INFLUENCE OF TEMPERATURE AND SALINITY ON THE SURVIVAL OF SOME BENTHIC INVERTEBRATES IN LABORATORY CONDITIONS

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ABSTRACT

Separating sea bays create a complex habitat forcing its denizens to quickly adapt to changing conditions different from those in the sea: salinity, temperature, chemical composition etc. Animals vary in tolerance of changing life conditions. Thus, investigating the borders of adaptive abilities in the animals living in these waters is extremely interesting and allows us to better understand the functioning of both marine and continental water ecosystems.

In this study, we have chosen several marine, brackish and freshwater inhabitants in order to study their adaptation potentials under laboratory conditions. The animals were kept in water mixtures with a salinity range of 0-24 psu and at different temperatures. Three Gammaridae species showed different salinity preferences: *G. lacustris* only survived in fresh and slightly brackish water, *M. obtusatus* did not tolerate any freshening, while *G. oceanicus* showed a wide range of salinity tolerance.

Chironomus salinarius showed high mortality in the laboratory. Coleopterans demonstrated no preferences in salinity. Amphipods survived better at low temperatures, chironomides and beetles at room temperature. High temperatures (30°C) are detrimental to all subjects regardless of salinity. At low temperatures, (0…4°C), amphipods stand a greater range of salinities than at higher temperatures.

INTRODUCTION

The White Sea is the youngest sea in the world (11.000 years), slowly separating from the Barents Sea after the glacier retreat 12.000 years ago (1). In the vicinity of the White Sea Biological Station, the coastline gradually rises after glacial pressure at an average rate of 4 mm/year (2). Sea bays isolate from the sea and transform into continental freshwater lakes. During ice formation, concentrated brine gathers at the bottom, and the freshened upper water layer escapes through the rapid ice melting, leading to a meromictic lake formation, when wind mixing only affects the upper layer, while the lower layers are stable. This process leads to a unique layered hydrological structure formation.

Separating sea bays create a complex habitat forcing its denizens to quickly adapt to changing conditions different from those in the sea: salinity, temperature, chemical parameters etc. Animals vary in tolerance of changing life conditions. Therefore, the study of their adaptation potentials is important for understanding the functioning of water body ecosystems. For instance, a salinity of 5-8 psu marks a principle boundary between seawater and freshwater hydrochemical processes (3). Therefore, brackish waters are of great interest for understanding the functioning of both marine and continental water reservoirs.

MATERIAL AND METHODS

For the current study, we have chosen a few invertebrate species found in Kislo-Sladkoye lake (a separated sea bay 1.5 km east of Nikolai Pertsov White Sea Biological Station of Moscow State University (WSBS), 66°32’53.5”N, 33°08’06.4”E) and Lower Ershovskoye lake (a meromictic lake - former gulf 2.5 km to the south-west of WSBS 66°32’21.4”N, 33°03’08”E). Their survival under dif-

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ferent temperatures and salinity in the laboratory was studied. Large jars with habitual water were used to transport live animals to the laboratory, where they were placed into plastic jars of 500 ml filled with 400 ml of experimental water.

Some of the animals were chosen due to their known ecological features. Three of the Gammaridae amphipods are known to live in varying salinities: *Gammarus lacustris* is a stenohaline freshwater species; *Marinogammarus obtusatus* is a strictly marine subtidal amphipod; *Gammarus oceanicus* has populations both in sea-water and brackish water (4). We also took *Chironomus salinarius*, a mass species of midge flies known for its unique tolerance of extreme salinitiesin Kislo-Sladkoye lake. Two species of marine coleopterans were picked due to the unusual case of finding the taxa in salty water. *Haliplus apicalis* is quite numerous in Kislo-Sladkoye lake and not yet well studied in the region. We found *Enochrus halophilus* in Kislo-Sladkoye lake and a similar marine lagoon on the Green Cape. This is the first note on this species for Russian seas.

Four experimental series were set: (a) a mixture of *M. obtusatus* and *G. oceanicus* found together 500 m west of the WSBS; (b) *G. lacustris* from Lower Ershovskoye lake; (c) *Ch. salinarius* larvae from Kislo-Sladkoye lake; (d) *Enochrus halophilus* and *Haliplus apicalis* imago from Kislo-Sladkoye lake.

Coleopterans were only held at room temperature (+20…24°C); amphipods and chironomids were exposed to 4 temperature intervals: 0…4°C, 15…18°C, 20…24°C, and 30°C.

Coleopterans were kept at the following salinities: 0, 8, 12, and 24.1 psu (essential for the White Sea at the experiment time). The other animals experienced a higher range of salinity: 0, 5 ,8, 10, 15, 20, and 24.1 psu. For the necessary salt concentration, seawater taken from the pier was mixed with plumb water.

Living animals were counted every 3 hours; dead corpses were removed immediately. The experiment lasted one month; animals received no food; water was changed every 5 days. Death of amphipods and coleopterans was registered by visual analysis or *via* contact test.

RESULTS AND DISCUSSION

The study resulted in survival dynamics for every species, visualized by graphs of survival curves. Optimal conditions for the following investigation of species were determined.

Figure 1 shows the survival curves for *G. oceanicus* in different salinities. Our results agree with previous investigations (5). Generally, *G. oceanicus* shows a high tolerance of different temperatures and salinities. The species form two types of populations: marine ones on lower intertidal and subtidal zones, and nearly freshwater in rock baths with freshwater inflow (4). In our study, we only picked samples from one marine population.

In Figure 2 the survival curve for *Marinogammarus obtusatus* is shown. This species does not tolerate freshening and is only found in full salinity in nature. Again, our data repeat the result of previous investigations (5).

The third amphipod species, *G. lacustris*, has a slightly higher adaptive potential than *M. obtusatus* (Figure 3), but in nature it is only found in freshwater reservoirs.

Comparison of the tolerance of different salinities in three Gammaridae species is shown in Figure 4. *G. oceanicus* has the highest adaptation potential of the chosen species; *M. obtusatus* shows the lowest tolerance.

Chironomus salinarius demonstrated low survival in laboratory conditions. This might be season-dependent, many of the larvae starting to undergo pupation or due to low oxygen content in the jars. The coleopterans *Enochrus halophilus* and *Haliplus apicalis* did not show any preference in salinity, and survived at high percentages during the whole series up to the end of our study.

Temperature preferences of chosen species were determined. Gammarids survive longer at low temperatures, while chironomids prefer room temperature (Figure 5). This result agrees with the natural conditions: Seawater in amphipod settlements is pretty low compared to the lake surface where insect larvae dwell.

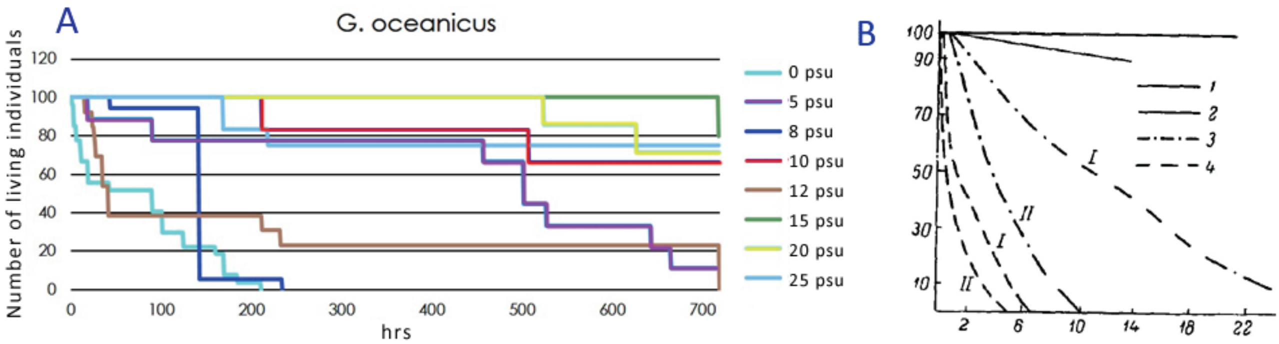

Figure 1. Survival curves for G. oceanicus in different salinities. A: our data; B: adapted from Tzvetkova, 1968. Two different populations are used for the study. I – brackish population, II – marine population. 1 – 24 psu, 2 – 16 psu, 3 – 7.6 psu, 4 – 0 psu.

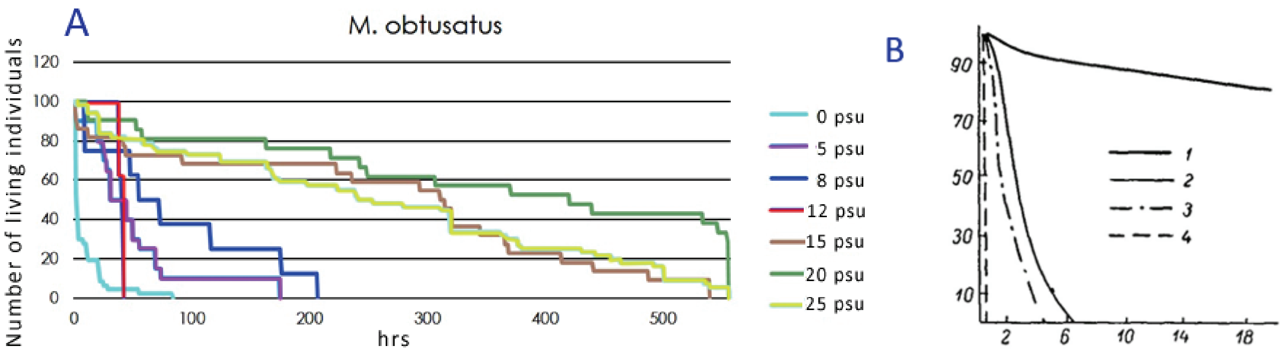

Figure 2. Survival curves for M. obtusatus in different salinities. 2 A - our data; 2 B - Tzvetkova, 1968. 1 – 24 ‰, 2 – 16 ‰, 3 – 7.6 ‰, 4 – 0 ‰.

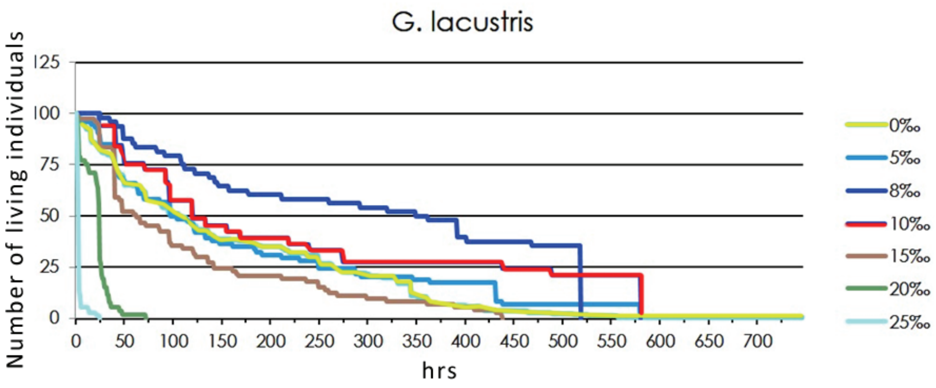

Figure 3: Survival curves for G. lacustris in different salinities. Low survival in 0‰ may be explained by poor quality of plumb water compared to natural lake water.

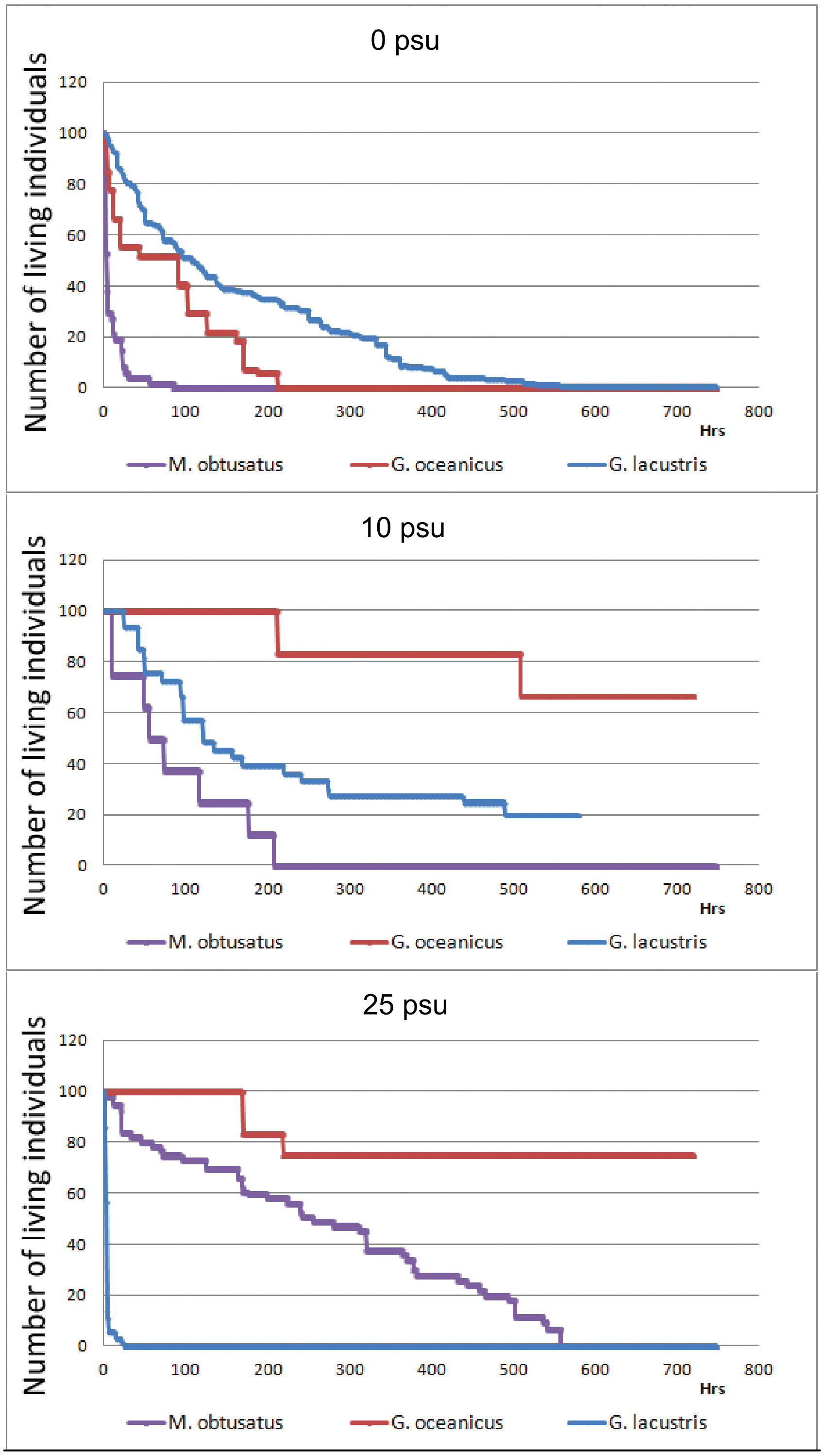

Figure 4: Comparison of the tolerance of three chosen salinities in three investigated Gammaridae species.

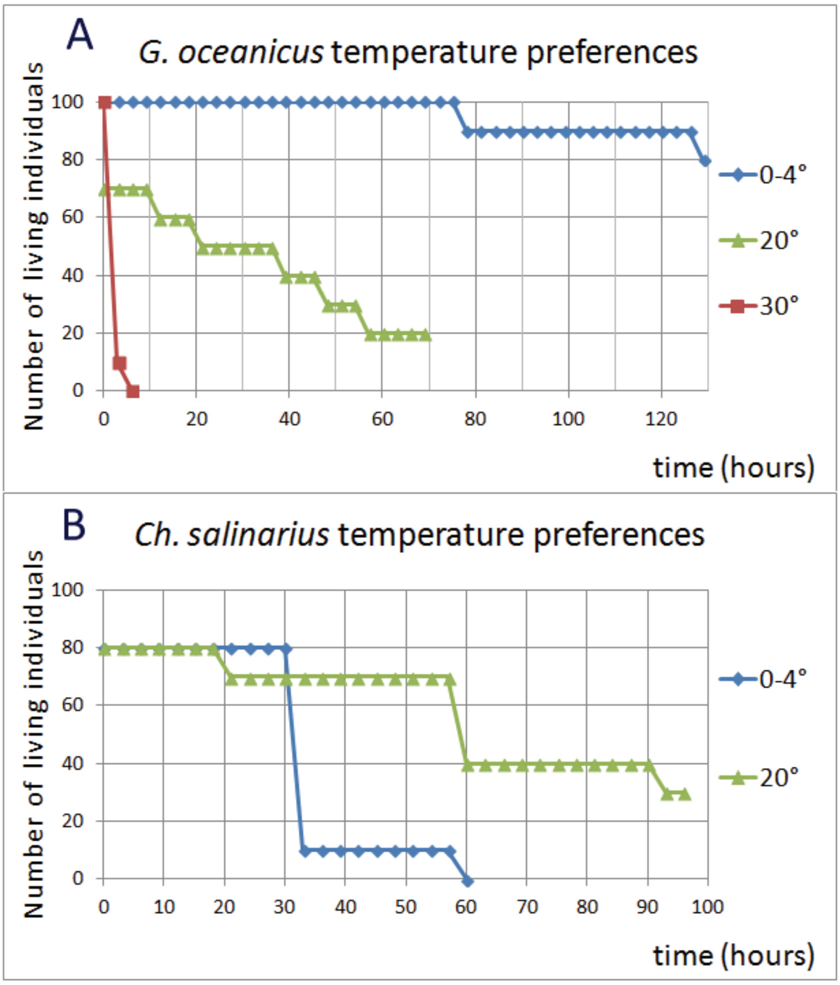

Figure 5. Temperature preferences shown in Gammarus oceanicus (A) and Chironomus salinarius (B) under constant salinities.

High temperature (30°C) is harmful to all species investigated, independent of salinity values. At low temperatures (0-4°C), Gammarids withstand a wider salinity range than at higher temperatures (Figure 6).

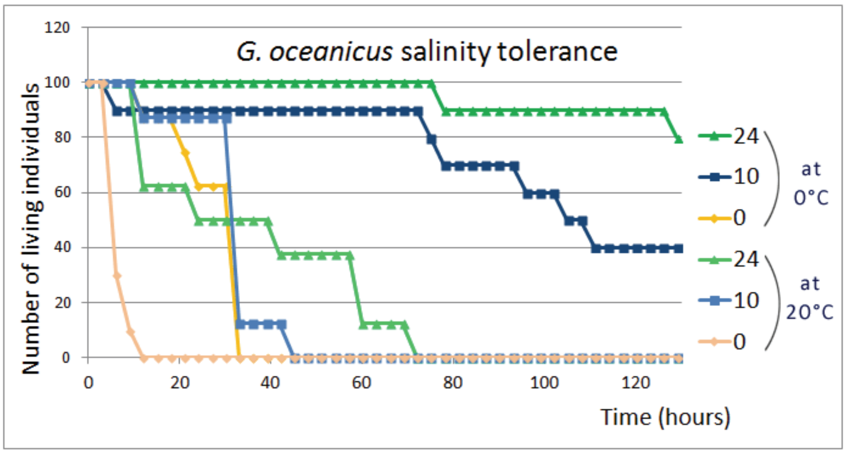

Figure 6. Salinity tolerance of gammarids at two different temperatures shown in Gammarus oceanicus. At low temperatures, these crustations tolerate a wider salinity range.

CONCLUSIONS

Studying the adaptation potentials of different hydrobionts is important for understanding the functioning of water body ecosystems. Few works have been done on the survival of inhabitants of separating sea bays under different conditions. Some studies of temperature, salinity, and oxygen content have been done only for a few mass species (3,4,5). Our results for those species agree with the results published by other authors. Additionally, we obtained new data on some ecological features in hydrobionts. More typical inhabitants of separating sea bays have to be examined under different temperatures, salinity, pH, and redox conditions.

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