

Can Expansion of Zebra Mussel, *Dreissena polymorpha* (Bivalvia) Influence the Numbers and Behaviour of Traditionally Herbivorous Mute Swan, *Cygnus olor* (Aves)?

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Abstract: Zebra mussel, *Dreissena polymorpha* belongs to the exotic species that have quickly invaded the whole Europe. The presence of novel species influences different features of the aquatic ecosystems. Many studies have shown significant changes in invertebrates' community or water quality as a result of zebra mussel invasion. The abundant populations of this bivalve can serve as an excellent food source for different animals. In our study we observed the change in the number of mute swans *Cygnus olor* on a local scale (Jeziorsko Reservoir), caused by the development of a stable zebra mussel population. The wintering and moulting population of swans doubled within two years at the reservoir as a result of exploitation of mussels. Moreover, the birds that fed on mussels during winter were in better condition (mean weight) in comparison with the individuals using bread as a food source ($x_1 = 9.36$ kg, vs. $x_2 = 8.51$ kg; $t^0 = 1.99$, $df = 58$, $p = 0.05$). This is the first observation of a traditionally herbivorous species feeding on mussels regularly and concentrating in areas rich in this type of food. The described situation shows high plasticity of the mute swan's feeding behaviour.

Key words: Mute swan, zebra mussel, feeding, population change

Introduction

Zebra mussel, *Dreissena polymorpha* is an example of a quickly expanding bivalve species in Europe. Its home range was constrained to Caspian and Black Seas before the 19th century (KERNEY, MORTON 1970). In western and central Europe, the first records came from Rotterdam (1826) and Hamburg (1830). After that time it spread throughout the whole continent, occupying available habitats. At the end of the 20th century, the species invaded North America, where its expansion was remarkably quick (HERBER *et al.* 1989, ALDRIDGE *et al.* 2004). Many different results of expansion were described in terms of impact on water quality (ALDRIDGE *et al.* 2004, REEDERS *et al.* 1989) and invertebrates or phytoplankton communities (JACK, THORP 2000, PACE *et al.* 1998, STRAYER *et al.* 1998, SMITH *et al.* 1998). The possible impact

on herbivorous birds was described in relation to the large-scale changes within ecosystems (NOORDHUIS *et al.* 2002). The presence of a new species affects the food web in the ecosystem, which afterwards impacts the number of consumers from different trophic levels (JOHNSON, PADILLA 1996). In our paper we present observations that reveal a direct relation between the zebra mussel invasion and the number and behaviour of the mute swan *Cygnus olor*, a traditionally herbivorous wildfowl species.

Material and Methods

Jeziorsko Reservoir was constructed in 1986 on the Warta River in central Poland (51°48'N, 18°40'E) (BARGIEL *et al.* 1998). The main role of the reser-

voir is to collect water in early spring and release it in summer when the water level in the Warta River drops down. Each summer the reservoir is emptied in 50% and water comes to its normal level during late winter. Jeziorsko Reservoir creates valuable feeding conditions for different species of waterbirds. Every year, during summer and autumn huge flocks of migrating geese, ducks and waders concentrate at the reservoir. Moreover, it is classified as European Important Bird Area for waterbirds (HEALTH, EVANS 2000).

The study period covered the years from 1987 to 2012. From 1987 onwards regular counts of wintering waterbirds were carried out at the reservoir each second decade of January. The counts were conducted also on 10 km trail along the river upstream and downstream of the reservoir. The results of the counts from the reservoir and from both trails along the river were used as an estimation of the mute swan's number at the study area during winter. The river trails were included in order to assess accurately the birds' number in the years when the reservoir was frozen and all swans occupied the river parts close to the reservoir, which were free of ice. Irregular surveys covering the whole reservoir were carried out in spring (April – June) and summer (July – September) annually. For these periods the maximum number of the observed swans was used as an estimation of the local population size.

Results

The mute swan counts revealed considerable changes in the population size both during summer and winter. The first period consisted of four years after the dam closure when population grew up suddenly and afterwards dropped dramatically (Fig. 1, Fig. 2). The species nearly disappeared from the reservoir within the next three years. A moulting flock was observed for the last time in 1989. The second phase, during which the local wintering and moulting population gradually recovered, started in 1998. The number of wintering birds exceeded 150 individuals in the following year (Fig. 1). A similar increase in the number of the moulting birds was observed, although it was not so clearly pronounced. As a result, a significant wintering and moulting population was established again. The number of spring migrants did not change significantly during the whole study period and stabilised at the level of 50-80 birds annually (Fig. 2).

From winter 1998/1999 onwards the observations of wintering birds showed that the mute swans had started to regularly use a new food resource consisting of zebra mussel's colonies. The swans were

foraging mainly at shallow parts of the reservoir or within 30 meters of the river downstream the dam in mixed flocks with coots *Fulica atra* and diving ducks. They constantly used typical up-ending posture to reach the mussels from the bottom. After each foraging bout, the birds appeared with clusters of shells in their bills that were crashed using the edges of the bill. The faeces found were black-and-grey in colour and consisted of fragments of zebra mussel shells mixed with sand. In winter 2002/2003 and 2008/2009 several birds were caught and ringed (by eight each winter). All of them were in good health state with significant body reserves (mean weight 9.36 kg, SD=1.54 kg; n=16). The individuals caught in the same periods in wintering flock from the town of Tomaszów Mazowiecki (51°30'N, 20°01'E), where up to 100 individuals from the local population spent winter in urban conditions and used bread as a main food source, were in a worse condition (mean weight 8.51 kg; SD=1.41 kg; n = 44; $t=1.99$, $df=58$, $p=0.05$).

Discussion

The changes in the mute swan population at Jeziorsko Reservoir showed three distinct phases. The first two phases represent a quick population growth and sudden decrease. The observed pattern can be explained by the presence of large areas of meadows that were flooded after the dam closure. The rapid increase in different animal populations at newly established reservoirs is a known phenomenon (BAXTER 1977, RIHA *et al.* 2009). The presence of unoccupied territories and abundant food sources owing to the quick development of water plants are regarded as the main factors responsible for the vast development of the waterbirds' community at new reservoirs. The initial suitable conditions usually change as the process of ecological succession at the reservoir influences different elements of the whole ecosystem. The increase of sediments in the reservoir that subsequently act on water quality and concentrations of nutrients are among the most significant processes responsible for the observed changes (RIHA *et al.* 2009). As a result many species do not find suitable conditions for their existence and the biodiversity at the reservoir is reduced. At the study place the areas covered with macrophytes were overgrown with willow that became a dominant plant within first five years since the dam closure (JANISZEWSKI, WŁODARCZYK 2004). Beneficial conditions for wildfowl deteriorated dramatically and resulted in rapid reduction of the mute swan numbers. Surprisingly, the local population recovered again after 5-7 years of severe reduction.

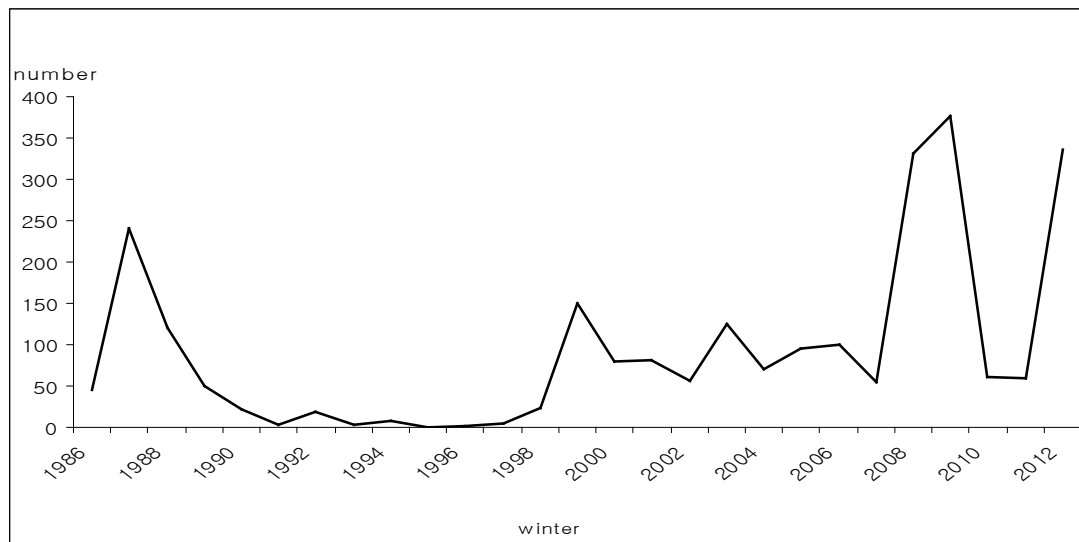


Fig. 1. Number of the mute swans wintering at Jeziorsko Reservoir and 20 km trail of the Warta River in the period 1986-2012

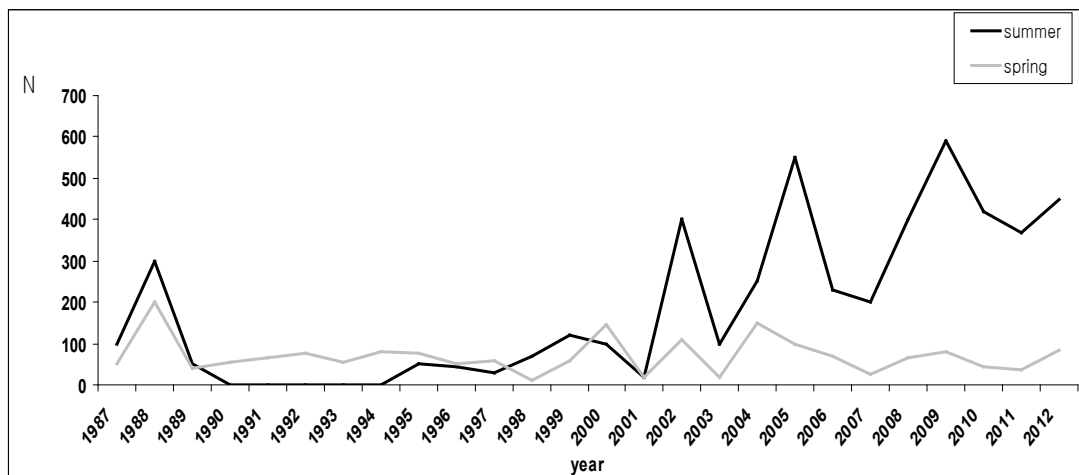


Fig. 2. The largest flocks of the mute swan observed at Jeziorsko Reservoir in spring (March – May, grey line) and summer months (June – August, black line) in the period 1987-2012

The observed increase in the number of birds can be explained only by the change in the suitability of the local conditions for wildfowl. Some factors important for swans, such as water management and human pressure (tourism, hunting), were constantly the same during the study period. Moreover, a traditional food source was reduced by the expansion of willow. However, in the middle of the 1990s the reservoir was colonised by the zebra mussels and year 1998 was the first season of the massive growth of its population (DUKOWSKA, GRZYBKOWSKA 2007). The mute swan's increase coincided with the first observations of a large flock of diving ducks *Aythya* sp. and coots *Fulica atra* at the reservoir. The migratory population of the coots increased from 100-200 individuals in 1990-1997 up to 3000-5000 birds in

1999-2000 (JANISZEWSKI, WŁODARCZYK 2004). These birds are traditionally dependent on molluscs as a main food source and development of a vigorous zebra mussels' population decisively should impact the number of coots, pochards and tufted ducks using Jeziorsko Reservoir as a feeding place during the postbreeding period. A similar scenario could explain the changes in the swan numbers when birds could exploit the same food source. The direct observations of the swans confirmed this assumption.

The mute swan is a typical herbivorous waterbird but can also feed on small fish, crustaceans or insects (BIRKHEAD, PERRINS 1986). Examples of unusual feeding behaviour are based on the observations of birds that feed occasionally on or swallow involuntary small animals attached to the plants (WIELOCH

et al. 2004). Cases where many birds were regularly feeding on meat or gathered in places with easy access to benthic invertebrates are unknown. Both behaviours were observed at Jeziorsko Reservoir. The described activity was possible as a result of the special water management implemented at the reservoir. The water level at Jeziorsko Reservoir drops down up to 2.5 metres each autumn. During that period the wildfowl, even without diving ability, can exploit benthic organisms from large area of the reservoir. In spring the reservoir is full of water and the mute swans cannot feed on benthic fauna. The number of

spring migrants did not change at the reservoir due to the presence of alternative food source. Switching to new food source confirmed the high plasticity of swans. The new behaviour was likely to help birds in surviving during the dangerous wintering period in good nutritional condition. Moreover, the reservoir became an important moulting place for individuals that switched to the new food source. The scarce data about the weight of the birds showed that zebra mussel can be an excellent food source for swans both in winter and during energetically exhausting moulting period.

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