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*Short Communication*

# Biometrics of the Swan Mussel *Anodonta cygnea*

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## Abstract

Studies of the swan mussel population in lake Dąbie (Odra estuary) were conducted in 2007. Measurements were taken of shell length, height and girth, and age was determined. The *Anodonta cygnea* individuals studied were from the 1+ to 5+ age classes. Clear differentiation was noted in the meristic characters of the mussels collected from the northern part of the lake (Dąbie Wielkie) and from the southern part (Dąbie Małe). The percentage share of individuals in the age structure was also different; however, individuals from the 2+ and 3+ age classes dominated in both parts of the basin. The share of the oldest individuals (4+ and 5+ age classes) was small in Dąbie Wielkie. Mean±SE mussel length of examined population from Dąbie Wielkie amounted to 65.6±0.04 mm, height 36.5±0.66 mm, and girth 21.2±0.43 mm. Means for meristic characters of shells *A. cygnea* from Dąbie Małe lake were length 65.6±1.06 mm, height 40.0±0.75 mm and girth 22.2±0.36 mm. The dependency among the meristic characters of shell length, height, and girth of the *A. cygnea* individuals studied exhibited a high, positive correlation. The correlation between the studied meristic characters and the age of the swan mussels did not exhibit a strong dependence.

**Keywords:** *Anodonta cygnea*, mussel biometrics, Lake Dąbie, Odra River estuary

## Introduction

The swan mussel (*Anodonta cygnea*) is one of the largest freshwater mussels. It is a palearctic species, inhabiting fresh and brackish waters (water salinity range of 0.1-0.2 PSU). In Poland, this species occurs below 500 m a.s.l., usually in shallow eutrophic aquatic basins, but also, although rarely, in rivers or oxbow lakes, canals, ponds, and flow-through lakes. It is also noted in artificial basins (artificial fish ponds, dam reservoirs) [1]. The swan mussel prefers nutrient-rich bottom sediments, but it also occurs at considerable distances from the shore, and at deeper depths. It also occurs in shallow littoral zones that are free of macrophytes, which differentiates it markedly from other *Unionidae*. It also inhabits the zone from about 0.2 m as well as depths of several meters. In Poland, the abundance of *A. cygnea* has declined suddenly due to increasing anthropogenic pressure affecting aquatic basins. Some of the most common threats include water contaminated by sewage, especially industrial and chemical wastewaters, petroleum and toxic substances, and runoff with artificial fertilizers and pesticides, as well as works to regulate and drain river valleys, mainly oxbow lakes. Increasingly in recent years, mussels are transferred to artificial ponds and garden water features; this activity is not only threatening to this species, it is also illegal. All of these factors have contributed to the degradation of the natural habitat of the swan mussel. *Anodonta cygnea* has a very narrow range of tolerance of negative environmental factors, which makes it a good bioindicator of clean, well-oxygenated waters with nutrient-rich bottom sediments. The systematic decline or outright loss of populations of swan mussels from basins is the result of chronic changes in environmental conditions. According to the law [2], *Anodonta cygnea* is a species under full protection in Poland, and since 1995 it has been listed in the "Red List of Threatened Animals in Poland" [3]

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with a status of E – endangered, Red List of the Animals of Brandenburg with a status of 3 – threatened, and the Red List of Animals from Mecklenburg-Vorpommern with a status of 3 – threatened [4].

In Poland, studies of the swan mussel have been performed by, among others, Lewandowski [5, 6], Świerczyński [7, 8], Zając [9], Chojnacki et al. [10], Rosińska et al. [11], and Ożgo et al. [12]. In 2007 similar research was performed by Chojnacki et al. in the southwestern part of the Szczecin Lagoon along the shoreline [13].

The present research was conducted on a population of *A. cygnea* in Lake Dąbie (lakes Dąbie Wielkie and Dąbie Małe) located in Szczecin. The research aimed to explore the relationship between measurable features of swan mussels (shell length L, height H, and girth G) and their age, as well as determine the age structure of the population.

## Study Area

Lake Dąbie is a large, post-glacial delta lake on the outskirts of the administrative border of the city of Szczecin (Fig. 1). It is also the continuation of the Regalica river, which is the eastern Odra. It is the fourth largest lake in Poland with a surface area of 56 km$^2$. The mean depth of Lake Dąbie is from 3.0-3.5 m, while the maximum depth is up to 8 m. The maximum width of the lake is 7.5 km, while the maximum length is 15 km. The lake is divided distinctly into two parts: the northern is Dąbie Wielkie (Big Dąbie), while to the south lies Dąbie Małe. The lake has a well-developed shoreline with many yacht rest-stops and marinas. It is also the only lake in Poland in which sea faring vessels and barges can moor. The basin is connected to the Odra current through a series of straits and canals. It is separated from the Odra by islands: Czapli Ostrów, Sadlińskie Łąki, Mienia, Wielka Kępa, Radolin, Czarnołęka, Dębina, Kacza, and Mewia. The lake is also the recipient of communal and industrial sewage from the southeastern section of the city (Załom, Dąbie, etc.) [14]. Nędzarek et al. [15] over the period 1997-2000 have observed the process of slow self-purification of the water in Lake Dąbie. Their research showed that the proportion of native organic matter was higher in Lake Dąbie compared with the Odra waters. Correlation between $BOD_5$ and chlorophyll *a* was strong in the water of Małe Dąbie.

## Materials and Methods

Twenty sampling sites were designated in Lake Dąbie Wielkie, and twelve in Dąbie Małe (Fig.1). The geographic coordinates are following for Dąbie Wielkie:
Station A: 53°26'289"N, 014°36'387"E
Station B: 53°26'470"N, 014°36'140"E
Station C: 53°26'713"N, 014°35'864"E
Station D: 53°26'803"N, 014°35'872"E
Station E: 53°27'235"N, 014°36'586"E
Station F: 53°27'426"N, 014°37'761"E
Station G: 53°27'231"N, 014°38'206"E
Station H: 53°26'949"N, 014°38'006"E
Station I: 53°27'906"N, 014°39'114"E
Station J: 53°29'041"N, 014°38'267"E
Station K: 53°29'925"N, 014°38'535"E
Station L: 53°30'127"N, 014°38'413"E
Station M: 53°30'264"N, 014°38'322"E
Station N: 53°30'840"N, 014°38'328"E

For Lake Dąbie Małe:
Station No. 1: 53°23'962"N, 14°39'397"E
Station No. 2: 53°24'N, 14°39'E
Station No. 3: 55°24'121"N, 14°39'566"E
Station No. 4: 55°24'N, 14°39'E
Station No. 5: 53°24'N, 14°39'E
Station No. 6: 53°24'257"N, 14°39'843"E
Station No. 7: 53°24'268"N, 14°39'873"E
Station No. 8: 53°24'470"N, 14°40'016"E
Station No. 9: 53°24'085"N, 14°38'074"E
Station No. 10: 53°24'773"N, 14°38'176"E
Station No. 11: 53°25'169"N, 14°38'299"E
Station No. 12 53°25'754"N, 14°38'291"E

The sampling was performed from the shore and from aboard a boat. The mussels were collected either one at a time from the bottom of the basin, or with a drag. In deeper waters, a triangular benthic drag was pulled across the

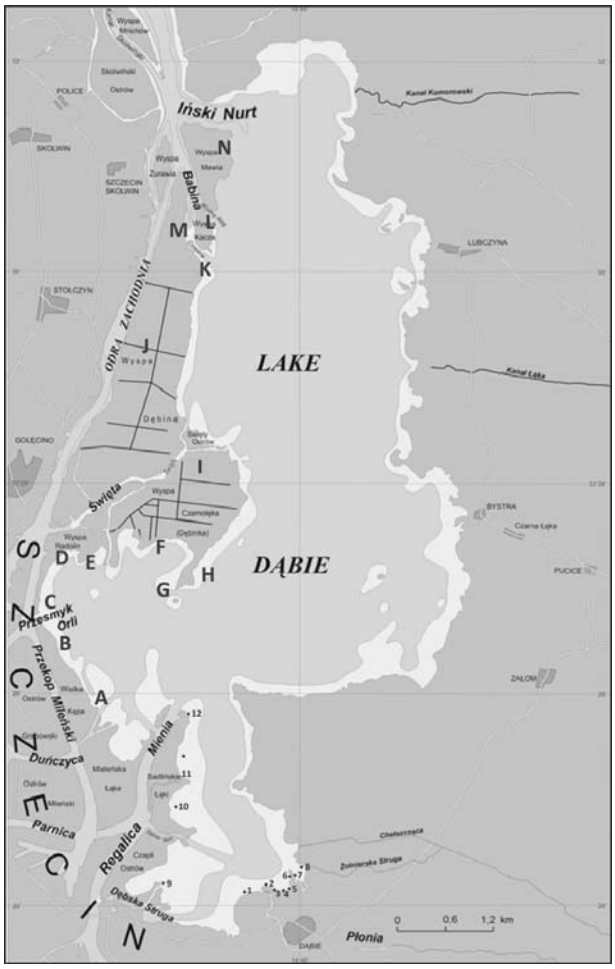


Fig. 1. Map of Lake Dąbie showing the sampling sites (from A to N – Dąbie Wielkie, from 1 to 12 – Dąbie Małe [24], changed).

Table 1. Mean±SE values of shell length, height, and girth in various age groups of *Anodonta cygnea* from lakes Dabie Wielkie and Małe.

| Lake | Variable | Age W [years] | Number of individuals | Length L Mean±SE [mm] | Height H Mean±SE [mm] | Girth G Mean±SE [mm] |
|---|---|---|---|---|---|---|
| Dąbie Wielkie | | 1+ | 48 | 61.2±1.67 | 36.6±1.05 | 19.6±0.50 |
| | | 2+ | 145 | 66.0±0.93 | 35.5±0.62 | 21.3±0.28 |
| | | 3+ | 88 | 67.3±1.13 | 37.9±0.70 | 21.9±0.34 |
| | | 4+ | 4 | 68.3±8.65 | 38.5±2.90 | 22.3±2.15 |
| | | 5+ | 1 | 68.0 | 45.0 | 21.0 |
| | Total | | 286 | | | |
| | Mean±SE | 2.2±0.20 | | 65.6±0.04 | 36.5±0.66 | 21.2±0.43 |
| | min-max | 1-5 | | 32-98 | 19-59 | 10-35 |
| | Variance | 0.533 | | 125.44 | 51.84 | 11.56 |
| Dąbie Małe | | 1+ | 10 | 60.4±1.64 | 37.4±1.55 | 20.7±1.04 |
| | | 2+ | 100 | 68.1±1.56 | 42.1±1.05 | 22.7±0.53 |
| | | 3+ | 39 | 64.2±1.96 | 38.1±1.56 | 21.3±0.71 |
| | | 4+ | 23 | 62.3±2.77 | 37.0±2.26 | 21.9±0.96 |
| | | 5+ | 11 | 58.9±4.81 | 35.4±3.23 | 22.4±1.39 |
| | Total | | 183 | | | |
| | Mean±SE | 2.6±0.07 | | 65.6±1.06 | 40.0±0.75 | 22.2±0.36 |
| | min-max | 1-5 | | 32-113 | 20-65 | 10-35 |
| | Variance | 0.968 | | 204.49 | 104.04 | 24.01 |

basin bottom by the boat. Samples of *A. cygnea* were collected from Dąbie Małe on 11.05.2007, 19.05.2007, 29.05.2007, and 12.09.2007, while in Dąbie Wielkie they were collected on 12.09.2007, 13.09.2007, and 19.09.2007. During the studies, the mussels were submerged in water, and following the measurements they were released back into the lake. A slide caliper was used to measure length [L], height [H], and girth [G] of each specimen (to the nearest 1 mm). Age was determined by counting the annual rings on the surface of the swan mussel shells.

The following statistical parameters were calculated: minimum, maximum, arithmetic mean, standard error SE, variation, and the linear correlation coefficient r.

## Results

### Analysis of Age Structure

The abundance of the swan mussels studied is presented by age class in Table 1. Among the *A. cygnea* individuals collected from Lake Dąbie, nearly half were in the 2+ age class. The second most abundant age category was that of 3+ mussels. The fewest number of individuals was classified as 5+ (total of 12 ind.). The mean age of *A. cygnea* from Lake Dąbie was slightly above 2 years (Table 1).

### Analysis of Meristic Characters of Shells

Among the *A. cygnea* individuals from Lake Dąbie that were measured, the largest shell was 113 mm long, while the smallest was 32 mm. The mean length value for the entire studied population was 65.6±0.04 mm in Dąbie Wielkie and 65.6±1.06 mm in Dąbie Małe (Table 1). The mean±SE length of the shells of specimens according to age classes is presented in Table 1. In Dąbie Wielkie, the length of the shell increased with age, while in Dąbie Małe, the individuals with the longest shells were 2+ individuals.

In Lake Dąbie, the highest shell was 65 mm, while the shortest was 19 mm (Table 1). The mean value of the height of the swan mussels from Dąbie Wielkie was 36.5±0.66 mm, while from Dąbie Małe, they were 40.0±0.75 mm. The mean value of shell height for individuals according to age class is presented in Table 1.

The maximum shell girth was 35 mm, and the minimum was 10 mm. The mean shell girth of *A. cygnea* from Dąbie was 21.2±0.43 mm (Table 1).

The dependence among the individual meristic characters was of high and medium correlation strength, while that among these characters and age was weak. The values of the correlation coefficients are presented in Table 2.

Table 2. The values of the correlation coefficients and $r^2$ for meristic characters (length L, height H, girth G, and age W) of *Anodonta cygnea* shells from lakes Dąbie Wielkie and Małe (empty – cannot calculate).

| Lake | Correlation | All | 1+ | 2+ | 3+ | 4+ | 5+ |
|---|---|---|---|---|---|---|---|
| Dąbie Wielkie | L-H | 0.602<br>$r^2$=0.36 | 0.785<br>$r^2$=0.62 | 0.621<br>$r^2$=0.39 | 0.472<br>$r^2$=0.22 | 0.847<br>$r^2$=0.72 | |
| | L-G | 0.811<br>$r^2$=0.66 | 0.877<br>$r^2$=0.77 | 0.810<br>$r^2$=0.66 | 0.722<br>$r^2$=0.52 | 0.984<br>$r^2$=0.97 | |
| | L-W | 0.170<br>$r^2$=0.03 | | | | | |
| | H-G | 0.663<br>$r^2$=0.44 | 0.709<br>$r^2$=0.50 | 0.713<br>$r^2$=0.51 | 0.572<br>$r^2$=0.33 | 0.908<br>$r^2$=0.82 | |
| | H-W | 0.103<br>$r^2$=0.01 | | | | | |
| | G-W | 0.218<br>$r^2$=0.05 | | | | | |
| Dąbie Małe | L-H | 0.834<br>$r^2$=0.69 | 0.785<br>$r^2$=0.62 | 0.825<br>$r^2$=0.68 | 0.811<br>$r^2$=0.66 | 0.856<br>$r^2$=0.73 | 0.879<br>$r^2$=0.77 |
| | L-G | 0.841<br>$r^2$=0.71 | 0.868<br>$r^2$=0.75 | 0.882<br>$r^2$=0.78 | 0.861<br>$r^2$=0.74 | 0.791<br>$r^2$=0.63 | 0.550<br>$r^2$=0.30 |
| | L-W | -0.144<br>$r^2$=0.02 | | | | | |
| | H-G | 0.875<br>$r^2$=0.77 | 0.937<br>$r^2$=0.88 | 0.921<br>$r^2$=0.85 | 0.879<br>$r^2$=0.77 | 0.835<br>$r^2$=0.70 | 0.597<br>$r^2$=0.36 |
| | H-W | -0.181<br>$r^2$=0.03 | | | | | |
| | G-W | -0.031<br>$r^2$=0.01 | | | | | |

## Discussion

The analysis of measurements and the meristic characters of the mussels from lakes Dąbie Wielkie and Małe indicated that the swan mussel population was dominated by young individuals from the 2+ and 3+ age classes. No dead mussels or even empty shells were found of individuals over the 5+ age class. Perhaps this species does not live longer than five years in the studied basin. Ökland (after Müller et al. [16]) explained the lack of the old shells in the shallow water with the labile environment (wave action, influence of ice in winter, possibility of dying, influence of predactors) which tends to increase the mortality rate and reduce the possibility of finding old shells. Chojnacki et al. [13] studied the age of the population ranging from 1 to 6 years, and this population was dominated by age classes 3+ (46%) and 2+ (23%). Age class 1+ individuals comprised just a small percentage of the whole population (13%). According to literature in the data, the maximum age for the European population is 15 years; however, most individuals are younger than ten years [17]. In studies of the Goczałkowice Dam Reservoir, Krzyżanek (after Chojnacki et al. [10]) confirmed the domination of swan mussels from the 8+ to 10+ age classes. Weber [18] investigated *Unionidae* in a northeastern German river between 1996 and 1998. The age structures of *Anodonta anatina* and *A. cygnea* (the Eldest were 14 years) appeared very unbalanced within the period of survey. In another northeastern German river, Recknitz near Bad Sülze, the age of swan mussels ranged from 3+ to 15+, and individuals 5+ and 6+ dominated [19]. Müller et al. [16] observed swan mussels to 10 years old, but from 5+ to 7+ were dominated in the shallow water of Lake Mattsee. Lewandowski [5] noted individuals aged over 14 years, although the decided dominants were 3+ and 6+, while in the Szeszupa River they were 4+. The domination by 2+ individuals and a maximum age of 5 years paints a picture of a younger population of *A. cygnea* in Lake Dąbie. Swan mussels achieve

sexual maturity in the second or third year of life [1]. This means it is possible that the studied population of swan mussels will develop in lakes.

The length of the *A. cygnea* shell can reach as much as 200 mm [20]. The mean length of swan mussel shells from Lake Dąbie (6.56 cm) is substantially smaller than that recorded for this same species in the region of lakes Binowo and Bobolin [10], or than that recorded by Kraszewski [21] in the Konin heated lakes system, or in the lakes of the Western Pomeranian region [11]. Studies by other authors also indicate that the dominant swan mussel individuals have shells ranging in size from 70-90 mm. Erdilal et al. [22] studied *Unio pictorum* and *A. cygnea* in Büyükçekmece Lake, Istanbul, and the average values of biometric measurements' of *A. cygnea* were: length 80.20 mm, height 44.18 mm, and girth 26.98 mm. Başçınar et al. [23] have reviewed higher values of biometrics. The mean meristic characters of swan mussels in Lake Çıldır in Turkey were length 104.2±0.52 mm (range 49.8-136.8 mm), height 54.1±0.24 mm, and girth 33.3±0.21 mm. In the German Recknitz River individuals of *A. cygnea* had shell lengths from 40 to 140 mm, and from 80 to 100 mm dominated [19]. The southwestern part of Szczecin Lagoon [13] has been shell length of *Anodonta cygnea* ranging from 46 to 100 mm, height 26 to 83 mm, and girth 16 to 52 mm. Anthropogenic pollution (mainly municipal sewage) might be a cause of the poor development of *A. cygnea* in Lake Dąbie, as expressed by the smaller shell size. In winter, the lake is the holding areas for broken ice from along the Lower Odra route. This concentration of ice in this shallow basin reaches to the bottom, where it and crushes everything. Mechanical destruction during severe winters might be one of the causes of the limited age of the population. The height and girth of the shells was also smaller than values reported in the literature.

The correlation dependencies of the meristic characters was strong, especially that between length and height and between length and girth. The longer the shell the higher and broader the girth. In studies of the Szczecin Lagoon, Chojnacki et al. [13] confirmed the highest correlations were noted between shell length and height and between length and girth. The correlation dependency between length and age was weak. Similar results were reported by Rosińska et al. [11], in a work that presents the correlation dependencies among meristic characters and the age of *A. cygnea* in Lake Żerdno (Drawskie Lakeland). Shell length does not increase with mussel age. This is reflected in the data and discussion of the meristic characters of the swan mussel in Lake Dąbie.

The similar shell sizes and age structure of the individuals studied in the two parts of Lake Dąbie (Wielkie and Małe) provide an unprecedented basis for concluding that the swan mussel populations are indeed a single population.

The known ecological phenomenon of another mussel, *Dreissena polymorpha*, using aggregations of swan mussel as a substrate and for locomotion, has been observed in Lake Dąbie.

## Conclusions

The swan mussel individuals from lakes Dąbie Wielkie and Małe comprise a single population that is characterized by a young age and an individual shell size that is substantially smaller than that published to date. The dependence among meristic characters (shell length, height, and girth) exhibited a medium or strong positive correlation dependency, while the correlation among these characters and age was weak, and in Lake Dąbie Małe they assumed negative values.

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