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Attitude to temperature factor of some endemic amphipods from Lake Baikal and Holarctic G*ammarus lacustris* Sars, 1863: A comparative experimental study

Отношение к температурному фактору ряда эндемичных амфипод из озера Байкал и голарктического G*ammarus lacustris* Sars, 1863: сравнительное экспериментальное исследование

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KEY WORDS: Amphipoda, endemics, ecology, thermopreference, thermoresistance, distribution, Baikal.
КЛЮЧЕВЫЕ СЛОВА: амфиподы, эндемики, экология, термопреферендум, терморезистентность, распространение, Байкал.

ABSTRACT: Comparative research of thermopreference and thermoresistance of amphipods (Crustacea: Amphipoda) from Lake Baikal and the surrounding area was carried out. In experiments Holarctic *Gammarus lacustris* Sars, 1863 and seven Baikalian endemic species were used. It is shown, that all investigated physiological characteristics directly relate with environmental conditions of each species. For deep-water amphipod species thermopreference behavior is poorly expressed and the high sensitivity to heating is estimated. Littoral species have the most advanced thermopreference reaction as well as a high level of thermoresistance. The absence of thermopreference reaction at *Brandtia parasitica* (Dybowsky, 1874), which parasite the baikalian sponges *Lubomirskia baikalensis* (Dybowsky, 1874) was observed. It is shown that extent of endemic amphipod species distributions from Lake Baikal could reflect their attitude to temperature factor as well.

РЕЗЮМЕ: Проведено сравнительное исследование термопреферендума и терморезистентности амфипод (Crustacea: Amphipoda) из озера Байкал и прибайкальских водоемов. В экспериментах использовали Голарктического *Gammarus lacustris* Sars и семь байкальских эндемичных видов. Показано, что все исследованные физиологические характеристики напрямую связаны с условиями обитания этих видов. У глубоководных амфипод термопреферентное поведение выражено слабо, установлена большая чувствительность к повышению температуры. Литоральные виды имеют более выраженное термопреферентное поведение и высокий уровень терморезистентности. Отмечено полное отсутствие термопреферентного поведения у вида *Brandtia parasitica* (Dybowsky, 1874) паразитирующего на губке *Lubomirskia baikalensis* (Dybowsky, 1874). Показано, что протяженность распространения эндемичных видов амфипод за пределами озера Байкал, связана с характером их отношения к температурному фактору.

Introduction

Gammarids (Crustacea: Amphipoda) from Lake Baikal and other Siberian waterbodies are of great interest to assess the influence of environmental factors on hydrobionts. Biodiversity of this group in Lake Baikal is extremely rich. Today, more than 257 species are been described [Takhteev, 1997]. The amphipod fauna from other Siberian lakes, besides small number of species, which were distributed from lake Baikal, mainly represented by Holarctic *Gammarus lacustris* Sars, 1863 [Bekman, 1954; Barnard, Barnard, 1983]. Living in the extremely different conditions, as in lake Baikal (from a zone of a surf down to minimum depths), and beyond its limits (in eutrophic shallow lakes), amphipods as a group have developed a wide variety of different specializations to specific environmental conditions [Kozhova, Izmest'eva, 1998].

Temperature is the most important factor influencing hydrobionts, especially poikilothermic crustaceans. Despite the importance of temperature as an environmental factor on hydrobionts of Baikal, the effects of temperature have been investigated insufficiently. The majority of publications dealing with baikalian amphipods consider questions of their systematics [Kamaltynov, 1992; Takhteev, 2000, etc.]. The experimental works with Baikal amphipods are represented poorly. There is only one thermopreference experimental investigation on deep-water baikalian amphipods [Brauer et

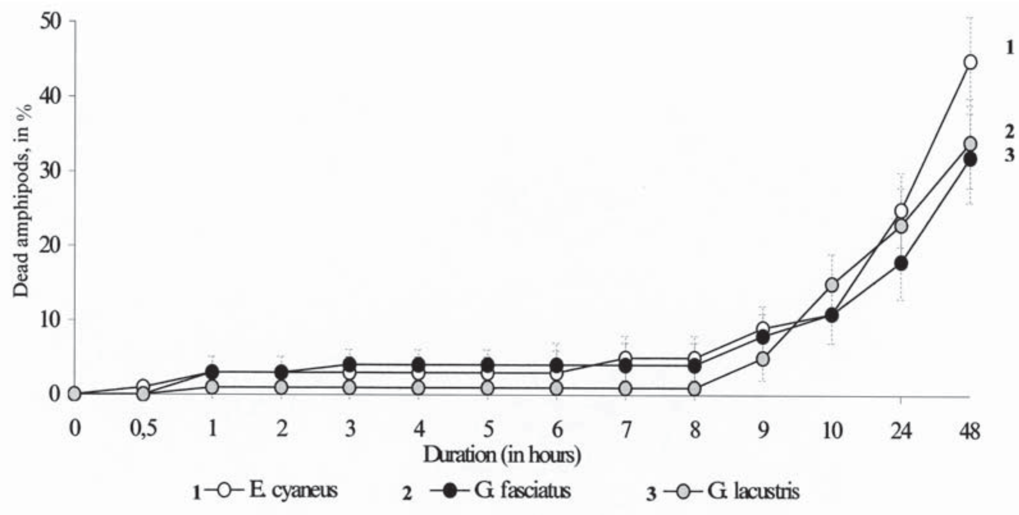

Fig. 1. Thermoresistance of amphipods *E. cyaneus, G. fasciatus, G. lacustris* at temperature 25°C (in % from control).
Рис. 1. Терморезистентность амфипод *E. cyaneus, G. fasciatus, G. lacustris* при температуре 25°C (в % от контроля).

al., 1984]. Earlier, some preliminary results of the current investigation were presented [Timofeyev et al., 2000].

By this reason the necessity of the comparative experimental study of thermopreference of Baikalian endemic gammarids and Holarctic *G. lacustris* looked to be obvious as also as an estimation of their thermoresistance.

Materials and Methods

The experiments were carried out in summer months during 1997–2000, at the baikalian biological station of Biology Research Institute at Irkutsk State University in settlement Bolshie Koty (Southern Baikal). In these experiments, holarctic *G. lacustris* and 7 endemic baikalian species were used. Littoral species: *Eulimnogammarus vittatus* (Dybowsky, 1874), *E. verrucosus* (Gerstfeld, 1858), *E. cyaneus* (Dybowsky, 1874), *Gmelinoides fasciatus* (Stebbing, 1899) and *Brandtia parasitica* (Dybowsky, 1874) (a parasite of the baikalian sponge, *Lubomirskia baikalensis* (Dybowsky, 1874). Deep-water fauna in experiments represented by *Ommatogammarus flavus* (Dybowsky, 1874) and *O. albinus* (Dybowsky, 1874) (the given species are eurybathic and can be found on depths from 3 m down to 1600 m, however, the basic zone of their habitation 100 down to 600 m depth [Beckman, 1984]). The catching of baikalian gammarids was held on depths mainly 0.5–20 m with use drag and with the help of scuba divers. For capturing deep-water amphipods special traps lowered to depths down to 100–200 m were used. *G. lacustris* was caught from shallow lake, located nearby to Bolshie Koty (1 km from Baikal Lake shore). Before the experiments, all amphipods caught were contained separately by species in 1–3 l. aquariums, in darkness, at temperatures 6–7°C (24 hours). Identification of species was made by use of A.Y. Bazikalova keys [1945].

Comparative research of amphipods thermoresistance was carried out in thermostatic cameras, at temperatures 25(±1), 30(±1)°C. In vessels (volumes 100 ml. - 200-ml.) amphipods were placed separately. Thus, the individual localization lead to an objective estimation of amphipods' resistance to temperature stress avoiding negative influences of the products of dead specimens living specimens. In experiments only adult crustaceans were used. Vessels were placed in cameras with the given temperatures and through every 5–10 minutes the number of died specimens was counted.

For thermopreference experiments standard techniques were used [Tsurnamal, 1978; Taylor, 1984]. In experiments a device, which allowed us to create and maintain a gradient of temperature in water from 3 up to 25°C, was used. Into this device we poured water by a layer in 5–6 cm., and after an establishment of a stable temperature gradient, 20–30 amphipods were placed in it. The device in regular intervals was shined. The registration of amphipod distribution in the device was carried out every 30 minutes for 5–6 hours. Usually, after first 30 minutes crustaceans became distributed in the certain order, forming congestions on temperatures, specially preferred for each species. The experiments were carried out with the adult and juvenile amphipods (except *B. parasitica* with which only adult specimens were used).

The sizes of amphipods used were: *E. verrucosus* 30 (±3) mm, juvenile 13 (±2) mm; *E. vittatus* 17 (±1) mm, juvenile 9 (±1) mm, *E. cyaneus* 14 (±1) mm, juvenile 7 (±1) mm; *G. fasciatus* 7 (±1) mm, juvenile 3 (±1); *B. parasitica* 5 (±1) mm; *O. albinus* 18 (±1) mm, juvenile 10 (±1) mm; *O. flavus* 20 (±1) mm, juvenile 10 (±1) mm; *G. lacustris* 14 (±2) mm, juvenile 8 (±1) mm. For each species a series of experiments was carried out, made in the different temporary periods and with various duration. The received materials were processed statistically [Glantz, 1998] with use of the software package "Biostat–3.01". On the figures means and confidential limits are shown. For comparison of curves used criterion χ^2. The conclusions of comparisons were made at 0.95.

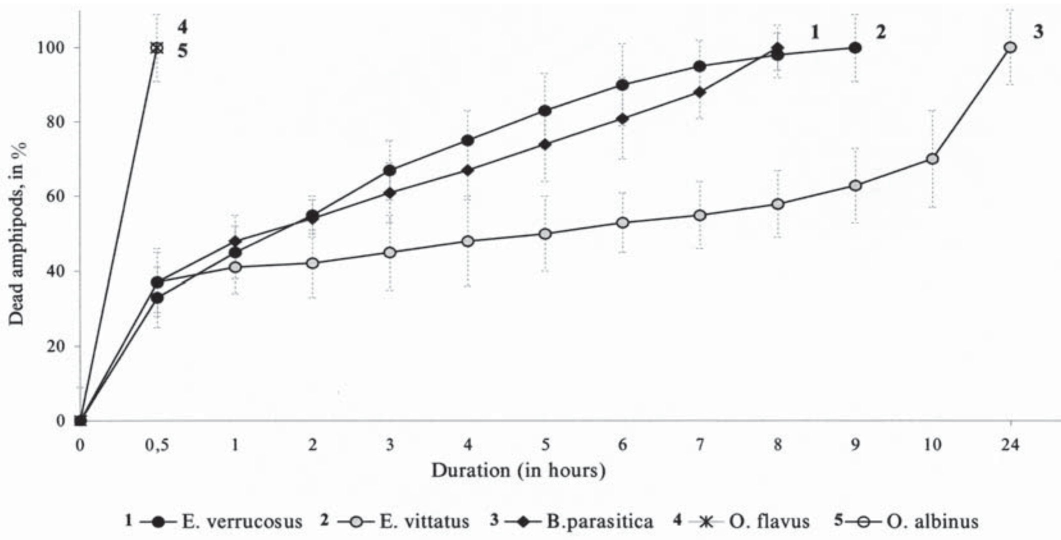

Fig. 2. Thermoresistance of amphipods *E. verrucosus, E. vittatus, B. parasitica, O. flavus and O. albinus* at temperature 25°C (in % from control).

Рис. 2. Терморезистентность амфипод *E. verrucosus, E. vittatus, B. parasitica, O. flavus* и *O. albinus* при температуре 25°C (в % от контроля).

Results and Discussion

Thermoresistance. As our experiments showed, all investigated amphipods species differed with respect to their resistance to heating. First, a series of experiments with temperature 25°C (Fig. 1,2) was made. The received materials allowed dividing all used species into 3 groups by degree of their resistance. The first group was represented by high resistant species: *G. fasciatus*, *E. cyaneus* and *G. lacustris*, the parameters of which resistance at 25°C were close (Fig.1). The second group was represented by less resistant species: *E. verrucosus*, *E. vittatus*, *B. parasitica*. It could be seen well from curves (Fig. 2) some branch from other species *E. vittatus* which shown itself as steadier species among the second group. The third group was represented by species, which have shown the highest sensitivity to heating: *O. flavus* and *O. albinus*.

The following series of experiments was carried out with the species, which have shown themselves as most resistant to temperature 25°C. The experiences carried out at 30°C. The results of the given experiments are showed (Fig. 3). From the diagram, the much resistance to heating of *G. fasciatus* and *G. lacustris*, than at *E. cyaneus* is visible. The parameters of *G. fasciatus* and *G. lacustris* thermoresistance were close.

Thus, all studied species by a degree of increasing of their thermopreference abilities could be arranged in the following line:
O. flavus = *O. albinus* < *E. verrucosus* = *B. parasitica* < *E. vittatus* < *E. cyaneus* < *G. lacustris* = *G. fasciatus*

Thermopreference. The thermopreference study of amphipods has revealed a rather wide variety of temperature preferences of all investigated species, and also different degree of expressing of thermopreference behavior. Among investigated amphipods, besides species with well-expressed temperature preference, the species with weakened or absolutely absent reactions were observed.

On Fig. 4 the distribution of *G. fasciatus* in thermogradient installation is shown. In experiments *G. fasciatus* demonstrated a preference for higher temperatures. The greatest concentration of adult crustaceans in experiments (30 %) was observed in the zone from 17–18°C. The experiments with juvenile amphipods of the given species have shown preferred temperatures of 15–16°C, where up to 31 % were accumulated.

The materials of experiences with *G. lacustris* are shown on Fig. 5. It could be visible, that preference to high temperatures also is characteristic for this species. The greatest quantity of amphipods (up to 33 %) was accumulated in a zone of 15–16°C. The definition of thermopreference of juvenile *G. lacustris* has shown that their preferred temperatures are in the range of 17–18°C, with a maximum of distribution in this zone 44 %.

Another pattern is observed in the experiments with *E. cyaneus*. The thermopreference curve of the given species is shown on Fig. 6. It's could be seen, that *E. cyaneus* also, as well as previous species had well-expressed preference behavior. However, in experiments, amphipods of the given species preferred somewhat lower temperatures. The greatest quantity of them (30 %) concentrated in a zone of from 11–12°C. The percentage of amphipods distribution in both directions from preferred zone was reduced in regular intervals. The least concentrations were marked in extreme points of a gradient. Juvenile *E. cyaneus* in experiences chose 9–10°C, with highest percent of concentration 32 %.

Results of experiences with *E. verrucosus* appreciably differed from the previous species (Fig.7). It is

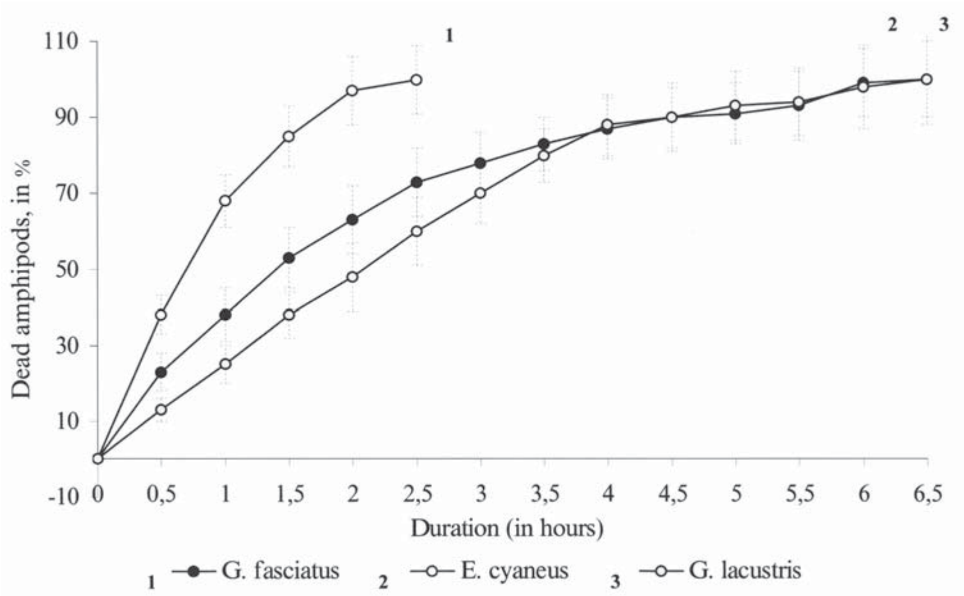

Fig. 3. Thermoresistance of amphipods *E. cyaneus, G. fasciatus, G. lacustris* at temperature 30°C (in % from control).
Рис. 3. Терморезистентность амфипод *E. cyaneus, G. fasciatus, G. lacustris* при температуре 30°C (в % от контроля).

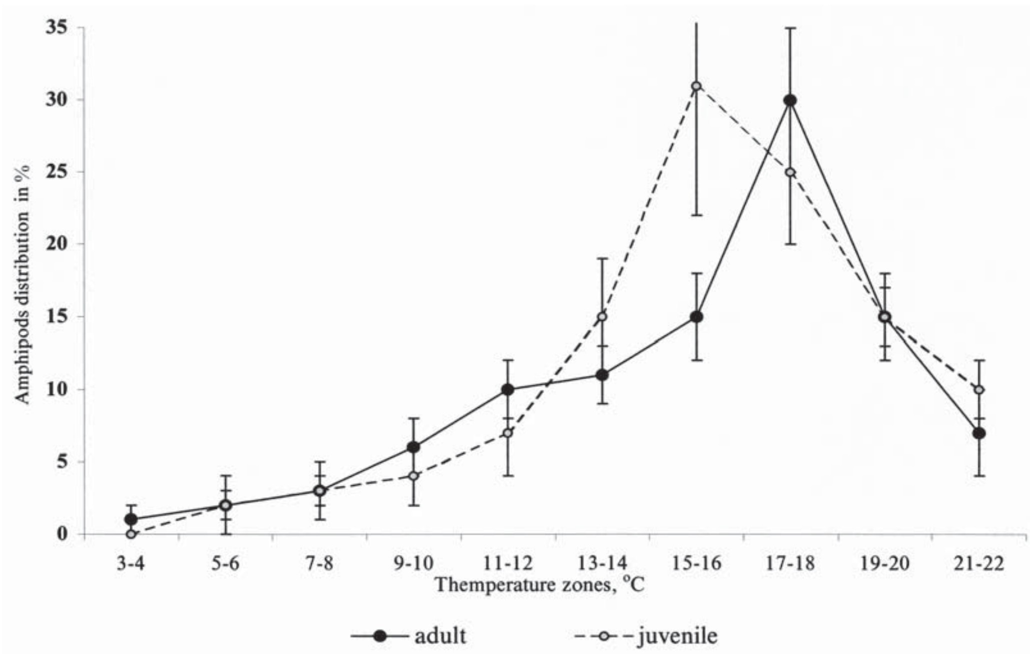

Fig. 4. Distribution of *G. fasciatus* in thermo-gradient installation, in %.
Рис. 4. Распределение *G. fasciatus* в термоградиентной установке, в %.

visible, that amphipods *E. verrucosus* preferred a temperature zone 5–6°C, where up to 30 % were concentrated. The displacement of the preference peak in gradient in the party of smaller temperatures is characteristic. Thus, if percent of amphipods in zones more than 10°C did not exceed a parameter in 10 %. For juveniles of *E. verrucosus,* higher preferred temperatures 11–12°C were observed, where up to 35 % of individuals of this species were concentrated.

The results of experiences with *E. vittatus* are shown in Fig. 8. As can be seen from this figure, the character of distribution in a temperature gradient of this species was close to those at *E. verrucosus*. The greatest percent of amphipods concentration in installation was fixed in zones 5–6°C. The peak of concentration at the given species 53 % was the highest concentration among all amphipods investigated. Juvenile *E. vittatus* also preferred a temperature zone 11–12°C, where up to 21 % were accumulated.

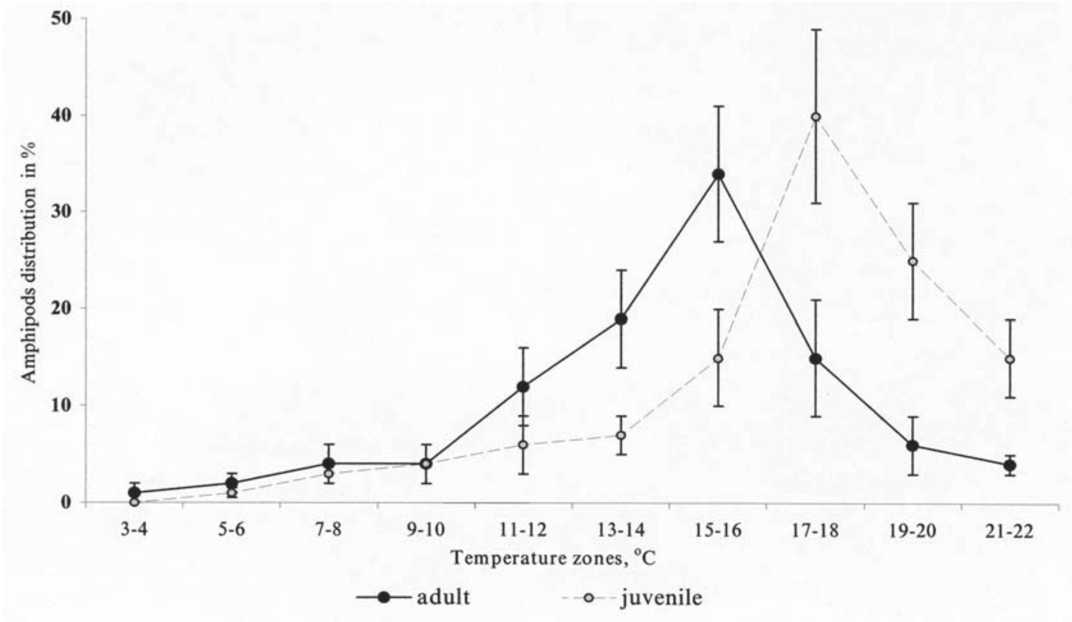

Fig. 5. Distribution of *G. lacustris* in thermo-gradient installation, in %.
Рис. 5. Распределение *G. lacustris* в термоградиентной установке, в %.

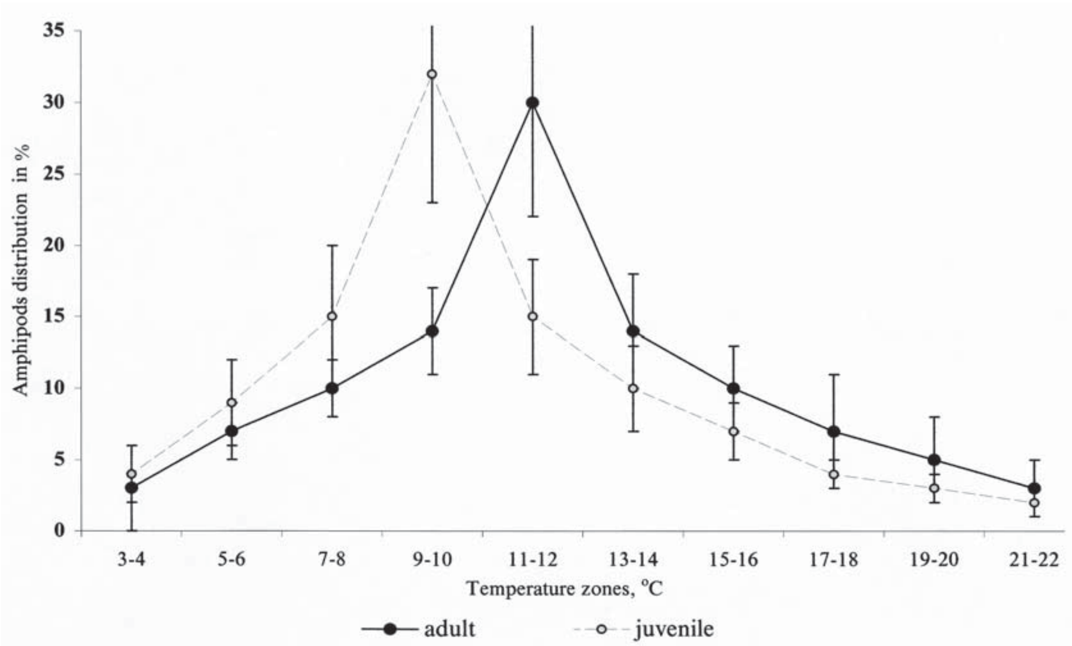

Fig. 6. Distribution of *E. cyaneus* in thermo-gradient installation, in %.
Рис. 6. Распределение *E. cyaneus* в термоградиентной установке, в %.

Materials received from experiments with the representative of deep-water fauna *O. flavus* are given in a Fig. 9. From this diagram it is visible that the greatest concentration of amphipods (20 %) was observed in a zone of the lowest temperatures (3–4°C). In experiments with juveniles of this species, we observed similar preferred temperatures of 3–4°C, with maximal percent of amphipods concentration 23 % was marked.

In experiences with a close species *O. albinus* a little bit higher peak of distribution in gradient was observed (Fig. 10). Preferred temperatures of *O. flavus* were close to those of *O. flavus,* in experiments up to 25 % of all amphipods preferred zone of lowest temperatures 3–4°C. A similar pattern was observed in the distribution of juvenile *O. albinus*, where up to 25 % specimens preferred 3–4°C. It is necessary to note, that in contrast

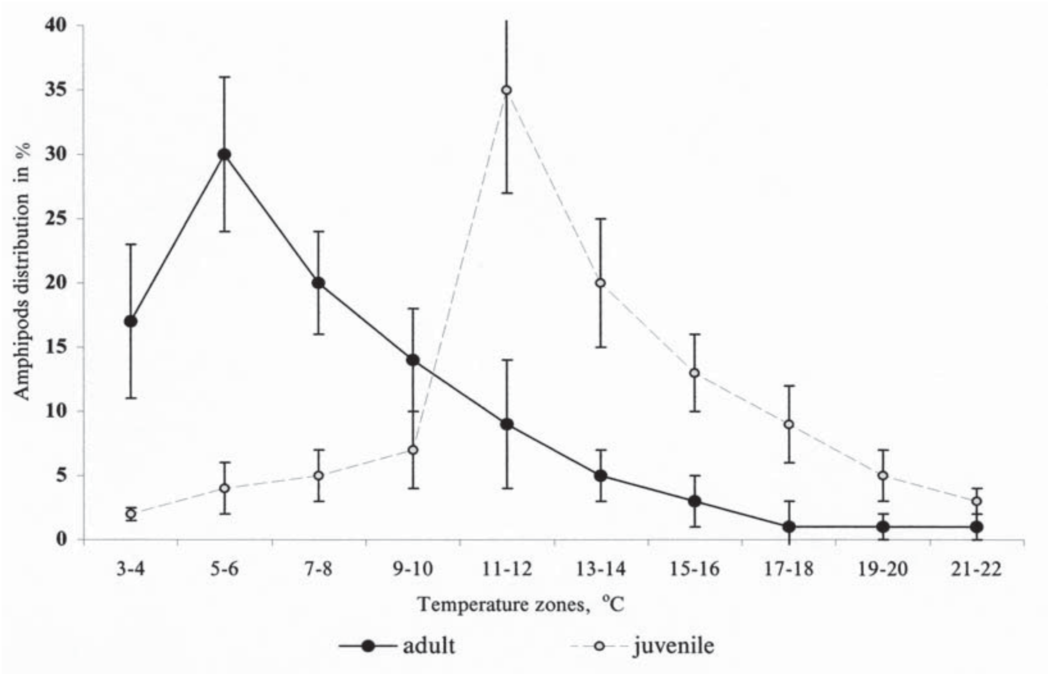

Fig. 7. Distribution of *E. verrucosus* in thermo-gradient installation, in %.
Рис. 7. Распределение *E. verrucosus* в термоградиентной установке, в %.

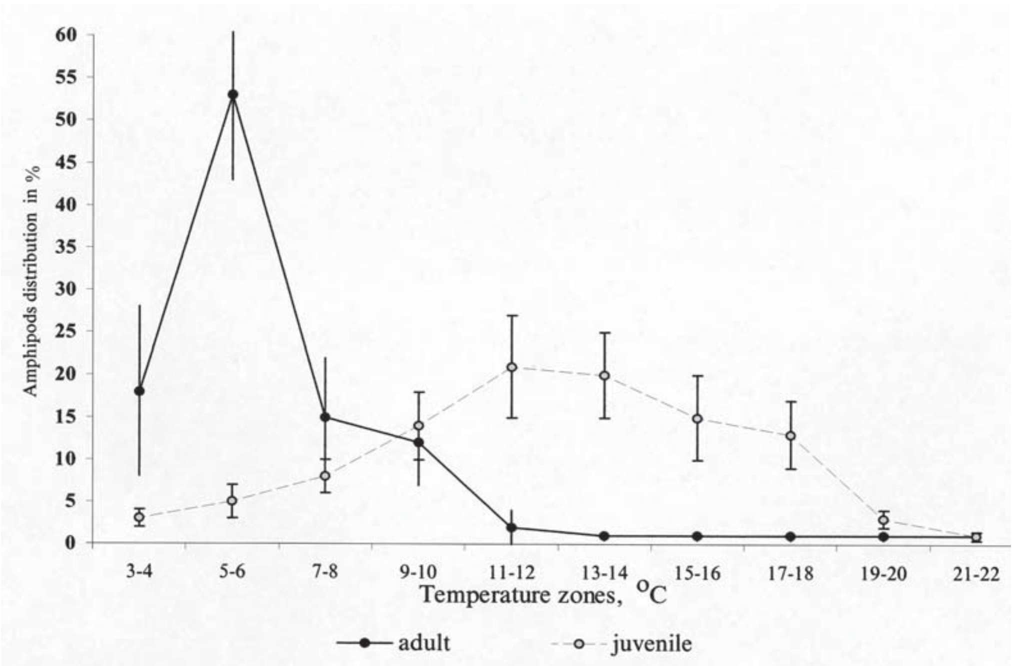

Fig. 8. Distribution of *E. vittatus* in thermo-gradient installation, in %.
Рис. 8. Распределение *E. vittatus* в термоградиентной установке, в %.

to all littoral species, deep-water *O. flavus* and *O. albinus* have shown appreciably lower percentage levels of thermopreference peaks.

Essentially different from the behaviors of the other amphipod species studied was the behavior of the parasite, *B. parasitica* (Fig. 11). It was found that in gradient installations, amphipods of this species did not show any thermopreference behavior and during all experiment settled down in the points where they were initially placed. The results of these experiments allowed making a conclusion about the absence at the given species thermopreference reaction [Timofeyev et al., 2000]. It is

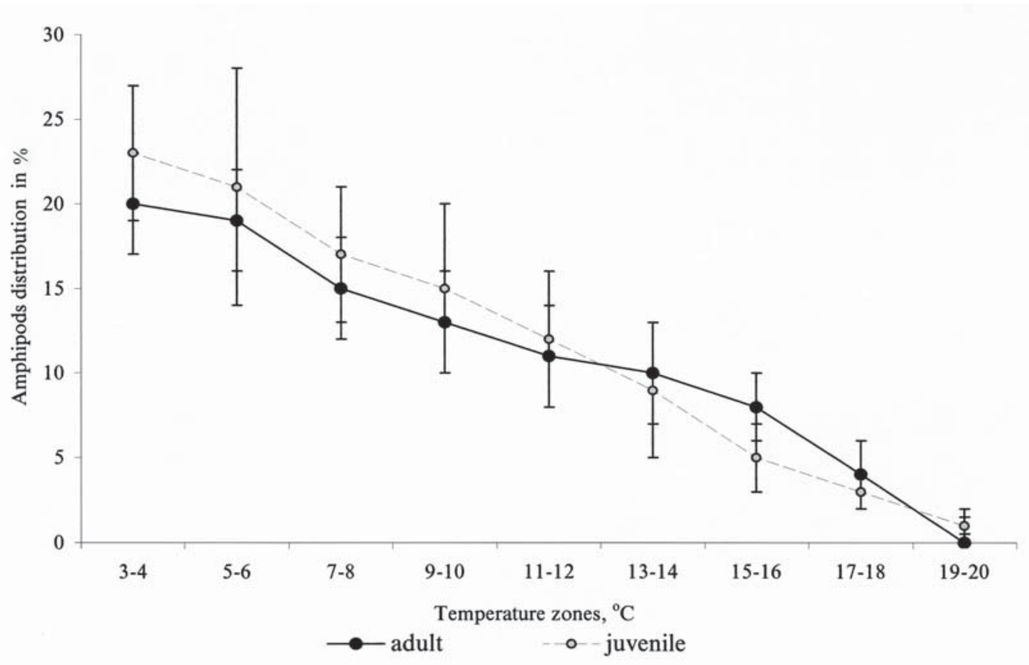

Fig. 9 Distribution of *O. flavus* in thermo-gradient installation, in %.
Рис. 9. Распределение *O. flavus* в термоградиентной установке, в %.

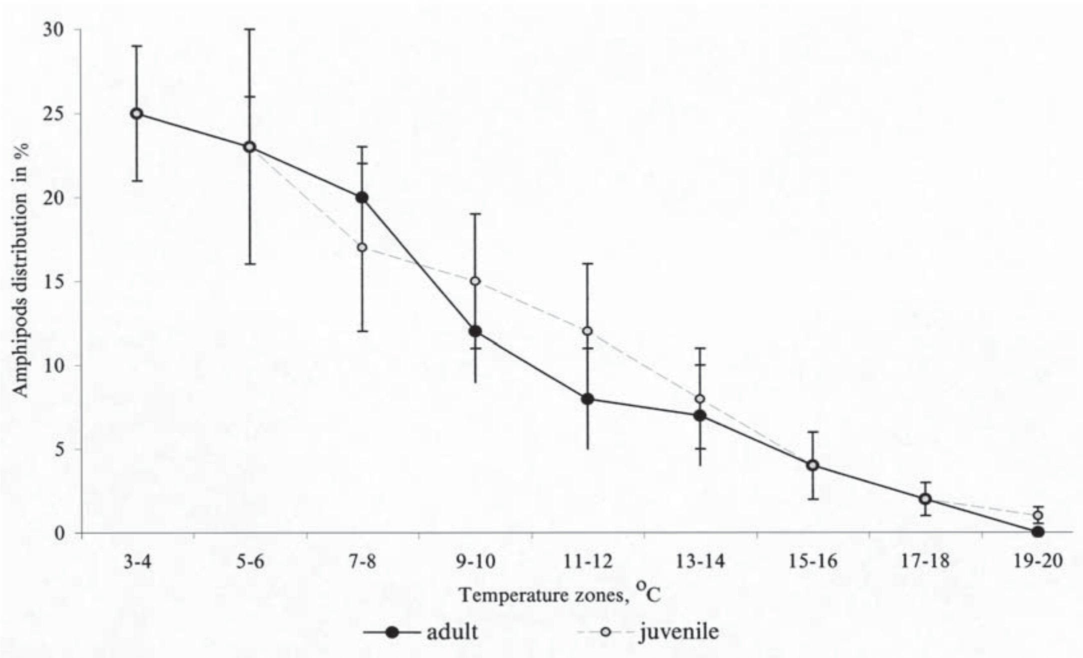

Fig. 10. Distribution of *O. albinus* in thermo-gradient installation, in %.
Рис. 10. Распределение *O. albinus* в термоградиентной установке, в %.

interesting to note that we observed another preference behavioral reaction which is characteristic for *B. parasitica*: in the presence of fragments of the sponge *L. baikalensis* in the same installation (on distance up to 25 cm), individuals of *B. parasitica* actively moved in them, and a bit later were concentrated on these fragments.

It is thus possible to divide all investigated amphipods into three groups based upon the thermopreferences of each. The first group was represented by species with well-expressed thermopreference behavior, their maximum concentrations were 30 % or higher. This group was represented by all littoral species: *E. cyaneus*, *E. vittatus*, *E. verrucosus*, *G. fasciatus*, *G. lacustris*. The second group was represented by deep-water amphipods *O. flavus* and *O. albinus* with poorly expressed thermopreference behavior. Maximal concentrations in

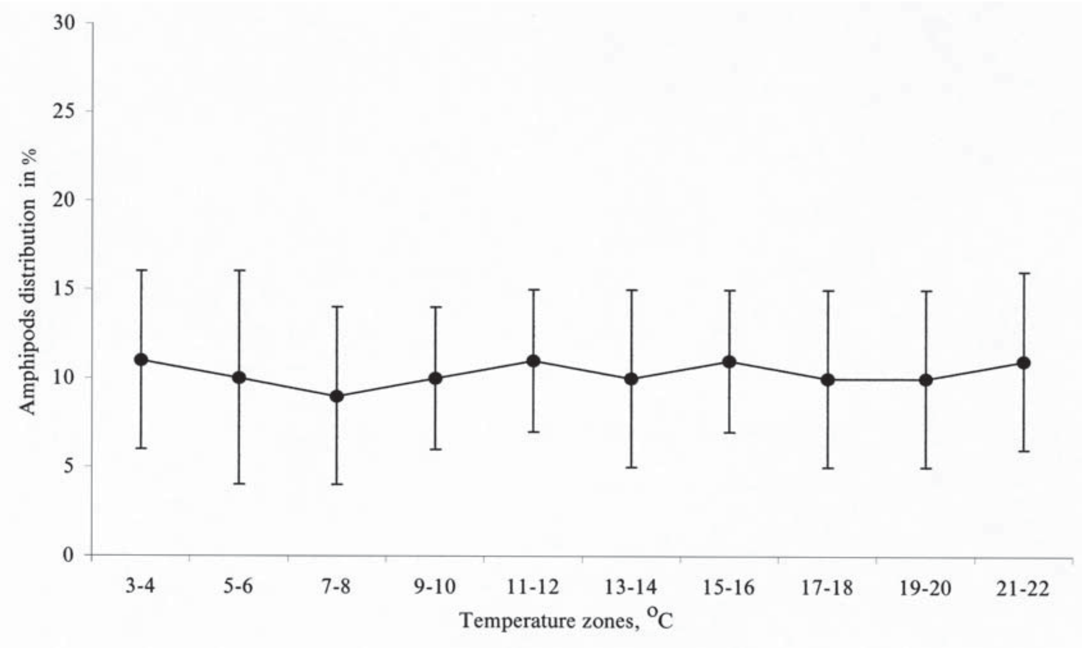

Fig. 11. Distribution of *B. parasitica* in thermo-gradient installation, in %.
Рис. 11. Распределение *B. parasitica* в термоградиентной установке, в %.

thermopreference zones for these species didn't reach 30 %. Third was presented by *B. parasitica,* the character of distribution of this species in thermogradient device was practically uniform. This species didn't express any thermopreference behavioral reaction.

It could be seen well from these experiments, that for littoral baikalian *G. fasciatus*, *E. cyaneus* and holarctic *G. lacustris* differences between thermopreferendum of juvenile amphipods and adults of the same species were 1–2°C. The similarity of distribution parameters for both age groups was estimated for deep-water *O. albinus* and *O. flavus*. In the same time, for littoral species *E. vittatus* and *E. verrucosus* the significant distinctions in distribution of the adult amphipods and juvenile of both species were observed.

By degree of increase of their thermopreference levels all species were arranged in the following order: *O. flavus* = *O. albinus* < *E. verrucosus* = *E. vittatus* < *E. cyaneus* < *G. lacustris* = *G. fasciatus*. From comparison of the given line to a line by thermoresistance, is could found, that the mutual positions of all endemic species in two lines were kept. The species, which preferred higher temperatures, accordingly were characterized by higher thermoresistance.

It must be stressed that the experimental data, received in laboratory, correlate closely with our observations of conditions of living zones of each amphipods species, in particular to their temperature modes.

So it is known, that *G. fasciatus* littoral species in Lake Baikal it submitted practically everywhere and rather widely distributed outside Lake Baikal. By its ecological characteristics, *G. fasciatus* is close to the cosmopolitan *G. lacustris*. Its especially plentiful in shallow bays i.e. zones with relatively increased for Baikal temperatures [Beckman, Bazikalova, 1951; Beckman, 1962]. Such characteristics relate well with its high thermoresistance ability and level of preferred temperatures revealed in experiments.

E. cyaneus is an inhabitant of the littoral zone and up to 90 % of its population occupies a narrow zone in a strip of a surf with depth up to 0.5 m [Weinberg et al., 1998], i.e. sites of littoral with the higher summer heating of water. Living in such conditions, apparently, is related to its rather high thermoresistance and level of preferred temperatures.

For *E. vittatus* and *E. verrucosus* it is interesting to note possible relation of distinctions in preferred temperatures by juvenile and adults stages with the expressed seasonal migrations. In summer time, when temperature of water increasing, adult amphipods of these species leaving from coast, moving in zones of the large depths, while juvenile amphipods remains in a zone of a beach [Weinberg, Kamaltynov, 1994; Weinberg, 1995]. The quoted authors, earlier presumably assumed, that migrations of *E. verrucosus* can be caused by summer increasing of water temperatures. The results of our experiments confirm this hypothesis. The same factors probably control the seasonal changes in the distribution of *E. vittatus*.

The preference of the minimal temperatures in experiments expressed by the representatives *O. flavus* and *O. albinus*, well relates with that on the depths, most preferred to them, stable low-temperature regime. Preferred temperatures of these species 3–4°C are close to temperatures of these depths zones (4–6°C at 100 m depth, 3.6°C at 200 m. depth and deeper). The decreased expression of preference behavior and their high sensitivity to heating are probably related to the absence of the any fluctuations of temperatures in their living zone.

The absence of thermopreferendum by *B. parasitica* could be related with its narrow parasitic specialization. Constant living on sponge *L. baikalensis*, apparently, does not require well-developed thermopreference behavior. At the same time, habitation of *B. parasitica* in littoral, i.e. zone with rather essential fluctuations of temperatures, was expressed in higher parameters thermoresistance, than at deep-water species.

G. lacustris is a species widely distributed in shallow and well warmed waterbodies of the Baikal region and through all of the Holarctic [Beckman, 1954; Barnard, Barnard, 1998]. This species lives in zones of seasonal and daily increases of temperatures. According to this, amphipods have high level of thermopreference and well resistant to the increased temperatures.

It was interesting to estimate how the attitude to the temperature factor relating with distribution of studied Baikalian endemics outside Baikal Lake. The comparison of obtained lines of species thermopreference and thermoresistance data about their distribution out from lake Baikal by the single out-flowing rivers system (Angara River – Enisey River) was made. Taking in account that in result of building several dams, Angara River and Enisey River were transformed into step system of reservoirs, that caused changing in all ecosystems, and led to domination of *G. fasciatus* [Safronov, 1999], for the given comparison the materials of amphipods distribution concerning to the period previous dams building were used. According to different sources [Bazikalova, 1945, 1957; Kozhov, Tomilov, 1949; Kozhov, 1931, 1962, etc.] outside Baikal those of studied species were observed: *E. vittatus*, *E. cyaneus*, *E. verrucosus*, *G. fasciatus*. The species *O. flavus*, *O. albinus* were not observed outside the lake. On various sites, depending on extension from Baikal, the number of species was reduced: on a site from a source Angara River up to Irkutsk (70 km from Baikal) were observed all 4 species —*E. vittatus*, *E. cyaneus*, *E. verrucosus, G. fasciatus*; on a site from Irkutsk up to Bratsk City (600 km from Baikal) were found 3 species — *E. vittatus*, *E. cyaneus*, *G. fasciatus*, on this site *E. verrucosus* left from common number of species; on a site from Bratsk city up to r. Enisey all three species were observed, however in Enisey *E. vittatus* was absent; on the most part along Enisey River *G. fasciatus* and *E. cyaneus* were observed, however in the second half of Enisey River last species was not marked, only *G. fasciatus* was presented, the zone of which distribution was stretched down until Enisey River connects with ocean. For such comparison we did not use *B. parasitica*, as its distribution first of all should be influenced by sponge distribution, instead of temperature factor.

By the range of distribution from Baikal by system of the rivers endemic species was could be placed in the following line: *O. flavus* = *O. albinus* < *E. verrucosus* < *E. vittatus* < *E. cyaneus* < *G. fasciatus*. It is visible, that this line also reflects general order showed in lines by species thermopreference and thermoresistance [Timofeyev, 2000].

Thus, it has been determined that the extent of baikalian amphipods distribution relates to their thermopreference and thermoresistance abilities. So it possible to propose that endemic amphipods distribution out of lake Baikal limits can be partially connected to character of their attitude to temperature factor as well.

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References

Barnard J.L., Barnard C.M. 1983. Freshwater Amphipods of the world. Mt. Veron: Virginia. 830 pp.

Bazikalova A.Y. 1945. [Amphipods of Baikal Lake] // Trudy limnol. stantsii. T.11. 440 pp. [in Russian].

Bekman M.Y. 1954. [Biology of *Gammarus lacustris* Sars from near baikalian lakes] // Trudy limnol. stantsii. T.14. P.268–311 [in Russian].

Brauer R.W., Jordan M.R., Roer R.D., Williams E.E., Bekman M.Y., Galazii G.I., Sidelyova V.G. 1984. Pressure effect on thermal preference behavior in gammarid amphipods from 600–1000 m in Lake Baikal // J. Therm. biol. No.3. P. 205–215.

Kamaltynov R.M. 1992. [On the present state of systematics of the Lake Baikal amphipods (Crustacea, Amphipoda)] // Zool. Zhurn. T.71. No.6. P.24–31 [in Russian, with English summary].

Kozhova O.M., Izmest'eva L.R. 1998. Lake Baikal. Evolution and Biodiversity. 447 pp.

Takhteev V.V. 1997. The Gammarus genus *Plesiogammarus* Stebbing, 1899, in Lake Baikal, Siberia (Crustacea Amphipoda Gammaridea) // Arthropoda Selecta. Vol.6. No.1–2. P.31–54.

Takhteev V.V. 2000. [Life forms of amphipods from Lake Baikal] // Problemy systematiki, ecologii i toksikologii bespozvonochnykh. Irkutsk: Irkutsk Univ. Press. P.12–21 [in Russian].

Taylor R. 1984. Thermal preference and temporal distribution in three crayfish species // Comp. Biochem. Phisiol. Vol.77. No.3. P.513–517.

Timofeyev M.A., Stom D.I., Shatilina J.M. 2000. Experimental study of some Siberian gammarids representatives to the temperature // Biodiversity and dynamics of ecosystems in North Eurasia. International conference. Novosibirsk. August 21–26, 2000. Abstracts. P.202–203.

Timofeyev M.A. 2000. [To the question of temperature influence on restriction of baikalian endemics distribution from Lake Baikal] // Bezopastnost biosfery. Ekaterinburg: "UGTU". P.104 [in Russian].

Timofeyev M.A., Shatilina J.M., Obuhova L.G., Ermakova E.V. 2000. Study of preference behavior of parasitic amphipod *Brandtia parasitica* (Dyb.) from lake Baikal // Ecotechnology in environmental protection and fresh water lake management. Proceedings of international symposium. October 17–20. 2000. PaiChai University. Taejon. Korea. P.262–263.

Tsurnamal M. 1978. Temperature preference of the blind prawn, *Typhlocaris galilea* Calman (Decapoda, Caridea) // Crustaceana. Vol.34. No.3. P.201–230.