Oceanological and Hydrobiological Studies
International Journal of Oceanography and Hydrobiology
Vol. XXXVI, No.3

Institute of Oceanography | (21-37) | University of Gdańsk
ISSN 1730-413X | 2007 | eISSN 1897-3191

DOI 10.2478/v10009-007-0017-2
Original research paper

Received: January 22, 2007
Accepted: July 12, 2007

Biometrics of the mussel *Anodonta cygnea* (L.) inhabiting in 2005 the Binowo and Bobolin Lakes near Szczecin

Juliusz C. Chojnacki[1], Agnieszka Lewandowska, Beata Rosińska

Agricultural University in Szczecin
Faculty of Food Science and Fisheries
Department of Marine Ecology and Environmental Protection
ul. K. Królewicza 4H, 71-550 Szczecin, Poland

Key words: species with status E-extinct, *Anodonta cygnea*, biometrics of mussels

Abstract

Research on the swan mussel population was conducted in 2005 on a sample of 497 individuals inhabiting Binowo and Bobolin Lakes, Szczecin, Poland. Length, width, height and age of individuals was examined. Binowo Lake was inhabited by individuals aged 1+ to 7+ years, while individuals aged 1+ to 6+ inhabit Bobolin Lake. Measurable features of swan mussels inhabiting Binowo Lake were as follows: individuals were 3.80 to 10.20 cm long, 1.70 to 5.70 cm wide, 0.70 to 3.70 cm thick, and in Bobolin Lake, 4.00 to 15.20 cm long, 2.20 to 7.70 cm wide, 0.80 to 5.70 cm thick. The age structure of both populations included individuals of diverse ages, with 3 and 4-year old individuals dominating in both lakes. A modest fraction of the youngest individuals (1,2-year old) as well as the oldest (6,7-year old) was observed in the examined lakes. All correlations between shell length, width, height and mussel age showed large positive correlations and results obtained from both lakes were similar.

[1] Corresponding author: *marecol@fish.ar.szczecin.pl*

INTRODUCTION

The swan mussel (*Anodonta cygnea* (L.)) is one of the largest freshwater mussels. This Palearctic species (distributed in all of Europe, Africa north of the Sahara and Asia south of the Himalayas) occurs in fresh and saline water with salinities from 0.1-0.2 PSU. In Poland, the species occurs 500 meters above sea level, primarily in shallow eutrophic water bodies, and rarely in slowly flowing rivers or ox-bow lakes, ponds or lakes with outlets. The species is more often found in artificial fish ponds or dams (Zając 2004). Swan mussels prefer rich bottom sediment, inhabit the shallow littoral zone without macrophytes as well as deep zones of lakes located far from the shore, which distinguishes this species from other representatives of the Unionidae family. Swan mussels are present from 0.2 m to a few meters depth. *A. cygnea* is a rare species in Poland, and its size is decreasing drastically due to increased human impact on lacustrine environments. The most frequent threats are as follows: water polluted with municipal sewage, which contains detergents, and industrial sewage with petrol derivatives and other toxic substances, as well as surface wash from agricultural fields, where fertilizers and pesticides with biocides are overused, the complete filling in and rubbishing of small ponds, and works connected with regulation and draining river lowland, ox-box lakes in particular. Moreover, the introduction of swan mussels in artificial ponds and garden pools has become very popular lately, but is illegal and endangers mussels. All of the above-mentioned factors destroy the natural habitat of swan mussels. *A. cygnea* is very vulnerable to any negative environmental changes, hence its presence indicates pure and well-oxygenated water with organic rich sediment. Permanent changes in environmental conditions have resulted in a permanent decline in size or even extinctions of swan mussel populations. In accordance with legal regulations (Act of April 27, 2001, Journal of Laws No.130, item 1456), *A. cygnea* has been protected by law since 1995 and is included in *The Red Data Book of Endangered Animals in Poland* (Głowaciński 1992) with status E-extinct, *The Red Data Book of Animals of Brandenburg* with status 3-endangered, *The Red Data Book of Animals of Meklemburg-Vorpommern* with status 3-endangered.

Swan mussels burrow in sediment and rarely crawl on the surface. They use their plough-like foot to dig in silt in order to find food and leave only their posterior extremity outside the sediment, which corresponds to the longer part of the shell. They usually live up to several tens of years and reach full maturity at an age of 2-3. They reproduce dioeciously; however, when they are isolated for longer periods of time in stagnating water bodies, they become hermaphroditic. Female mussels lay their eggs in the male palleal cavity, where they are fertilized. When they hatch, the larvae are expelled into the water where they attach themselves to fish and within 8-10 weeks metamorphose into mussels. The hosts of swan mussels are as follows: eel - *Anguilla anguilla*, pike - *Esox lucius*, tench - *Tinca tinca*, pumpkinseed sunfish- *Lepomis gibbosus*, perch - *Perca fluviatilis* oraz three-spined stickleback - *Gasterosteus aculeatus* (Zając 2004).

Swan mussels play a significant role as incubators for the eggs of bitterling- *Rhodeus sericeus,* whose population is endangered in Poland. Their presence stimulates males of bitterling, who display nuptial colour. Female bitterlings lay their eggs in the incurrent notch of a swan mussel. When larvae of bitterling are 11 mm long they are ready for independent life and leave the gill cavity of the mussel through the excurrent siphonal notch. *A. cygnea* expells many larvae called glochidia, which attach themselves to fish. Hence, extinction of swan mussels in water bodies may result in the extinction of bitterlings (Kujawa 2004).

Polish water bodies are inhabited by six species of the Unionidae family: *Anodonta anatina*, *Anodonta cygnea*, *Anodonta complanata*, *Unio pictorum*, *Unio crassus* and *Unio tumidus* (Urbański 1957). All of them are protected by law.

The present research was conducted on a population of *A. cygnea* in two lakes located in the vicinity of Szczecin, the Binowo and Bobolin Lakes. The research aimed to explore the relationship between measurable features of swan mussels and their age as well as determine the age structure of the population. Research was conducted separately in the Binowo and Bobolin Lakes and examined whether individuals of both lakes can be regarded as one population.

Binowo Lake (also called Binowskie Lake) is located in Stare Czarnowo commune, near Binowo village in the area of Szczeciński Park Krajobrazowy Puszcza Bukowa (Szczecin's Landscape Park Bukowa Forest), in the middle of Polana Binowska (Lipnicki 1993). Binowo Lake has no outlet and covers an area of about 52.4 ha, of which 1.7 ha is occupied by emergent macrophytes. The water surface is 40.5 m above sea level. The lake is mesotrophic and an overload of biogenic substances, BOD_5, and *E. coli* index lower the water purity. Mean depth is 5.5 m with a maximum depth of about 9.4 m, maximum length is 1.3 km and width 730 m, with shoreline length developed in the eastern part – 4125 m.

The lake shore is dry, forested on the west, and partly boggy on the east and north with dense beds of reed and rushes. The high biodiversity of organisms is a distinctive feature of the lake, and there is heavy fishing pressure. Progressive water pollution is resulting in irreversible changes; for example, powan has gone extinct and European whitefish is endangered. The southeastern part of the lake borders on Binowo village and a modern golf course situated on the eastern edge of „Jarząbki" (a recreation centre) is located southeast of the lake.

Moreover, there are numerous holiday cottages and campsites in the lake catchment area (Lipnicki 1993, pers. com. from a resident of Binowo village).

The Bobolin Lake borders a village under the same name, located 10 km west of Szczecin. A tourist border crossing to Germany was opened in Bobolin - Schwennenz in 1996. Actually, the name of this lake isn't mentioned in the literature; however, the inhabitants of Bobolin village call it Bobolin Lake. There are no data concerning limnological inventories or research on lake chemistry. Bobolin is a typical lake, lacking an outlet and situated in a hollow between moraines. The lake shore is densely covered by the common reed *Phragmites communis*, and plants such as *Stratiotes aloides* and *Polygonum amphibium* are found there as well. Bobolin is eutrophic, with a significant inflow of organic and inorganic matter from fields and meadows situated higher than the lake. The lake water is brownish with low transparency and an unpleasant odour (Filipiak, Sadowski 1994). A village inhabitant and community worker, Henryk Jabłoński, provided the Department of Marine Ecology and Environmental Protection of the Agricultural University of Szczecin with information regarding swan mussels in Bobolin Lake.

MATERIALS AND METHODS

Materials

Swan mussels were collected at Binowo Lake five times during 2004/2005 (organisms were removed, measured and returned to the lake): December 4, January 15, July 7, August 18 and 23. The research was conducted along the entire shore at places free of dense beds of the common reed *P. communis* and reed-mace *Typha latifolia*. Individuals of *A. cygnea* were buried in the sandy bottom, and at the rockier sampling site were found among common reed, outside common reed beds and under jetties located near the recreation centers. A type of escape was observed from places neighbouring lakeside beaches and meadows where tourists usually relax, swan mussels occurred at such places at the edges of beaches near common reed. In total 287 individuals were measured.

Swan mussels of Bobolin Lake were collected twice in 2005: June 26 and July 3. 210 individuals were measured, and they occurred at similar places as in Binowo Lake.

Measurement methodology

Individuals of *A. cygnea* were measured with the use of a slide caliper to an accuracy of 1 mm. Length [L], width [H] and height [G] of mussels were measured; age [W] of swan mussels was examined by counting annual growth on the shell surface (Figure 1). While taking measurements, individuals were immersed in the lake water and upon completion they were immediately released back into the water. The arithmetic mean, standard deviation s, coefficient of variation Vs, range R, variance s^2, correlation coefficient r, covariance (X,Y), and regressions were calculated according to Łomnicki (2003).

Interpretation of the correlation size (while considering sample size):

r ranging 0.0-0.2 – lack of correlation
r ranging 0.2-0.4 – small correlation
r ranging 0.4-0.7 – medium correlation
r ranging 0.7-0.9 – large correlation
r ranging 0.9-1.0 – very large correlation

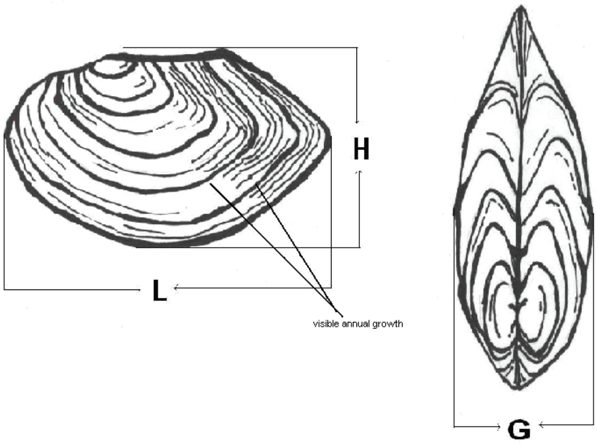

Fig. 1. Illustration of a swan mussel shell with measured features indicated: length [L], width [H], height [G] and visible annual growth (Czechowski et al. 1994, modified).

RESULTS

Analysis of the age structure

Size of the examined swan mussels by age group is shown in Table 1. Individuals of *A. cygnea* collected on July 7, August 18 and 23, 2005 from Binowo Lake were 1 to 7 years old. Four-year old mussels were most abundant (112 individuals, 39% of the population). Five-year old mussels were second in abundance with 80 individuals (28%). One- and 2-year old mussels were least abundant (12 individuals' altogether), and comprised 4% of the examined

Table 1

Mean values of shell length [L], width [H] and height [G] in various age groups of *Anodonta cygnea* collected in Binowo and Bobolin Lakes, Szczecin region

Area	Age [years] W	Number of individuals N	Mean length [cm] L	Mean width [cm] H	Mean height [cm] G
Binowo Lake	1+	6	3.86	2.16	0.85
	2+	6	5.83	3.54	1.56
	3+	46	6.96	3.77	2.04
	4+	112	7.93	4.17	2.43
	5+	80	8.44	4.44	2.58
	6+	26	8.63	4.59	2.67
	7+	11	8.98	4.80	2.84
Bobolin Lake	1+	8	6.10	3.74	1.64
	2+	78	8.42	4.49	2.70
	3+	88	12.56	6.30	4.24
	4+	21	13.13	6.70	4.72
	5+	11	13.46	6.95	4.80
	6+	4	12.36	6.73	4.43

population. Therefore, 4-, 5- and 3-year old individuals dominated the population while 1-, 2-, 6- and 7-year olds occurred in small numbers. The mean age of mussels in Binowo Lake was slightly above 4 years, with a range of 6 and coefficient of variation 26.6% (Table 2).

Table 2

Mean, total, minimum, maximum, range, variance, standard deviation, and coefficient of variation for length [L], width [H], height [G], and age [W] of individuals of *Anodonta cygnea* collected from Binowo Lake

Variable	Length [cm] L	Width [cm] H	Height [cm] G	Age [years] W
Number of shells	287	287	287	287
Mean	7.9	4.2	2.4	4.4
Minimum	3.8	1.7	0.7	1.0
Maximum	10.2	5.7	3.7	7.0
Variation range	6.4	4.0	3.0	6.0
Variance	1.3	0.3	0.2	1.3
Standard deviation	1.1	0.6	0.5	1.2
Variation coefficient [%]	14.2	13.5	23.7	26.6

Bobolin Lake was inhabited by swan mussels aged 1 to 6, and was dominated by 3-year old individuals (88 individuals, 42%) with 2-year olds second in abundance (37%). The least numerous were the oldest (2%) and the youngest (4%). The mean age of swan mussels in Bobolin Lake was 2.8, with a range of 5 and coefficient of variation 35.3% (Table 3).

Table 3

Mean, total, minimum, maximum, range, variance, standard deviation, and coefficient of variation for length [L], width [H], height [G], and age [W] of individuals of *Anodonta cygnea* collected from Bobolin Lake

Variable	Length [cm] L	Width [cm] H	Height [cm] G	Age [years] W
Number of shells	210	210	210	210
Mean	10.9	5.6	3.6	2.8
Minimum	4.0	2.2	0.8	1.0
Maximum	15.2	7.7	5.7	6.0
Variation range	11.2	5.5	4.9	5.0
Variance	6.7	1.4	1.3	1.0
Standard deviation	2.6	1.2	1.1	1.0
Variation coefficient [%]	23.7	21.3	31.4	35.3

Analysis of mussel length

Among the measured *A. cygnea* of Binowo Lake the longest shell was 10.2 cm and the shortest was 3.8 cm (Table 2). Mean shell length of the mussel population was 7.92 cm. Mean shell length of 1-year old individuals was 3.86 cm, 2-year olds 5.83 cm, 3-year olds 6.96 cm, 4-year olds 7.93 cm, 5-year olds 8.44 cm, 6-year olds 8.63 cm and 7-year olds 8.98 cm, respectively (Table 1). The youngest and oldest individuals, which were also the longest, were the least represented. Mussel length of some 220 individuals ranged from 7 to 9 cm. The range was 6.40, standard deviation 1.12, and coefficient of variation 14.2% (Table 2).

Among the measured *A. cygnea* of Bobolin Lake the longest shell was 15.2 cm and the shortest 4 cm. Mean mussel length of the population was 10.89 cm (Table 3). Mean shell length of 1-year old individuals was 6.10 cm, 2-year olds 8.42 cm 3-year olds 12.56 cm, 4-year olds 13.13 cm, 5-year olds 13.46 cm and 6-year olds 12.36 cm, respectively (Table 1). The distribution of mussel length in the lake was non-normal; individuals 11-14 cm long and 7-9 cm long were dominating, with the fewest individuals ranging from 3 to 6 cm. The range was 11.2, standard deviation 2.58 and coefficient of variation 23.7% (Table 3).

Analysis of mussel width

The width of measured *A. cygnea* of Binowo Lake ranged from 5.70 to 1.70 cm (Table 2). Mean shell width of the population was 4.20 cm. Mean mussel width of 1-year old individuals was 3.86 cm, 2-year olds 3.54 cm, 3-year olds 3.77 cm, 4-year olds 4.17 cm, 5-year olds 4.44 cm, 6-year olds 4.59 cm and 7-year olds 4.80 cm, respectively (Table 1). Individuals with shell width ranging from 3.5 to 4.5 cm dominated. The range was 4, standard deviation 0.56, and coefficient of variation 13.5% (Table 2).

Among the measured swan mussels of Bobolin Lake the widest shell reached 7.70 cm, the narrowest 2.20 cm. Mean shell width of the population was 5.61 cm. Mean shell width of 1-year old individuals was 3.74 cm, 2-year olds 4.49 cm, 3-year olds 6.30 cm, 4-year olds 6.70 cm, 5-year olds 6.95 cm and 6-year olds 6.73 cm, respectively. Individuals with shell width ranging from 4.0 to 4.5 cm and from 5.5 to 7 cm dominated (Table 1). The range was 5.5, standard deviation 1.17, and coefficient of variation 21.3% (Table 3).

Analysis of mussel height

The height of measured *A. cygnea* of Binowo Lake ranged from 0.70 to 3.70 cm. Mean mussel height of the population inhabiting Binowo Lake was 2.40 cm. Mean bivalve height of 1-year old individuals was 0.85 cm, 2-year olds 1.56 cm, 3-year olds 2.04 cm, 4-year olds 2.43 cm, 5-year olds 2.58 cm, 6-year olds 2.67 cm and 7-year olds 2.84 cm, respectively (Table 1). Individuals with shell height ranging from 2 to 3 cm were dominating. The range was 3, standard deviation 0.46, coefficient of variation 23.7% (Table 2).

Shell height of swan mussels inhabiting Bobolin Lake ranged from 0.70 to 3.70 cm. Mean bivalve height of the population inhabiting this lake was 2.40 cm. Mean shell height of 1-year old individuals was 1.64 cm, 2- year olds 2.70 cm, 3- year olds 4.24 cm, 4- year olds 4.72 cm, 5- year olds 4.80 cm, and 6-year olds 4.43 cm, respectively. Individuals with mussel height ranging from 2 to 3 cm dominated (Table 1). The fraction in height of the remaining individuals was similar to the share in length and width. The range was 4.9, standard deviation 1.14, and coefficient of variation 31.4% (Table 3).

Correlation between mussel length and width

There was a significant correlation between shell length and width of mussels occurring in Binowo Lake. The correlation coefficient was positive with an r value of 0.92: the correlation between these two features was high and the regression equation took the form of $y = 0.53 + 0.46x$ (Figure 2).

In Bobolin Lake the correlation was similar to that in Binowo Lake. The correlation coefficient was 0.92 and regression equation $y = 1.05 + 0.42x$ (Figure 3).

Correlation between mussel length and height

In Binowo Lake the correlation coefficient was $r = 0.91$, with regression equation $y = -0.59 + 0.38x$ (Figure 4).

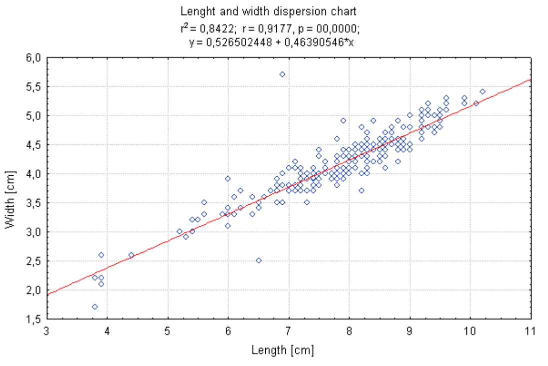

Fig. 2. Relationship between length [L] and width [H] in *Anodonta cygnea* collected from Binowo Lake.

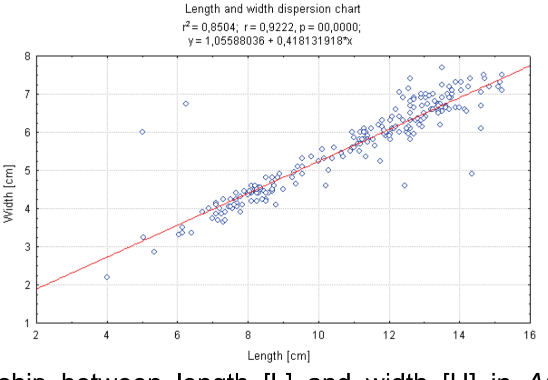

Fig. 3. Relationship between length [L] and width [H] in *Anodonta cygnea* collected from Bobolin Lake.

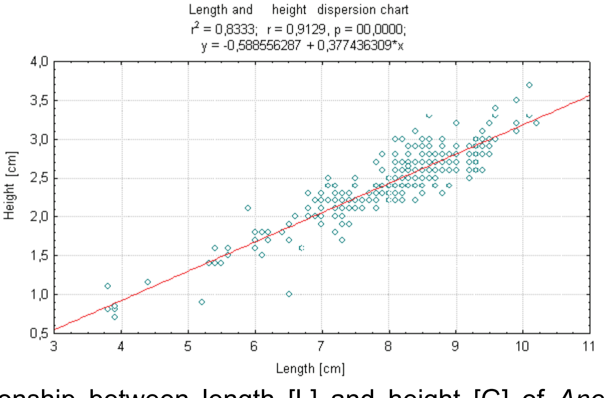

Fig. 4. Relationship between length [L] and height [G] of *Anodonta cygnea* collected from Binowo Lake.

In Bobolin Lake mussel length and height were highly correlated (r = 0.86), with a regression of y = -0.52 + 0.38x (Figure 5).

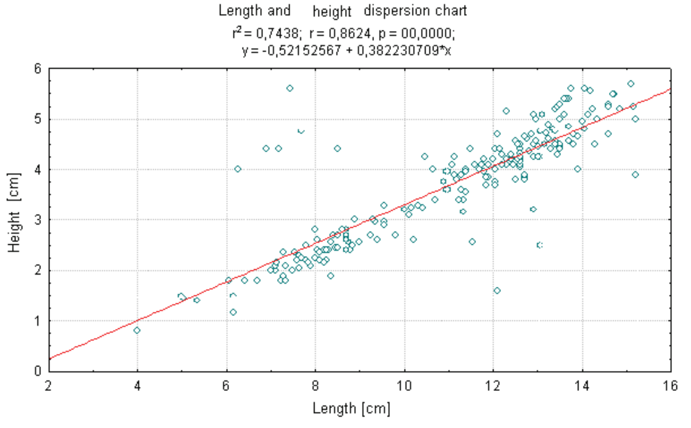

Fig. 5. Relationship between length [L] and height [G] of *Anodonta cygnea* collected from Bobolin Lake.

Correlation between mussel width and height

In Binowo Lake the correlation coefficient between mussel width and height was r = 0.86, and the regression equation took the form of y = -0.56 + 0.70x (Figure 6).

In Bobolin Lake, shell width and height were highly correlated (r = 0.84), and the regression equation took the form of y = -0.98 + 0.82x (Figure 7).

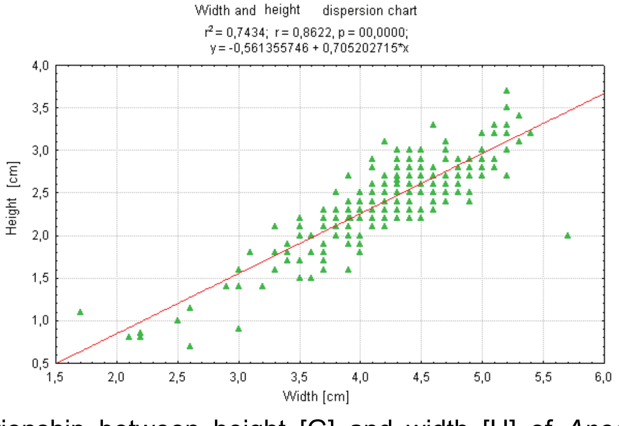

Fig. 6. Relationship between height [G] and width [H] of *Anodonta cygnea* collected from Binowo Lake.

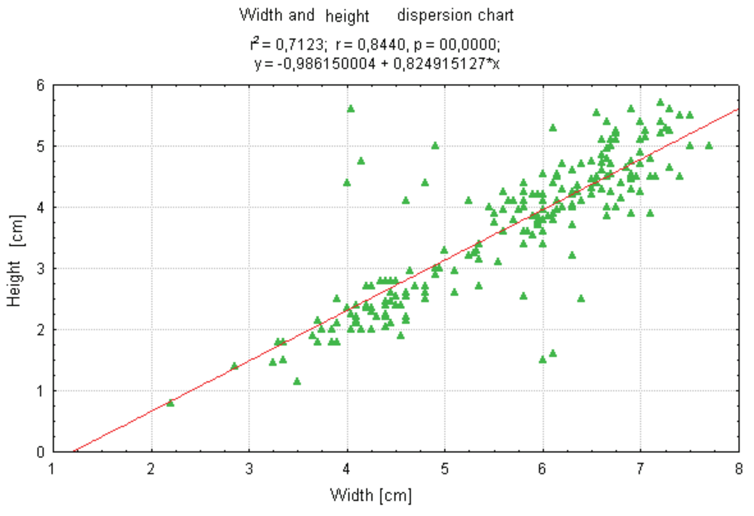

Fig. 7. Relationship between height [G] and width [H] of *Anodonta cygnea* collected from Bobolin Lake.

Correlation between age and mussel length

In Binowo Lake the correlation coefficient was r = 0.65. The regression equation shown in Figure 8 took the form of y = -5.17 + 0.63x. In Bobolin Lake, mussel shell width and height were highly correlated (r = 0.7) and the regression equation took the form of y = 5.63 + 1.86x (Figure 9).

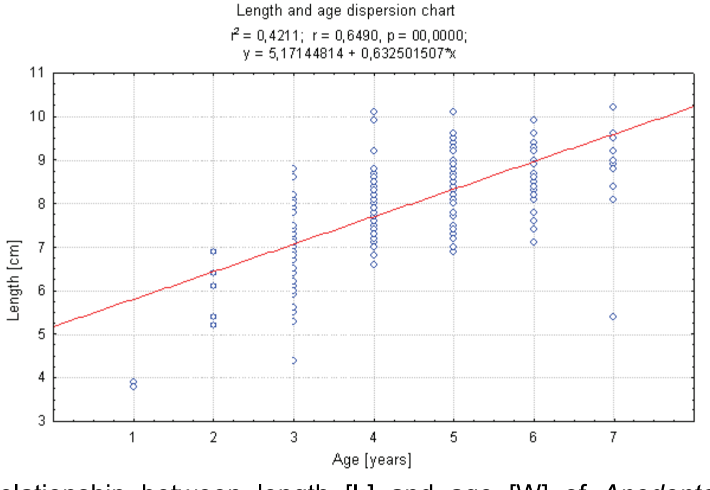

Fig. 8. Relationship between length [L] and age [W] of *Anodonta cygnea* collected from Binowo Lake.

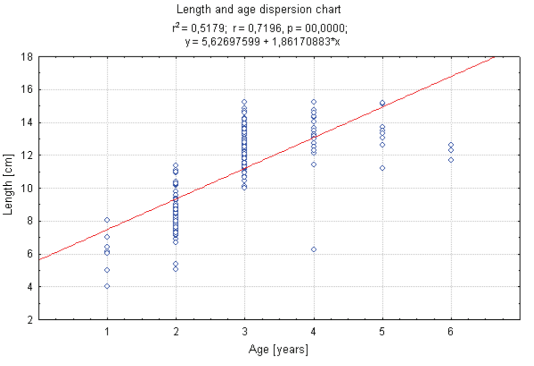

Fig. 9. Relationship between length [L] and age [W] of *Anodonta cygnea* collected from Bobolin Lake.

Correlation between age and mussel width

In Binowo Lake mussel age and width were moderately correlated (r = 0.62), and the regression equation took the form of y = 2.88 + 0.30x (Figure 10). In Bobolin lake mussel age and width were also moderately correlated (r = 0.56), and the regression equation took the form of y = 3.12 + 0.88x (Figure 11).

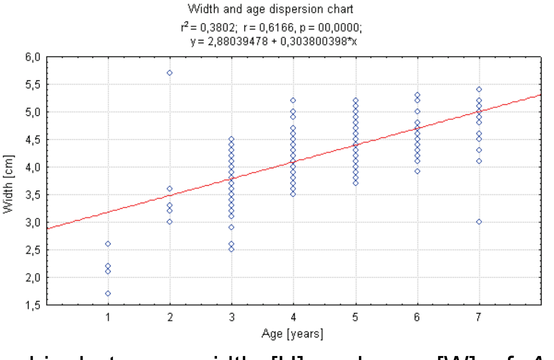

Fig. 10. Relationship between width [H] and age [W] of *Anodonta cygnea* collected from Binowo Lake.

Correlation between mussel age and height

In Binowo Lake mussel age and height were moderately correlated (r = 0.62), and the regression equation took the form of y = 2.88 + 0.30x (Figure 12). In Bobolin lake age and height were also moderately correlated (r = 0.69), and the regression equation shown in Figure 13 took the form of y = 1.40 + 0.79x.

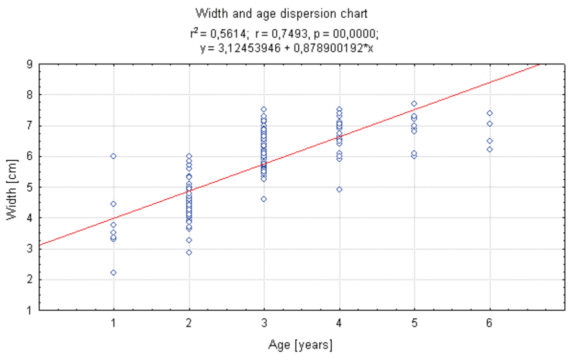

Fig. 11. Relationship between width [H] and age [W] of *Anodonta cygnea* collected from Bobolin Lake.

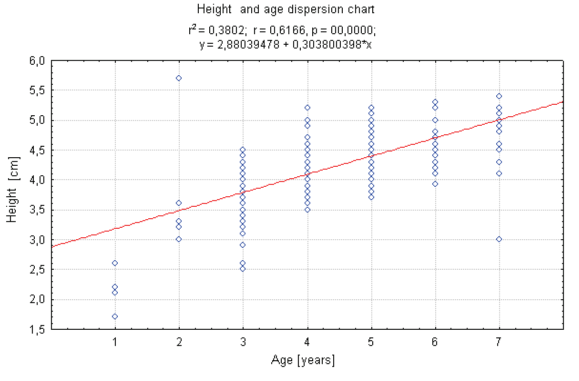

Fig. 12. Relationship between height [G] and age [W] of *Anodonta cygnea* collected from Binowo Lake.

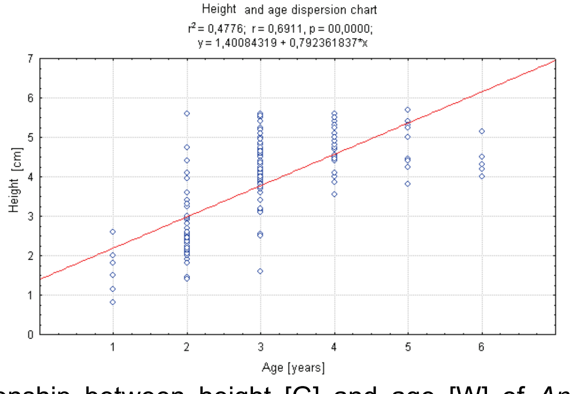

Fig. 13. Relationship between height [G] and age [W] of *Anodonta cygnea* collected from Bobolin Lake.

DISCUSSION

Information on *A. cygnea* is rarely provided in the malacological literature. Research on population ecology and dynamics and their dependence on habitat conditions has been limited, and we should bear in mind that this species is endangered both in Poland and Europe. Considering the endangered status of the swan mussel and its importance in self-purification of water bodies (mussels filtrate water), far more attention should be paid to this species and more detailed research should be conducted.

Measurements of mussels inhabiting Binowo and Bobolin Lakes show that the swan mussel population is dominated by individuals aged 2+, 3+, and 4+ years old. No individual aged 7 or older (alive or empty shell) was found in either lake. It is possible that swan mussels of the examined lakes do not live up to the age of 7 years. According to the inventory of fauna conducted by Stare Czarnowo commune in 1996, under order from the Nature Conservation Office in Szczecin (Biuro Konserwacji Przyrody w Szczecinie), no *A. cygnea* was found in Binowo Lake. According to the literature, the maximum age in European populations is 15, however, the majority live less than 10 years (Ravera & Sprocati 1997). Krzyżanek (1989), examining mussels of Zbiornik Goczałkowski, found that 8 to 10-year old swan mussels dominated while Lewandowski (1990) found 14-year old individuals with 3- and 6-year old individuals dominant, and 4-year old individuals dominating in the Szeszupa River.

The small fraction of young mussels (1+ and 2+ in Binowo Lake, 1+ in Bobolin Lake) may indicate strong fluctuations in the population caused by deteriorating physical and chemical conditions of the habitat due to anthropogenic pollution. Zając (2002) states that swan mussels reach maximum density at a particular successional stage of a water body. The older the water body, the less abundant the swan mussels, and both studied lakes are beginning to grow in. Another explanation for the low fraction of young mussels could be the extinction of hosts for parasitic larvae (glochidia) i.e. eel, pike, tench, pumpkinseed sunfish, perch and even three-spined stickleback. Fish of both lakes are intensively caught by professional fisherman, anglers and birds. As larvae are unable to develop in the absence of hosts, this may explain the unstable situation in Bobolin Lake. Additionally, mussels of the examined lake are used by some village inhabitants as food for poultry.

The shell of *A. cygnea* can be up to 20 cm long (Wirbellose 2001). Mean shell length of mussels inhabiting Binowo Lake (ca. 8 cm) were similar to results obtained by Kraszewski (2005) in the heated lake system near Konin. Moreover, results obtained by other authors indicate dominance by individuals with shell lengths of 7-9 cm.

Comparing length and width within age groups in both lakes, we can infer that the highest growth rates occur when they are 2-years old. Swan mussels reach maturity when they are 2 – 3 years old.

All correlations between length, width, height and age of the *A. cygnea* population were small. Correlations between measurable features were very strong, between length and width and length and height in particular. Hence, the longer the shell, the wider and higher it is. Therefore, wide swan mussels are usually thicker. The correlation between length and age is moderate; the longer the shell, the older the swan mussel.

Some individuals aged 2+, 3+, 4+ and 5+ of Bobolin Lake were similar in terms of length and width. However, there were some 2- and 3-year old individuals that were larger than 5- and 6-year old mussels. A similar situation took place in the case of mussels 4+, 5+ and 6+ from Bobolin Lake. Better habitat conditions (e.g. water richer in organic matter) during the period of most intensive growth, i.e. when mussels are 2-years old, were the cause of this situation.

In a comparison of individuals of both lakes, it can be stated that swan mussels inhabiting Bobolin Lake have better conditions for growth than those of Binowo Lake. Measurements within age groups demonstrate that mussels of Bobolin Lake are twice as large as those of Binowo Lake, likely the result of "exploitation" by local people in order to feed poultry. Decreased competition for food may have resulted in better growth. I hypothesize that competition for food in Binowo Lake was fiercer and as a result, swan mussels are smaller there. However, testing of this hypothesis requires further research on the population in Bobolin Lake.

The decline in size of *A. cygnea* in Bobolin Lake led to two main changes in the population: an increase in reproduction among surviving adults (while size of adults declines, egg production and expelled larvae increase) as well as a decline in the natural mortality of adults (Begon et al. 1999).

The *A. cygnea* population is threatened by the use of the lakes for recreation by local people as well as by use as a watering place for animals. Many destroyed shells were found while conducting research in Bobolin Lake; they were partly or completely smashed. While in Binowo Lake both damaged and dead mussels were found (comprising 7% of the population).

Podolski (2005) cite that *A. cygnea* is a species with low tolerance for extreme physical and chemical parameters, big measurements, low metabolic activity, lack of an observed daily cycle, and relatively long life expectancy. Hence, swan mussels are considered good bioindicators of incident contamination. Under normal conditions, they spend most of their life (some 70%) filtering water, which provides them with both oxygen and food. In the case of a sudden change in conditions (e.g. thermal or chemical contamination), they stop filtering and tightly close their shells. A prolonged situation leads to mass death of swan mussels. This is the reason that AMU Innovation and Technology Transfer Centre (Centrum Innowacji i Transferu Technologii UAM) in Poznań introduced the project „ Early warning system for water pollution using *A. cygnea* as a bioindicator". The project is based on monitoring the living activity of mussels, and has worked successfully for a few years at the water intake site in Poznań (Podolski 2005).

Moreover, a case that is well known in ecology was observed in Binowo Lake: *A. cygnea* is used by *Dreissena polymorpha* as a means of transport. A biofouling consisting of 1 to 3 alive *D. polymorpha* was found on the shells of 7 individuals of *A. cygnea* (Rosell et al. 1999).

Although the mussels of both lakes differ in terms of shell colour and size, the age structure is similar, and given results of the correlation analyses, it can be stated that the populations of both lakes are one population, distinctive for lakes in the Szczecin region.

CONCLUSIONS

- 497 individuals of *A. cygnea* of two lakes located in the vicinity of Szczecin were measured in 2005. Binowo Lake is inhabited by mussels aged 1+ to 7+ years, and Bobolin Lake by 1+ to 6+ year olds. The age structure contained individuals of diverse ages, and mussels aged 3 - 4 dominated in both lakes. Individuals in the youngest (1,2) and oldest (6,7) age classes made up a small fraction of the examined population.
- In 2005, Binowo Lake was inhabited by mussels 3.80 to 10.20 cm long, 1.70 to 5.70 cm wide and 0.70 to 3.70 cm thick. In Bobolin Lake these values were 4.00 to 15.20 cm, 2.20 to 7.70 cm, 0.80 to 5.70 cm, respectively.
- All relationships among measurable features, length, width, and height of the shell and mussel age were positively correlated, and results obtained from both lakes were similar.
- In a comparison of the two lakes, swan mussels in Bobolin Lake were inferred to have experienced better living conditions, as they are twice as large. Considering that the age structure of mussels inhabiting both lakes were similar as well as correlations between their length, width, height, and age, swan mussels inhabiting both lakes can be regarded as a single population.

REFERENCES

Ministry of Environment. (2001). *Act of April 27, 2001*. Warszawa: Journal of Laws No.130, item 1456 (in Polish: Dz. U. Nr 130, poz. 1456)

Begon, M., Mortimer M. & Thompson D.J. (1999). *Ecology of populations*. Warszawa: Polsk. Wyd. Nauk. (in Polish)

Czechowski, W, Gajewski W. & Garbaczewska G. & Nowakowski E. (1994). *Biology*. Warszawa: Państw. Wyd. Roln. Leśn. (in Polish)

Filipiak, J. & Sadowski J. (1994). *Lakes of Szczecin*. Szczecin: Akad. Roln. Wyd. II (in Polish)

Głowaciński, Z. (1992). *The Red Data Book of Endangered Animals in Poland*. Warszawa: Państw. Wyd. Roln. Leśn. (in Polish)

Kraszewski, A. (2005). *Unionidae from the system of heated lakes near Konin*. In Presented at the 21st National Malacology Seminar 8 April 2005. Toruń, Poland: Wyd. Uniw. Mikoł. Kopernika.

Krzyżanek, E. (1989). The Role of Unionidae in the Goczałkowice reservoir. *Wszechświat*. 90 (3), 57 – 8. Polskie Towarzystwo Przyrodników im. Kopernika. Kraków. from: www.wszechswiat.agh.edu.pl (in Polish)

Kujawa, R. (2004). Różanka. Przyroda Polska, (11/2004), 15-6. Liga Ochrony Przyrody, Warszawa, from www.przyrodapolska.home.pl (in Polish)

Lewandowski, K. (1990). Unionidae of the Szeszupa River and of the Lakes along its course in Suwalski Landscape Park,. *Ekologia Polska*, (38, 3-4), 271-86.

Lipnicki, W. (1993). *Beech forest – miniguidebook*. Szczecin: Centr. Ośr. Inform. Techn. (in Polish)

Łomnicki, A. (2003). *Introduction to statistics for naturalists*. Warszawa: Polsk. Wyd. Nauk. (in Polish)

Podolski, G. (2005). *Chcieliśmy ulepszyć monitoring jakości wody do picia, a jednocześnie zabezpieczyć się przed ewentualnymi atakami szaleńców-terrorystów. Gazeta Samorządu i Administracji*. 195(21/2005), 23-5. Warszawa: Grupa Wydawnicza INFOR S.A. from: www.gsia.infor.pl (in Polish)

Ravera, O. & Sprocati A.R. (1997). Population dynamics, production, assimilation and respiration of two freshwater mussels: Unio mancus, Zhadin and Anodonta cygnea Lam. *Mem. Ist. Ital. Idrobiol*., (56), 113-30.

Rosell, R.S., Mguire C.M.& McCarthy T.K. (1999). First reported settlement of the Zebra Mussel Dreissena polymorpha in the Erne System, CO. Fermanagh, Northern Ireland. *Biology and Environment: Proceedings of the Royal Irish Academy*, Vol. 98B, (3), 191-3.

Urbański, J. (1957). *Krajowe ślimaki i małże. Klucz do oznaczania wszystkich gatunków dotąd w Polsce wykrytych*. Warszawa: Państw. Zak. Wyd. Szkol. (in Polish)

Wirbellose. (2001). *Grosse Teichmuschel (Schwanenmuschel). Anodonta cygnea L.* Retrieved September 7, 2006, from http://www.bsh-umweltladen.de/bsh/2000-wirbelloser.htm (in German)

Zając, K. (2002). Habitat preferences of the swan mussel Anodonta cygnea (Linnaeus 1758) (Bivalvia, Unionidae) in relation to structure and successional stage of floodplain waterbodies. *Ekologia (Bratislava)*, 21(4), 345-55.

Zając, K. (2004) *Anodonta cygnea - The Polish Red Data Book of Animals – Invertebrates*. Retrieved Juny 23, 2006, from http://www.iop.krakow.pl/pckz/opis.asp?id=128&je=pl (in Polish)