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CARDIUM GLAUCUM (POIRET, 1789) POPULATION FROM GDAŃSK BAY (BALTIC SEA)

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ABSTRACT

Cardium glaucum from Gdańsk Bay reaches the age of four years, length 20–22 mm and dry weight up to 1550 mg. The population is dominated by 1st age-group, that is the individuals that survived one winter. The highest growth rate of molluscs was observed in the first year of their life, it decreased with the increase of age. The highest mortality rate in the year cycle occurred in June and July, that is during the spawning of mature molluscs. Mortality increases with age and it is highest between third and fourth year of life. *C. glaucum* is a dioecious mollusc with equal contribution of females and males. The reproduction takes place in Gdańsk Bay in the second half of June. The beginning of spawning season depends upon temperature conditions.

1. INTRODUCTION

Earlier data on *C. glaucum* mainly refers to molluscs of the sea waters and usually concern the occurrence and distribution (e. g. Tulkki 1961, Russell 1971, 1972, Boyden and Russell 1972, Barnes 1973), the composition of the population (Petersen 1958, Muus 1967), the age and growth rate (Brock 1980a), sex, reproduction period and larval stages (Rygg 1970, Boyden 1971 Kingston 1974a,b, Lucain and Martin 1974) and the ecological conditions (Boyden 1969). There are several papers on the distribution of *C. glaucum* in the brackish, Baltic water (Koli 1961, Brock 1980b), where the species is one of the most important components of demersal fauna. The information on the population of *C. glaucum* from Gdańsk Bay is very modest and incomplete. (Demel 1935, Demel and Mańkowski 1951, Demel and Mulicki 1954, Jażdżewski 1962) and apart from the data on the distribution and biomass of *C. lamarki* (= *C. glaucum*) (Żmudziński 1967) there is no information as to the population composition in relation to length and body weight, age and growth rate, mortality, sex and reproduction period. In connection with this, the aim of this paper is to fill the elements of biology lacking and give more detailed description of the *C. glaucum* population from Gdańsk Bay.

2. MATERIAL AND METHODS

Thirty samples of *Cardium* were taken, one per month, during the period of from August 1976 to December 1978. The station was situated in Gdynia about 0.5 nautical miles from the shore, on the sandy bottom at a depth of 3 m (Fig. 1). The salinity in this region oscillate from 6.5 to 7.5‰, and temperature from 1.8°C (in winter) to 19.3°C (in summer) in average. 7379 individuals were submitted to detailed analysis. The samples were taken with a dredge 100×50 cm and a net with the mesh size 1×1 mm. The samples were later fixed in a solution of 4% formalin. The material was submitted to the following analyses:

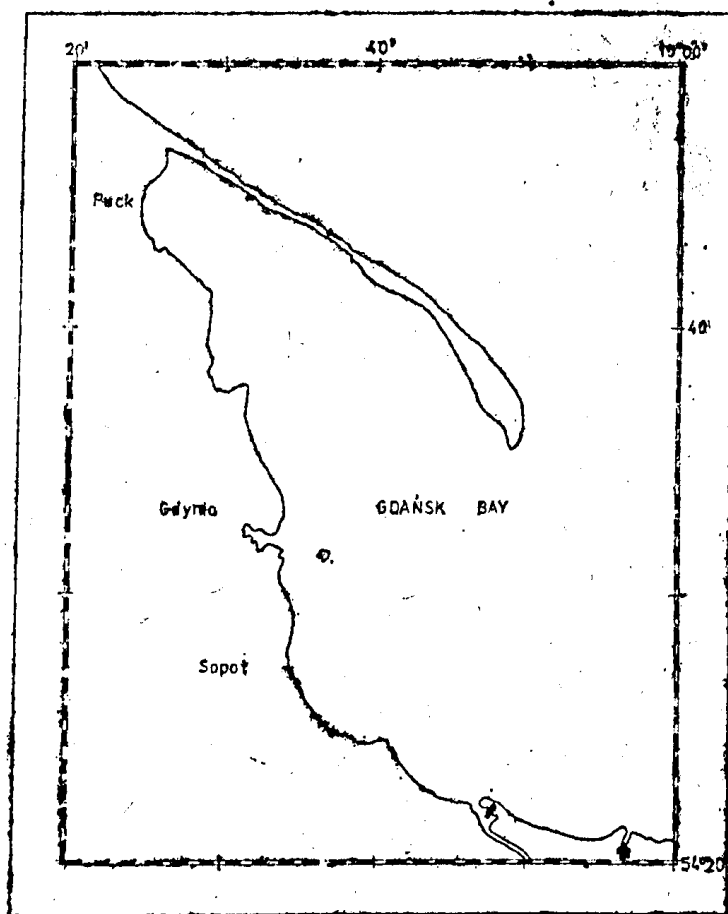


Fig. 1. Gdańsk Bay, investigation area. Circle — sampling station

— length of individuals; individuals were classified into groups with an interval of 1 mm to the length of 10 mm, and with an interval of 2 mm when over 10 mm (measurements were made to the nearest 0.1 mm).

— dry weight; through drying the individuals of each length class at a temperature of 70°C until a constant weight was obtained. The weight of shells was obtained through maceration of dried individuals in 10% KOH, until all the organic parts of the molluscs have dissolved. The determinations were made to the nearest 1 mg.

— age and growth rate; basing on the measurements of the annual growth rings, which are formed on the shell surface during the winter (Orton 1962). This method was used to determine the age of 1249 individuals.

— sex; on the basis of microscopical analysis of the gonads.

— mortality; basing on the number of empty individuals in each age group.

3. RESULTS

LENGTH AND WEIGHT

Single individuals of *C. glaucum* in Gdańsk Bay attained the maximum length up to 26 mm, but most of them did not exceed 20–22 mm. Animals 2–6 mm and 10–16 mm long were most numerous, 64.3 and 7.8%, respectively. Molluscs over 10 mm long constituted only 9.9% of the population (Fig. 2).

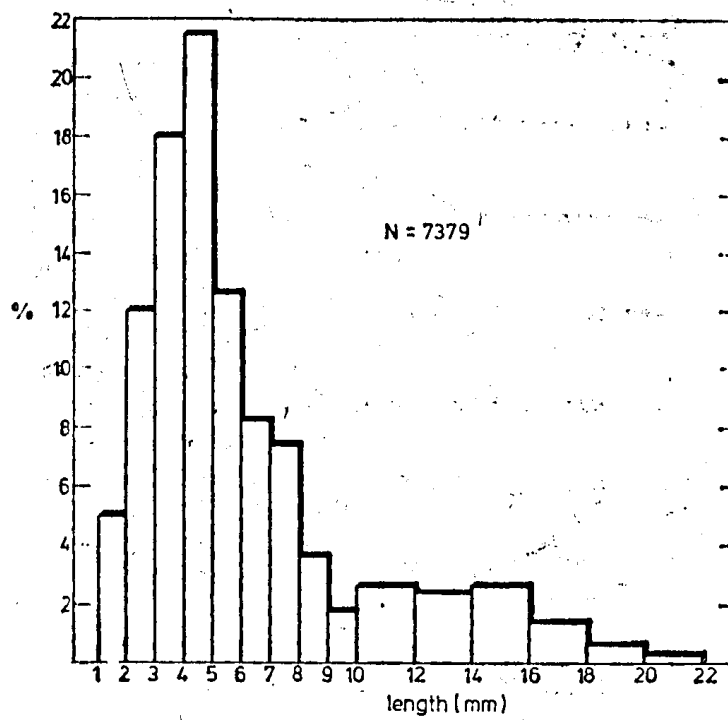


Fig. 2. Length distribution in *C. glaucum*

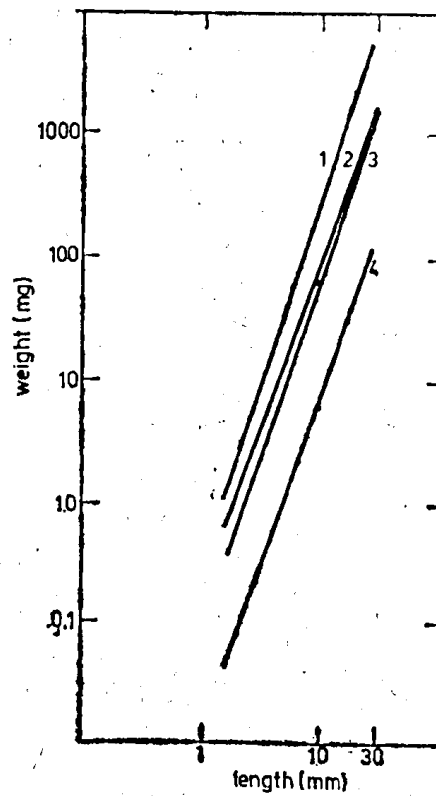


Fig. 3. Relation between weight (W) and length (L) in *C. glaucum*. 1 — wet weight, $W=0.12 L^{3.28}$, 2 — dry weight, $W=0.07 L^{3.26}$, 3 — shell weight, $W=0.06 L^{3.27}$, 4 — body weight $W=0.005 L^{3.33}$

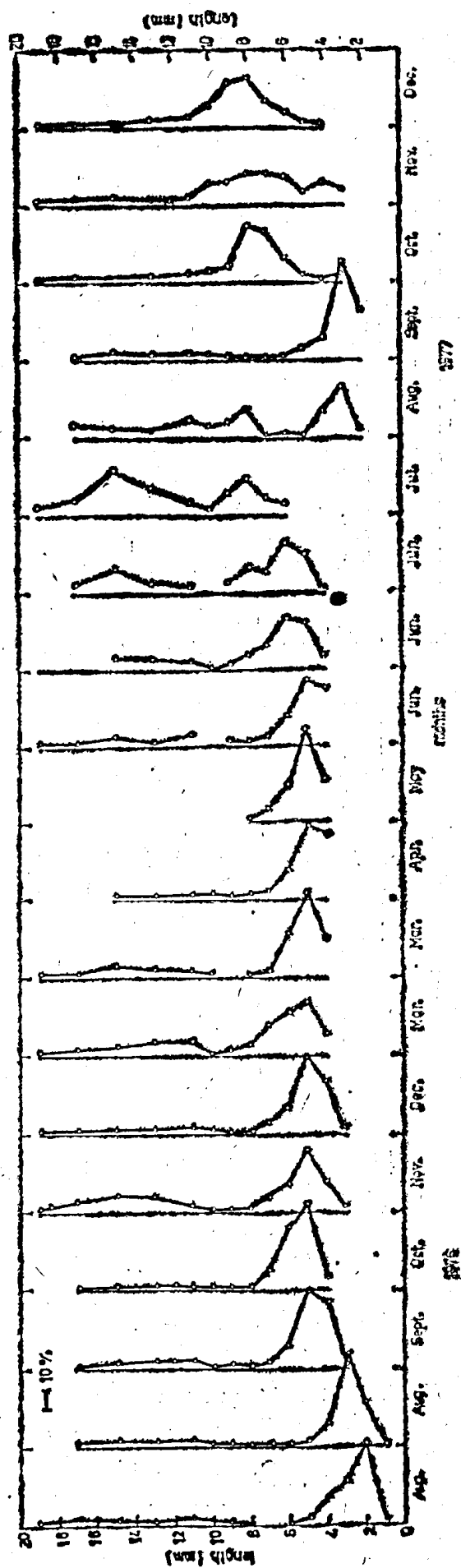


Fig. 4. Population seasonal changes of length

The weight of individuals attained on average 1.3 mg when at a length of 2 mm to 229.6 mg at a length of 10 mm. Single individuals attained the maximum length of 26 mm and weight up to 5000 mg.

The dry weight constituted from 53.2 to 55.9% of wet weight and is from 0.7 mg (2 mm long) to 123.7 mg (10 mm long). The weight of the shell constituted 90.2 to 93.8% of the dry weight. The dry body weight ranged from 0.05 mg at a length of 2 mm to 8.9 mg at a length of 10 mm.

The relationship between the length and weight of individuals was approximated by the power function (Fig. 3).

There were certain small seasonal differences in the body weight of molluscs of the same length. The lowest body weight was observed during the winter period. An increase in body weight was noted in spring with the highest values in May/June. From June to winter months a drop in body weight was observed.

AGE AND GROWTH RATE

The analysis of the annual growth rings prove that the population of the *C. glaucum* from Gdynia Bay is represented by five age groups. The age group I predominated (54.4%, Tab. I). The 0 age group individuals were in the range of up to 14 mm length, some individuals with a length of over 10 mm had growth ring visible, these animals had undoubtedly lived through one year, but for some reasons their annual ring did not form, or was mechanically rubbed off. The first age group (with one annual ring) was in the range from 7 to 19 mm, with a mean length of 11.9 mm, individuals of the II age group were in the range 10–21 mm (mean value 15.2 mm) and the III age group from 16 to 22 mm (mean 18.5 mm).

The monthly analyses of the population composition (Fig. 4) shows that from the beginning of August to October the growth rate of the sedentary individuals have been 1 mm per month and that during this period their length had increased from 2 to 5 mm. Then till June growth is inhibited and later there is a slight increase in growth and the following reproductive period.

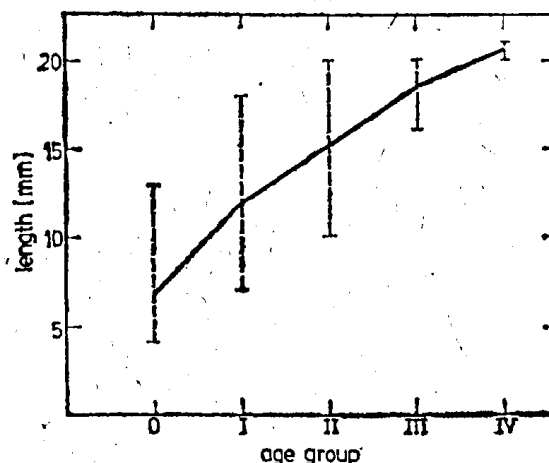


Fig. 5. *C. glaucum* growth in length. The mean growth line is shown

The growth rate of the *Cardium* decrease with age (Fig. 5). The highest annual increment was observed to the moment until the first ring of annual growth had formed, its value was on average 6.9 mm, in the IV age group the average value was only 2 mm.

SEX AND REPRODUCTION PERIOD

C. glaucum is a dioecious species. In the population males predominated having about 0.7% more than females. In the monthly samples considerable fluctuations in the percentage of males and females were observed. Usually the percentage of females was the range 43–56% (Fig. 6).

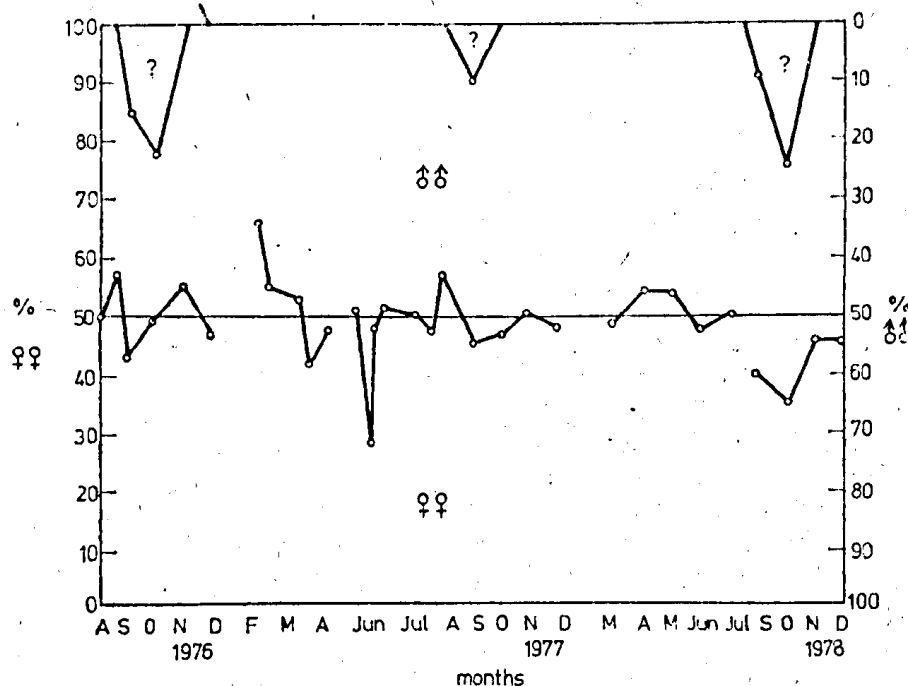


Fig. 6. Percentages of males and females in *C. glaucum* population. (?—undetermined sex)

In 2.7% of the individuals of the populations the sex was not determined. They were found in samples taken in September and October and their percentage was then 9–23%. The percentage of males and females were close each other and did not vary with age. Sex could not be determined in 12.8% of individuals of age group 0, only (Fig. 7).

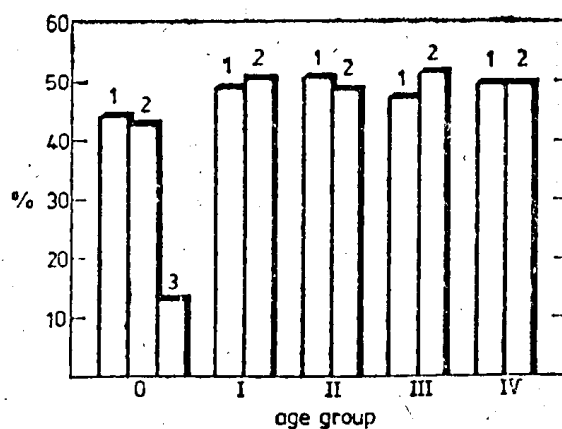


Fig. 7. Percentages of females (1), males (2) and individuals with sex undetermined (3) depending of age group

Table I. The composition of *C. glaucum* population depending upon age and length

Length (mm)	0			I			II			III			IV			Total	
	No. of indiv.	% in group	% in popu- lation	No. of indiv.	% in group	% in popu- lation	No. of indiv.	% in group	% in popu- lation	No. of indiv.	% in group	% in popu- lation	No. of indiv.	% in group	% in popu- lation	No. of indiv.	% in popu- lation
1-2																	
2.1-3																	
3.1-4																	
4.1-5	10	3.4	0.8													10	0.8
5.1-6	53	17.8	4.3													53	4.3
6.1-7	64	21.5	5.1													64	5.1
7.1-8	69	23.2	5.5	11	1.6	0.9										80	6.4
8.1-9	54	18.2	4.3	39	5.7	3.1										93	7.4
9.1-10	32	10.8	2.6	65	9.7	5.2										97	7.8
10.1-11	10	3.4	0.8	86	12.7	6.9	3	1.3	0.2							99	7.9
11.1-12	2	0.7	0.2	117	17.2	9.4	2	0.9	0.1							121	9.7
12.1-13	2	0.7	0.2	105	15.5	8.4	10	4.4	0.8							117	9.4
13.1-14	1	0.3	0.1	93	13.7	7.4	25	11.0	2.0							119	9.5
14.1-15				72	10.6	5.8	44	19.4	3.5							116	9.3
15.1-16				50	7.4	4.0	50	22.1	4.0							100	8.0
16.1-17				24	3.5	1.9	37	16.3	3.0	4	9.1	0.3				65	5.2
17.1-18				16	2.3	1.3	28	12.3	2.3	8	18.2	0.6				52	4.2
18.1-19				1	0.1	0.1	15	6.6	1.2	9	20.4	0.7				25	2.0
19.1-20							11	4.8	0.9	14	31.8	1.2				25	2.0
20.1-21							2	0.9	0.1	4	9.1	0.3	1	50	0.1	7	0.5
21.1-22										5	11.4	0.4	1	50	0.1	6	0.5
Total	297	100	23.9	679	100	54.4	227	100	18.0	44	100	3.5	2	100	0.2	1249	100

In Gdańsk Bay reproduction of *C. glaucum* takes place in the second half of June. The reproduction period depends on the temperature conditions. The water temperature increase faster in the Puck Bay and reproduction begins 10–14 days earlier than in Gdańsk Bay. In 1977 the reproduction period in Gdańsk Bay began on about 20 June, while in 1978 around 7–8 June, it had later stopped due to the sudden temperature drop, it was latter observed again around the 18 June. The *C. glaucum* reproduction is synchronised in time and lasts about 2 weeks; individuals of all age groups reproduce.

MORTALITY

From October to April 1977 the percentage of empty shells were about 20%. From May a distinct increase in % of empty shells were observed, in July it reached 85%, and in August it fell to about 10% and December 2% (Fig. 8). While investigating the percentage of empty shells on classes of length (Fig. 9) it was observed that the highest percentage was among animals of 3–5 mm length (38%), and 20–22 mm (50%). In the other length classes it was 10–30%.

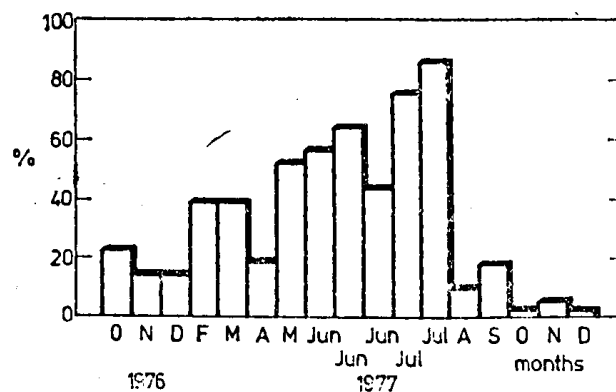


Fig. 8. Percentage of empty shells in the samples

Basing on the population composition in relation to age (Tab. I) the survival rate of each age group can be calculated, or the mortality rate (Fig. 10). Assuming that the number of I age group individuals is 100% it is possible to calculate the percentage of other age groups. The mortality increases in the following age groups and is 66.7% in the II age group, 93.6% in the II, 99.6% in the IV and attains 100% in the V age group. This calculation may be carried out assuming that the annual population recruitment of the *Cardium* is a constant value and that the population is in biological equilibrium. This method was checked for the population of *Dreissena polymorpha* from Firth of Szczecin (Wiktor 1969). Individuals of the 0 age group can

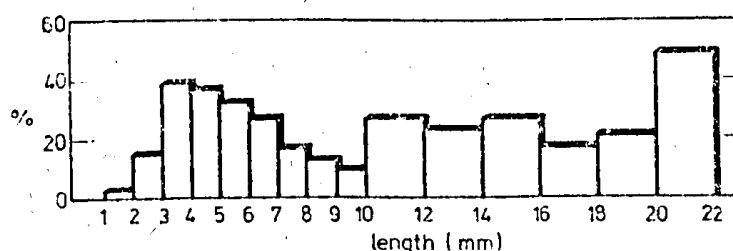


Fig. 9. Percentage of empty shells in the length classes

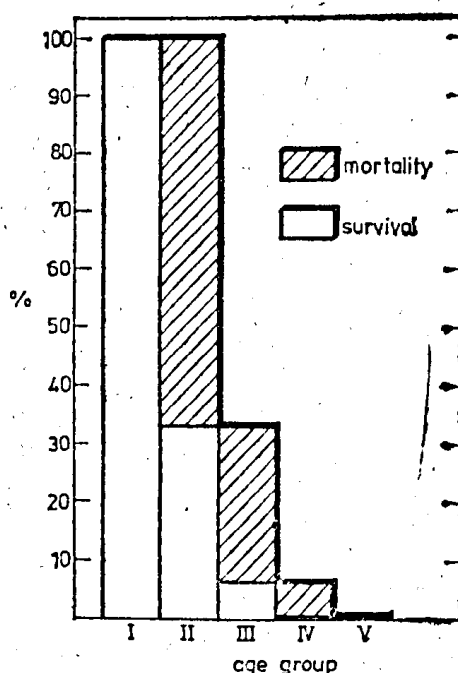


Fig. 10. Mortality and survival rate of each *C. glaucum* age group

not be considered as the initial age group, because they are only found in samples from July to winter, while animals of the I age group can be found in the material during the whole year.

4. DISCUSSION

The *C. glaucum* attains a length of 32 mm in the sea waters (Petersen 1958, Tulkki 1961, Muus 1967), while in the brackish waters they were 24–26 mm. In Gdańsk Bay which has salinity of 6.5–7.5‰ the *Cardium* rarely attains a length of 26 mm, most molluscs do not exceed the length of 20–22 mm. The situation in the Azov Sea for the population of *C. glaucum* seems to be similar, the molluscs attain a length of 26 mm ($S=12‰$) and in the Aral Sea ($S=10‰$) they are 14 mm (Karpevič 1964). The most numerous in the Aral Sea are individuals 5–7 mm long which conforms with the observations carried out in Gdańsk Bay, where molluscs 2–6 mm in length predominate. The *Cardium* attains length 2–6 mm in its first months of life and winters at such a length. The value of the wet weight carries an error due to the water enclosed between the shells and that of body tissues, of this value of dry weight were used in the investigations.

Seasonal changes in the body weight of *C. glaucum* were observed by Petersen (1958). The highest values were noted in spring, the lowest in autumn and winter. Recent investigations had proved these observations. The increase of body weight in spring is related to the development of the gonads. A great decrease in body weight was observed immediately after reproduction. The shell weight is more or less constant and does not undergo seasonal changes, this proves that the reproductive cells are responsible for the fluctuations in body weight.

When comparing the individuals of the same length, but originating from Gdańsk Bay and from its North-Western part, Puck Bay, it was observed that the *Cardium* from the muddy Puck Bay had a weight 60% smaller than that from the sandy

Gdańsk Bay (Wołowicz 1975). Petersen (1958) suggests that the *C. glaucum* is greatly influenced by the microhydrographic and micro-topographic conditions such as the character of the sea bottom, the water flow, trophy, which may in small reservoirs be varied. In the case of Gdańsk Bay the *Cardium* is influenced by worse trophical conditions.

As a result of investigations on the growth rate it was found that it is greatest in summer and early autumn; this is from June to October when the length increase was 1 mm per month. During the winter months the length increase is stopped probably due to the unfavourable temperature and trophic conditions. The growth rate of *C. glaucum* depends on temperature and salinity conditions, the water dynamics and trophy. In the Aral Sea the growth rate was 6.8 mm in the first year and about 2 mm in the following years. The 0 age group *Cardium* from the Caspian Sea are 7.5–8.3 mm and they increase in length 2–2.5 mm annually. According to Brock (1979) allopatric populations of *C. glaucum* attains a length from 9.7 to 11.6 mm, depending upon the reservoir, before the first annual ring of growth is formed. The increase in the second and third season ranges from 2.9–8.0 mm. According to Muus (1967) individuals of the 0 age group originating from the Danish fiords, growth is stopped in October when the individuals are 3–11 mm long. Petersen (1958), observed that individuals of the 0 age group attain a length from 2.5 to 12–13 mm, and of the II age group from 11.5–17.0 mm to 24–27 mm.

The age attained by the *C. glaucum* in Gdańsk Bay is 4 years, which conforms with the data given by Muus (1967), who determined the maximum age for this species and found it to be 3.5 years, and Brock (1980) four growth seasons. In the Azov Sea it attains 5 years and in Aral Sea 7 years at a length of 24 mm (Karpević 1964).

The relation in sexes in the *C. glaucum* population is close to the value of 1. In the material taken for investigation there were 48.3% females, 49.0% males and 2.7% individuals with unidentified sex; they were found in the samples taken in September and October and belonged to the new recruitment which was then 2–3 months old and was of a length smaller than 5 mm. In these individuals the first gametogenesis was to take place and the sex identification at this stage was impossible. Boyden (1971) had observed that in the *C. glaucum* population of the coasts of England females predominated and were 38.3% (males 27.3%) of the population. Molluscs with the sex unidentified were a large percentage 34.4%. Different results were obtained by Kingston (1974a) who observed that males predominated in two populations of SE England; they were 54.6% and 58.3%. All individuals had their sex identified. The *Cardium* is sexually active throughout its whole life and the relation of sexes in the population does not vary with age. Ansell (1961) had come to the same conclusion after investigation on the sex of *Venus striatula*.

The reproductive period depends to a great extent on the temperature conditions and differences in habitat factors. In the Gdańsk Bay as in the Trondheimsfjord (Rygg 1970) spawning takes place in the second part of June at a water temperature of above 15°C. In the Danish waters spawning has taken from 15 June to September with the maximum in July and depends of the locality and year (Brock 1982). Muus (1967) had observed *Cardium* spat and suggests that the individuals of the shallow, internal part of bay, thus of higher water temperature have their reproductive season earlier than those of the sandy shoals. This can be related to the conditions in Gdańsk Bay where reproduction in the isolated, by sandy shoal, internal part of bay takes place two weeks earlier than in the open bay. Off the coasts of Normandy the reproductive period takes place at the beginning of summer (Lucaïn, Martin 1974). In the Crought river estuary (England) reproduction lasts about 50 days with a peak in the 14–17 day of June (Boyden 1971). In the Aral Sea reproduc-

tion begins in May and lasts till September with a peak in June-July (Karpevič 1964). In Gdańsk Bay no portion spawning was observed similar to that of the Azov Sea (Karpevič 1964) also no second reproductive period was noted. It was not found that the molluscs which had settled could take part in the spawning in the same year.

In the *C. glaucum* population during the period from November to July, mortality shows a constant increase tendency: in July it reaches the value of 85%. The exceptionally high mortality in the period of June and July is most probably related to the reproductive period of the mature *Cardium* individuals which die after spawning period. During this period many of the dead molluscs still had tissue remains in shells, gonads though were empty. It is possible that is due to the low content of dissolved oxygen caused by a mass phytoplankton bloom. According to Muss (1967) this is often the cause of mortality increase. The rapid mortality drop as from August is related to the transition of new *Cardium* group to a sedentary mode of life. The high mortality in winter can be the result of ice cap for long period; this was observed in the shallow part of Gdańsk Bay.

5. SUMMARY

In *Cardium glaucum* population the most numerous are individuals 2-6 mm in length; they constitute 64% of the entire population. The analysis of the annual rings of growth proves that in this basin the *Cardium* attains 4 years of age when 20-22 mm in length and a weight of up to 2000 mg (dry weight); water in the tissues constitutes 52.3-55.9. 90% of the dry weight is taken up by the shell. The I age group predominated in the population (animals which had survived through one winter). The highest annual increment of the mollusc was observed in its first year of life (6.9 mm), it decreased with age. In the annual cycle the highest mortality was observed in June and July (over 80%) this was during the reproduction period of the mature molluscs. The rate of mortality increases with age and is highest between the third and fourth year of life (93.7%). *C. glaucum* is a dioecious mollusc of equal per cent of sexes. The percentage of both sexes was not observed to vary depending on age. The reproduction in Gdańsk Bay takes place in the second half of June.

6. STRESZCZENIE

W populacji *C. glaucum* najliczniej reprezentowane są zwierzęta o długości 2-6 mm, stanowiąc ponad 64% wszystkich osobników. Z analizy pierścieni przyrostów rocznych wynika, że w akwencie tym sercówka osiąga wiek do 4 lat, przy długości 20-22 mm oraz ciężarze ponad 2000 mg, (masa sucha); 52.3-55.9% stanowi woda zawarta w tkankach. W suchej masie ponad 90% stanowi masa muszli. W populacji dominowała I grupa wiekowa tzn. zwierzęta które przeżyły jedną zimę. Najwyższe tempo wzrostu małży obserwowano w pierwszym roku życia (6.9 mm), malało ono wraz z osiąganym wiekiem. W cyklu rocznym najwyższą śmiertelność stwierdzono w czerwcu i lipcu (ponad 80%) czyli w okresie rozrodu małży. Śmiertelność rośnie z wiekiem i jest najwyższa pomiędzy trzecim i czwartym rokiem życia (93.7%). *C. glaucum* jest małżem rozdzielnopłciowym o jednakowym udziale płci. Rozród sercówki w Zatoce Gdańskiej odbywa się w drugiej połowie czerwca.

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