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SOME ASPECTS OF THERMAL TOLERANCE OF *Anodonta* FROM HEATED KONIŃSKIE LAKES[1]

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A B S T R A C T. Thermal tolerance of *Anodonta* and *Unio* was studied under experimental conditions. Most tolerant to a gradual and stepwise temperature increase to 35°C were Chinese *Anodonta*, very numerous in Konińskie lakes, and among them - individuals up to 5 cm. Critical water temperature, at a gradual daily increase, was 31°C.

Key words: *Unionidae* (*Anodonta*, *Unio*), THERMAL TOLERANCE, HEATED WATER

INTRODUCTION

Thermal resistance of the organisms acquired during an adaptation to heated water conditions is still poorly known. Most of the studies were carried out on cyprinid fishes and the results became a basis for the determination of the upper permissible values for thermal contamination of Polish surface waters (Horoszewicz 1973, Horoszewicz, Backiel 1979). Studies on the invertebrates were performed on individuals from natural and non-heated environments (Damusova 1963, Koniev 1973, Siergiejeva, Jaroslavceva 1987, Smirnova 1973). Thus, an extrapolation of the results over animals from heated waters may be misleading in forecasting the water quality changes, mass development of the species, or changes in biotic structure of the ecosystems caused, among others, by the technical projects or water heating. Studies on the zoobenthos of Konińskie lakes (Wielkopolskie Lake District, Warta River and Gopło Lake watershed), supplying cooling water to the two power plants, revealed that there were abundant populations of two large *Anodonta* species in the system. Their biomass in certain zones of the heated channels reached very high values, up to 50 kg/m^2 (Protasov et al. 1994, 1997, Zdanowski et al. 1996). The molluscs were brought to the lakes from Hungary in the eighties, together with the stocking material of silver and bighe-

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ad carps. At the same time also stone moroco (*Pseudorasbora parva*) was brought to the lakes. Basing on the shell morphology, the molluscs were temporarily identified by J. I. Starobogatov (unpubl.) as *Sinanodonta gibba* (Benson) and *S. orbicularis* (Heude). Detailed studies by A. Piechocki (unpubl.) revealed that the species classified as *S. gibba* was a species known in Europe as *Anodonta woodiana woodiana* (Lea, 1834). It is abundant in Hungary and its detailed description can be found in Kiss (1995). The species lives mainly in the littoral zone of Konińskie lakes, and the other species, more numerous and still in course of being identified, lives in warm water discharge channels. Distribution of the molluscs in Konińskie lakes and channels was described by Protasov et al. (1994, 1997), and by Afanasjev et al. (1996).

MATERIAL AND METHODS

Thermal tolerance of *Unionidae* was studied using two methods. Death time of individuals (lack of shell-closing reaction to mechanical irritation) and time of gill tissue degeneration (irreversible inactivation of the ciliary epithelium) were measured.

Observations on the response to temperature increase were performed on 42 individuals of non-identified *Anodonta sp.* from Konińskie lakes and channels. Shell length to width ratio of the molluscs was 2.7 - 3.5. Eight individuals of *Unio tumidus* were also used. Thermal resistance of the tissues (203 samples) was studied in 12 individuals of Chinese *Anodonta sp.* from Konińskie lakes, and in 15 individuals of *Anodonta cygnea* and *A. anatina* from the Dnieper River.

The experiments were carried out in 65 l aquaria filled with water from the discharge channel of "Konin" power plant, in which molluscs of different size but similar total biomass were placed. Initial water temperature was always equal to that in the channel at the moment of harvesting the molluscs, and ranged from 28 to 32°C in particular series of the experiment. DO level in the water was 6.65 - 6.76 mg/l, and initial BOD_5 was from 1.00 to 1.28 mgO_2/l. Water in the aquaria was mixed and aerated during the experiment using aquarium pumps of 400 l/h flow, simulating natural conditions. Temperature was maintained with 0.1°C accuracy using two thermoregulated heaters. Survival of the molluscs was studied under three thermal regimes: gradual temperature increase (1), stepwise increase up to critical value of 40°C (2), and abrupt temperature fluctuations (3 - fig. 1). Conditions were uniform for all three groups due to water exchange between the experimental and the control aquaria. The

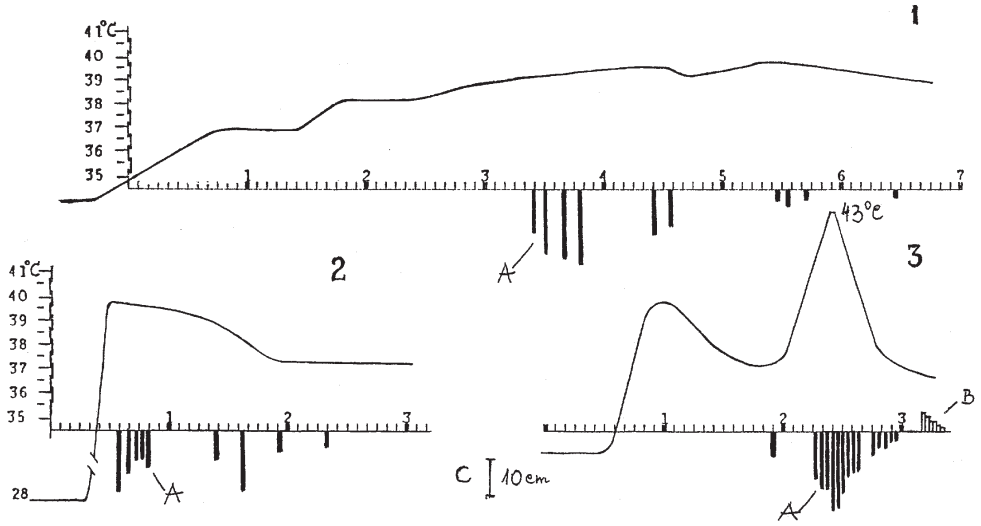

Fig. 1. Death time of Chinese *Anodonta sp*. under three thermal regimes: gradual temperature increase up to the critical value of 40 °C (1), stepwise increase to 40 °C (2), and abrupt temperature fluctuations within the range 34 - 40 °C and 37 - 43°C (3). A - dead individuals, B - live individuals. C - bar height equals to 10 cm of the mollusc length.

connection was discontinued after 24 h, and thermal conditions were changed according to the experimental design.

The molluscs used for a determinations of thermal resistance of the tissues were kept in aquaria at about 20°C. Isolated gill tissues were placed in a vessel filled with water from the experimental aquaria. Exposure time of each gill sample was 10 min., then ciliary epithelium activity was observed using a microscope. In case of a lack of activity, the sample was placed at 20°C, and examined again after 30 min.

RESULTS

The results of the experiment revealed that Chinese *Anodonta sp*. from the discharge channel of "Konin" power plant were very resistant to high temperatures. Decrease of motility and lack of shell-closing reaction to mechanical irritation was observed at a temperature above 35°C. The molluscs died at 39.2 - 39.8°C (fig. 1).

Small individuals, up to 5 cm, were most resistant to a temperature increase. In the case of a gradual increase, they survived 3 days at 39 - 40°C, and tolerated short (1

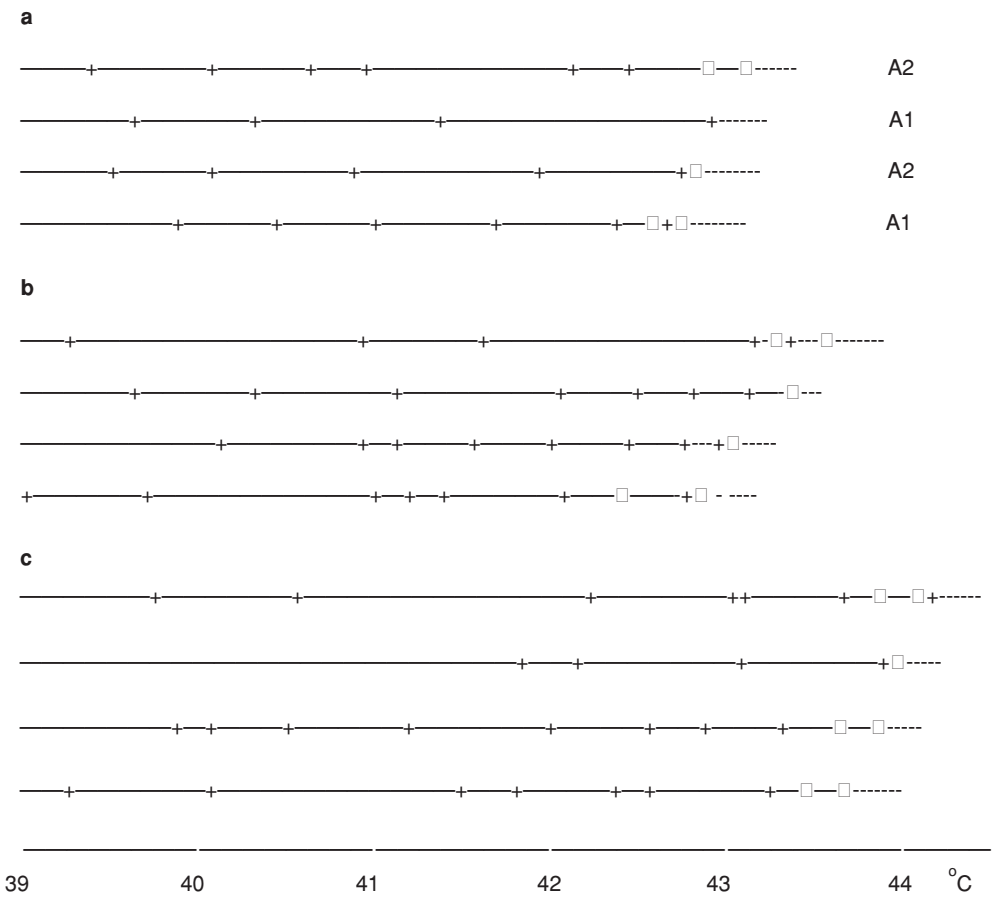

Fig. 2. Activity of gill ciliary epithelium of *Anodonta cygnea* (A1), *Anodonta anatina* (A2), and *Unio tumidus* (b) from the Dnieper River, and Chinese *Anodonta sp.* (c) from Konińskie lakes after 10 min. exposure to various temperatures. + active epithelium, # epithelium reactivates, —- epithelium does not reactivate.

- 2 h) exposures to 43°C. The individuals of the average and the biggest size survived in 39°C, but not more than one day.

The individuals adapted to 28°C died within several hours (up to 24 h) after an abrupt increase of temperature to 40°C and its subsequent slow decrease. The molluscs adapted to 34°C died after another temperature increase to 40°C, although some of them survived one hour in 43 °C.

Experiment carried out on *Unio pictorum* revealed that these molluscs were much less tolerant to high temperature comparing to *Anodonta sp*.

At a gradual increase of temperature to 39 °C the individuals of 4.5 - 8.0 cm died after 4 - 5 h.

The study on thermal tolerance of the gill tissue revealed that Chinese species of *Anodonta* was the most resistant (fig. 2). In that species irreversible inactivation of the ciliary epithelium took place at 43.6 - 44.1°C. For *Anodonta cygnea* and *A. piscinalis* from the Dnieper the values were 42.5 - 42.8°C, and for *Unio tumidus* -43.0 - 43.5°C.

CONCLUSIONS

Thermal tolerance of the molluscs may be determined using several methods: measuring the time of an inactivation of the gill ciliary epithelium (Smirnova 1973, Sergiejeva, Jaroslavceva 1987), observing the muscle tissue inactivation of the mollusc foot after 10 minutes of exposure to the experimental temperatures (Damusova 1963), or determining temperatures at which 50% of the animals die within 10 min (Koniev 1973). Observations on shell-closing reaction to mechanical irritation in various temperatures are also performed (Sergiejeva, Jaroslavcev 1987). The most accurate results are obtained simulating the three thermal situations that may occur in heated waters: gradual or stepwise temperature increase or sharp fluctuations of the water temperature. Such a model was applied in the present study.

Many data indicate that among freshwater molluscs, *Unio tumidus*, *Unio pictorum* and *Anodonta anatina* are the most tolerant to high temperatures (Damusova 1963, Smirnova 1973, Sergiejeva, Jaroslavceva 1987, Koniev 1973). Irreversible inactivation of the ciliary epithelium in these species takes place within 10 minutes at temperatures: 43.5, 42.7, and 41.6°C, respectively. *Sphaerium corneum* and *Dreissena polymorpha* are much less tolerant: ciliary epithelium of these species is inactivated within 10 minutes at temperatures 40.2 and 39.6°C respectively (Afanasjev, Szatochina 1993).

The results of the study on thermal tolerance of *Unio tumidus* from Konińskie lakes confirmed the values presented above. Thermal resistance of the Chinese *Anodonta sp*. was 0.5°C higher compared with *Unio* and *Anodonta* from natural and heated waters. Unlike *D. polymorpha* and *Medea* (Afanasjev, Szatochina 1993), in *Anodonta sp*. the young individuals up to 5 cm were the most resistant. Molluscs of an intermediate body size died first. This fact ensures continuous renewal of the populations in Konińskie lakes. Chinese species of *Anodonta* predominated over the native species of *U-*

nio and *Anodonta*, inhabiting almost all the channels and forming colonies the biomass of which reached over 10 kg/m^2 (Protasov *et al*. 1994, 199 .

At gradual water temperature increase, value critical for that species was 39°C. Even short but sharp temperature increase over 40 °C would result in mass mortality of breeding individual and population renewal might last at least several years.

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STRESZCZENIE

NIEKTÓRE ASPEKTY TERMICZNEJ TOLERANCJI MAŁŻY RODZAJU *Anodonta* Z SYSTEMU PODGRZANYCH JEZIOR KONIŃSKICH

Zbadano eksperymentalnie termiczną tolerancję małży rodzaju *Anodonta* i *Unio*, określając czas ginięcia osobników po zaobserwowaniu braku reakcji zamykania muszli przy podrażnieniu mechanicznym oraz czas utraty aktywności nabłonka migawkowego tkanek skrzel. Doświadczenia prowadzono na niezidentyfikowanym gatunku małża chińskiego (*Anodonta sp.*) i *Unio tumidus* z jezior konińskich oraz *Unio tumidus*, *Anodonta cygnea* i *Anodonta anatina* z Dniepru.

Najmniej odporne na wysokie temperatury były osobniki *Unio pictorum*. Odporność chińskiego małża *Anodonta sp.*, zwłaszcza osobników o wymiarach do 5 cm, okazała się wyższa (o 0.5^{o}C) niż gatunków rodzaju *Unio* i *Anodonta* (rys. 1). Krytyczną dla małża temperaturą wody przy stopniowym jej podnoszeniu jest 39^{o}C. Wyniki ten jest zgodny z obserwacjami reakcji nabłonka migawkowego skrzel (rys. 2). Nieodwracalna utrata jego aktywności następowała u osobników małża chińskiego w temperaturze 43.6 - 44.1^{o}C, podczas gdy u *Anadonta cygnea* i *Anodonta piscinalis* - przy 42.5 - 42.8^{o}C, a *Unio tumidus* - 43.0 - 43.5^{o}C. Względem sporadycznie występujących rodzimych gatunków rodzaju *Unio* i *Anodonta*, przejmując funkcję dominanta w zespole mięczaków, zasiedlając praktycznie wszystkie kanały, gatunek chińskiego małża tworzy skupiska o biomasie kilkunastu kilogramów na 1 m^2 powierzchni dna (Protasov i in. 1994, 1997).

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