance of the mollusc fauna has been reported by many authors (Berg 1938, Feliksiak 1938, Hunter-Russel 1953, 1961, Żmudziński 1957, Stańczykowska 1959, 1960b, Bakker 1959, Tasjunas 1959, Ökland 1964). In lake Łebsko this variation appears to be greater than has been described by these authors. It may be presumed that the cause is, among other things, the more rapidly changing ecological factors of

the habitat, which have a strong effect on the molluscs. The great variability of the fauna in lake Łebsko has also been emphasized by Guttowa (1956).

In his description of the ecology of brackish waters Odum (1963) has stated that their basic feature is a great variability. The above described variation in the distribution and abundance of the molluscs, for which there is sometimes no causative explanation, seems to be a specific feature of the mollusc fauna of lake Łebsko.

## V. SUMMARY

1) In the brackish lake Łebsko 31 mollusc species were found, the freshwater forms showing a clear predominance (94%);

2) The abundance and the distribution of the mollusc fauna depend on the joint action of the ecological factors;

a) the least favourable conditions for molluscs are found in areas with sand bottom, with no vegetation, and subject to waves of considerable force and rapid currents (molluscs occur there sporadically or by chance only);

b) the most suitable conditions exist in environments with medium-muddied bottom, abundant vegetation, and where the waves and currents are not strong (the most abundant mollusc populations are found there; maximum number of species – 17, and of individuals – 900/m²);

3) In lake Łebsko salinity is not the most important factor limiting the occurrence of freshwater molluscs;

4) A specific feature of the distribution and abundance dynamics of the mollusc fauna in lake Łebsko is the great variation in time and space, the number of species and of individuals in populations vary from environment to environment, from season to season and from year to year (maximum variation in time – up to 13 species and 800 individuals per 1 m²; maximum variation in space – up to 17 species and 900 individuals per 1 m²).

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## REFERENCES

1. Bakker, K. 1959 – Feeding habits and zonation in some intertidal snails – Arch. neerl. Zool. 13: 230–257.
2. Berg, K. 1938 – Studies on bottom animals of Esrom lake – Mem. Acad. roy. Soc. et Lettres Danemark, sec. sc. 9 ser. 8: 1–225.
3. Boettger, C. 1950 – Ein Beitrag zur Frage des Ertragens von Brackwasser durch Molluskenpopulationen – Hydrobiol. 2: 360–378.

4. Bursa, A., Wojtusiak, K., Wojtusi ak, K. J. 1947 – Badania nad fauną i florą Zatoki Gdańskiej dokonane przy pomocy hełmu nurkowskiego – Bull. Acad. Pol. Sci. B, 2: 213–249.
5. Cichon-Lukanina, E. A. 1958 – Pitanie nekatorych presnovodnych *Gastropoda* – Trudy mosk. techn. Inst. 9: 122–144.
6. Demel, K. 1927 – Zbiorowiska zwierzęce na dnie morza polskiego – Spraw. Kom. fizjogr. 6: 111–137.
7. Demel, K. 1935 – Estudes sur la fauna bentique et sa repertition dans les eaux polonaises de la Baltique – Arch. Hydrobiol. Ryb. 9: 310–333.
8. Demel, K. 1951 – Życie morza. Zarys Oceanografii Biologicznej – Gdańsk, 590 pp.
9. Demel, K. 1962 – Ekologia i biogeografia morza – Gdańsk.
10. Drozdowski, A. 1961 – Badania ilościowe nad fauną mięczaków okolic Płutnowa – Zesz. nauk. UMK, biol. 8: 83–143.
11. Feliksiak, S. 1938 – Badania morfologiczno-biologiczne nad otułką (*Myxas glutinosa*) – Arch. Nauk biol. TNW 7: 3–53.
12. Frömming, E. 1956 – Biologie der mitteleuropäischen Süsswasserschnecken – Berlin, 313 pp.
13. Gaevskaja, C. H. 1966 – Rol vysših vodnych rastenii v pitanii životnych presnych vodoemov – Moskva, 327 pp.
14. Gresens, J. 1928 – Versuche über die Wiederstandsfähigkkeit einiger Süsswassertiere gegenubër Salzlösusgen – Z. Morphol. Ökol. 12: 706–800.
15. Guttowa, A. 1956 – Badania nad planktonem jezior Łebsko i Sarbsko – Pol. Arch. Hydrobiol. 3 (15): 270–290.
16. Hartog, C. D. 1963 – The distribution of the snail *Aplexa hypnorum* in Zuid-Beveland in relation to soil and salinity – Basteria, 27: 8–13.
17. Hubendick, B. 1947 – Die Verbreitungsverhältnisse der limnischen Gastropoden in Südschweden – Zool. Bidr. Uppsala, 24: 419–559.
18. Hunter-Russel, W. 1953 – On migration of *Lymnaea peregra* (Müller) on the shores of Loch Lomond – Proc. roy. Soc. Edinburgh, 65: 84–105.
19. Hunter-Russel, W. 1961 – Annual variations in growth and density in natural populations of freshwater snails in the west of Scotland – Proc. zool. Soc. London, 136: 219–253.
20. Jaeckel, S. 1960 – Zur Molluskenfauna der Binnensalzsstellen von Bad Oldesloe – Schr. naturw. Ver. Schl. 30: 39–46.
21. Jażdżewski, K. 1962 – Kilka uwag o faunie dennej Zatoki Puckiej – Przegl. zool. 4: 286–290.
22. Kinne, O. 1964a – Non-genetic adaptation to temperature and salinity – Helgoländ. wiss. Meeresunters. 9: 433–458.
23. Kinne, O. 1964b – Physiologische und ökologische Aspekte des Lebens in Ästuarien – Helgoländ. wiss. Meeresunters. 11: 131–156.
24. Klekowski, R. Z. 1961 – Survival of *Planorbis planorbis* L. and other snails in diluted sea-water and during the following dessication – Pol. Arch. Hydrobiol. 9 (22): 343–406.
25. Klekowski, R. Z. 1963 – Water balans and osmoregulation in the snail *Coretus corneus* L. under conditions of dessication and in diluted sea-water – Pol. Arch. Hydrobiol. 11 (24): 219–240.
26. Klimowicz, H. 1958 – Mięczaki Zalewu Wiślanego i zależność ich rozmieszczenia od zasolenia – Pol. Arch. Hydrobiol. 5 (18): 94–123.
27. Lindberg, H. 1948 – Zur Kenntnis der Insektenfauna im Brackwasser des Baltischen Meeres – Comment. biol. Helsingfors. 10: 1–206.

28. Macan, T. T. 1961 – Factors that limit the range of freshwater animals – Biol. Rev. 36: 151–198.
29. Meier-Brook, C. 1963 – Über die Mollusken der Hochschwarsken der Hochvogesengewässer – Arch. Hydrobiol. 28: 1–46.
30. Miëgel, H. 1958 – Zur Molluskenfauna der Eifelmaare – Gewässer u. Abwässer, 5: 48–58.
31. Mikulski, S. J., Giziński, A. 1961 – Obserwacje nad fauną denną jeziora Wdzydze – Roczn. Nauk. roln. 93D: 142–162.
32. Mikulski, S. J., Karassowska, K. 1960 – Studia nad zbiorowiskami zwierzęcymi roślinności pływającej i zanurzonej jeziora Drużno – Ekol. Pol. A, 8: 326–354.
33. Mulicki, Z. 1957 – Ekologia ważniejszych bezkręgowców dennych Bałtyku – Pr. morsk. Inst. ryb. Gdynia, 9: 313–379.
34. Odum, P. M. 1963 – Podstawy ekologii – Warszawa, 560 pp.
35. Ökland, J. 1964 – The eutrofic lake Borrewann (Norway) – an ecological study on shore and bottom fauna with special reference to gastropods including a hydrographic survey – Folia Limnol. Scand. 13: 1–337.
36. Raabe, Z. 1956 – Badania nad parazytofauną mięczaków słodkowodnych w wodach słonawych – Acta par. polon. 4: 376–406.
37. Redeke, H. C. 1922 – Zur Biologie der Niederlandischen Brackwassertypen. Ein Beitrag zur regionalen Limnologie – Bird. Dierk. 22: 329–335.
38. Redeke, H. C. 1933 – Über den jetzigen Stand unserer Kenntnisse der Fauna der Brackwassers – Verh. int. Vereinig. Limnol. 6: 46–51.
39. Remane, A., Schlieper, H. 1958 – Die Biologie des Brackwassers – Binnengewässer, 22: 1–348.
40. Sandner, H. 1953 – Z badań nad wodami słonawymi w Polsce. Ekologia pijawek (*Hirudinea*) jezior: Łebsko i Sarbsko – Ekol. Pol. A, 3: 55–72.
41. Schäfer, H. 1953 – Untersuchungen zur Ökologie von *Bithynia tentaculata* – Arch. Molluskenk. 82: 67–70.
42. Schlesch, H. 1938 – Bemerkungen über die Verbreitung der Süsswasser und Meeresmollusken in Ostlichen Ostseegebiete – Ann. Soc. Nat. Univ. Tartu, 43: 37–64.
43. Segersträle, S. G. 1957 – Baltig Sea – Geol. Soc. America. Memoir. 67: 751–860.
44. Soszka, G. (in press) – Historia jeziora Łebsko – Biul. PIHM.
45. Stańczykowska, A. 1959 – Rozmieszczenie i dynamika liczebności żyworódki paskowanej *Viviparus fasciatus* Müll. na terenie łachy Konfederatki – Ekol. Pol. B, 5: 56–60.
46. Stańczykowska, A. 1960a – Charakter występowania mięczaków na kilku gatunkach roślin wodnych – Ekol. Pol. B, 6: 333–338.
47. Stańczykowska, A. 1960b – Obserwacje nad skupieniami *Viviparus fasciatus* Müll. na terenie łachy wiślanej Konfederatka – Ekol. Pol. A, 8: 21–48.
48. Stańczykowska, A. 1964 – On the relationship between abundance, aggregations and „condition" of *Dreissena polymorpha* Pall. in 36 Mazurian lakes – Ekol. Pol. A, 12: 653–690.
49. Tasjunas, I. 1959 – Kormovoj zoomakrobentos zaleva Kiršju Mares – Trudy Akad. Nauk. Lit. SSR, 3: 191–293.
50. Välikangas, J. 1933 – Über die Biologie der Ostsee als Brackwassergebiet – Verh. int. Vereinig. Limnol. 6: 46–61.
51. Wiktor, J. 1960 – Zarys warunków biologicznych Zalewu Szczecińskiego – Pol. Arch. Hydrobiol. 7 (20): 8–28.
52. Wiktor, J. 1962 – Ilościowe i jakościowe badania fauny dennej Zalewu Szczecińskiego – Pr. morsk. Inst. ryb. Gdynia, 11: 80–112.

53. Zienkiewicz, L. 1959 – Morza ZSRR, ich fauna i flora – Warszawa, 526 pp.
54. Žadin, V. J. 1952 – Molljuski presnych i solonovatych vod SSSR – Moskva-Leningrad, 378 pp.
55. Żmudziński, L. 1957 – Zoobentos Zalewu Wiślanego – Pr. morsk. Inst. ryb. Gdynia, 9: 453–500.
56. Żmudziński, L. 1961 – Atlas zoobentosu Bałtyku – Gdynia, 66 pp.
57. Żmudziński, L. 1967 – Zoobentos Zatoki Gdańskiej – Pr. morsk. inst. ryb. Gdynia, 14: 47–80.

## WYBRANE ZAGADNIENIA EKOLOGII MIĘCZAKÓW (*MOLLUSCA*) SŁONAWEGO JEZIORA ŁEBSKO

### Streszczenie

Analizowano rozmieszczenie i dynamikę liczebności mięczaków w powiązaniu ze zmiennością wybranych czynników środowiska. Terenem pracy było słonawe jezioro Łebsko (zasolenie we wschodniej części zbiornika może przekraczać 7 S‰), które jest płytkim, polimiktycznym, w znacznym stopniu zeutrofizowanym zbiornikiem o bardzo silnym falowaniu i zróżnicowanym podłożu (od piaszczystego do mulistego). Zbiornik łączy się z Morzem Bałtyckim kanałem-rzeką Łebą, przez który następują wlewy wód morskich. Materiał zbierano z 33 stanowisk (głównie litoralnych) w latach 1963–1966 (fig. 1). Stanowiska charakteryzowały się różnorodnością i zmiennością rodzaju podłoża, ilości roślinności, falowania i prądów, zasolenia oraz głębokości (tab. II). Materiał zbierano aparatem Ekmana (532 próby), ramką ilościową (737 prób) i dragą (66 prób). Poza tym przeprowadzono analizy wody na zasolenie.

Badano zależności między występowaniem i dynamiką liczebności mięczaków a następującymi czynnikami ekologicznymi: falowaniem i prądami wody, charakterem podłoża, ilością roślinności i zasoleniem. Zwrócono również uwagę na ilościową i jakościową zmienność mięczaków w czasie i przestrzeni. Jest ona następstwem złożonych procesów współdziałania wielu czynników ekologicznych i ich zmienności, a niekiedy również działania czynników przypadkowych.

W badanym słonawym zbiorniku stwierdzono 31 gatunków mięczaków (w tym 8 gatunków małży i 23 gatunki ślimaków), wśród których zdecydowaną przewagę miały gatunki słodkowodne (94%).

Stwierdzono wyraźny wpływ na występowanie i dynamikę liczebności mięczaków litoralu następujących czynników: intensywności ruchu wody, charakteru podłoża i ilości roślinności (fig. 3–5).

Najmniej sprzyjające warunki dla mięczaków w jeziorze Łebsko obserwuje się w środowiskach o podłożu piaszczystym, bez roślinności, eksponowanych na bardzo silne falowanie lub gwałtowne prądy wody (mięczaki występują w nich sporadycznie i przypadkowo). Najdogodniejsze warunki panują w środowiskach o podłożu średnio zamulonym, z dużą ilością roślinności, o słabym prądzie lub falowaniu (mięczaki występują w nich najliczniej, maksymalnie 17 gatunków i 900 osobników/$m^2$). Stwierdzono, że zasolenie nie jest decydującym czynnikiem ograniczającym występowanie mięczaków słodkowodnych w tym jeziorze (fig. 6).

Specyficzną cechą rozprzestrzenienia i dynamiki liczebności fauny mięczaków jeziora Łebsko jest bardzo silna zmienność w czasie i w przestrzeni (fig. 7–10). Wyraża się ona zmianami liczby gatunków i liczebności osobników w różnych środowiskach, w różnych sezonach i latach (maksimum zmienności w czasie: do 13 gatunków i 800 osobników/m²; maksimum zmienności w przestrzeni: do 17 gatunków oraz 900 osobników/m²).

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