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W TORUNIU

Toruń, 19.06.2026
city, date

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Album no.: 503225

DOCTORAL DISSERTATION ABSTRACT

Scientific discipline:

Biology Sciences

Title of the doctoral dissertation:

Invasions of *Corbicula* clams as a component of global change affecting native mussel populations in Europe

Doctoral dissertation abstract:

European native freshwater bivalves play important roles in inland ecosystems, including water filtration, matter cycling, substratum stabilisation and the creation of microhabitats for other organisms. At the same time, they are among the groups particularly vulnerable to environmental pressures because they are characterised by limited mobility, long life cycles and often a low capacity for rapid population recovery after disturbances. The main threats to freshwater bivalves include habitat degradation, changes in hydrological regimes, pollution and invasive species.

Among the most widespread invasive freshwater bivalves are representatives of the genus *Corbicula*. These clams can reach high densities, compete with native bivalves for food and space, and modify substratum structure through the presence of living individuals and the accumulation of empty shells. Such substratum modification may affect habitat selection, locomotion and burrowing of native bivalves. *Corbicula* clams may also be more resistant to

some abiotic factors, including periodic water-level decline and air exposure, which may be particularly important under conditions of intensifying hydrological droughts.

The main aim of this doctoral dissertation was to determine how the invasion of clams of the *Corbicula* complex and hydrological drought affect the functioning of European native freshwater bivalves. Functioning was understood as a set of organismal responses to biotic and abiotic pressures, including habitat selection, behaviour, survival, growth, physical condition, energy reserves measured as glycogen content in the foot, and parameters of oxidative–antioxidant balance, including lipid peroxidation measured as TBARS in the foot and digestive gland, as well as total oxidant status (TOS) and total antioxidant status (TAS) measured in the digestive gland. The study was conducted on native bivalves representing two families: Unionidae, i.e. *Unio tumidus* and *Anodonta anatina*, and Sphaeriidae, i.e. *Sphaerium rivicola*. *Corbicula* clams were treated both as a factor modifying the substratum and affecting native Unionidae, and as a comparative taxon in relation to the native *S. rivicola* under hydrological drought conditions.

Three research studies were conducted as part of the dissertation. The first study assessed the effects of living *Corbicula* clams and their shells on substratum choice, locomotion and burrowing of *U. tumidus* and *A. anatina*. The second study determined the long-term consequences of a five-month field exposure of native unionids to the presence of *Corbicula* clams, considering survival, growth, physical condition, glycogen content and oxidative stress indicators. The third study compared the effects of hydrological drought on the survival and behaviour of the native *S. rivicola* and invasive *Corbicula* clams by analysing responses to water-level decline, air exposure and substratum drying.

The results of the first study showed that substratum modification by *Corbicula* clams affected habitat selection and behaviour of native unionids. *Unio tumidus* and *A. anatina* avoided substrata modified by living *Corbicula* clams and their empty shells. *Unio tumidus* avoided substrata with *Corbicula* shells already at a density of 1400 shells m^{-2}, whereas *A. anatina* responded at a density of 2100 shells m^{-2}. Both species avoided living *Corbicula* clams at a density of 1400 ind. m^{-2}. On modified substrata, native unionids travelled longer distances than in the control, indicating difficulties in finding a suitable place to settle, and burrowed more shallowly or more slowly than in the control. These results indicate that *Corbicula* clams may act as habitat-modifying organisms, limiting the availability of suitable microhabitats for native unionids.

The results of the second study showed that the five-month presence of *Corbicula* clams under field conditions did not cause a strong lethal effect in native unionids. Mortality of *A. anatina* and *U. tumidus* was low and did not depend on the presence of *Corbicula* clams or on the overall density of bivalves. However, the effects of *Corbicula* clams were expressed at the level of sublethal responses. In *A. anatina*, high density reduced shell length growth. Shell width growth and wet mass gain were higher in treatments with *Corbicula* clams than in controls with the same overall density, but this effect most likely resulted from reduced intraspecific pressure rather than from a direct positive effect of the invasive clams. In *A. anatina*, the presence of *Corbicula* clams and higher density increased TBARS levels in the foot, whereas TOS and TBARS levels in the digestive gland were lower in treatments with *Corbicula* clams than in controls. In *U. tumidus*, no changes in growth or physical condition were found, and TBARS levels in the foot decreased at high density and after the addition of *Corbicula* clams at constant unionid biomass. In the high-density treatment with *Corbicula* clams, *U. tumidus* also showed lower TAS levels and higher glycogen levels than in the other treatments. These results indicate that the long-term effects of *Corbicula* clams on native unionids were mainly sublethal, organ- and species-specific, and that stronger physiological costs occurred in *A. anatina*.

The results of the third study revealed clear differences in resistance to hydrological drought between invasive *Corbicula* clams and the native *S. rivicola*. All *Corbicula* individuals survived 15 days of air exposure, even at 2% water content in the substratum. In *S. rivicola*, 50% mortality was observed after 5.3 days of air exposure, at 12% water content in the substratum, and 90% mortality after 7.9 days, at 8.5% water content in the substratum. The two taxa also differed in their behavioural strategies. *Sphaerium rivicola* actively moved towards more humid zones, but the effectiveness of this response depended on the distance to the refuge. *Corbicula* clams did not show horizontal migration following the receding water line, but remained in place and burrowed deeper into the substratum. This indicates that *S. rivicola* mainly used an escape strategy, whereas *Corbicula* clams used a strategy of remaining in place and enduring unfavourable conditions.

In summary, the results of this dissertation indicate that clams of the genus *Corbicula* can affect native freshwater bivalves at several levels. First, they modify the physical structure of the substratum, thereby limiting the availability of suitable microhabitats and hindering burrowing and locomotion of native unionids. Second, their presence may induce sublethal

responses involving growth, oxidative stress and energy metabolism. Third, the greater resistance of *Corbicula* clams to substratum drying may favour their advantage over more sensitive native species under hydrological drought conditions. Invasions of clams of the genus *Corbicula* should therefore be considered a component of global change whose effects depend not only on biotic interactions, but also on abiotic factors such as water-level decline and substratum drying.

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