Salinity tolerance of *Mytilocypris henricae* (Chapman) (Crustacea, Ostracoda)

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Abstract

Salinity tolerance, and the effects of temperature upon it, of the Australian ostracod *Mytilocypris henricae* (Chapman) was determined in direct transfer experiments using adults. Animals were subjected to a combination of 11 salinities (ranging between 0.0 g · l^{-1} and 45.0 g · l^{-1}) and 4 temperatures (10, 15, 20 and 25 ° C). Survival was analysed using two statistical techniques: the logit linear model and the proportional hazards model. Results show that both salinity and temperature have a significant effect on survival, but there is no significant interaction between temperature and salinity.

Introduction

Very little is known about salinity tolerance per se of non-marine ostracods. The present study focusses on salinity tolerance of the Australian ostracod *Mytilocypris henricae*, as determined by direct transfer experiments. It forms part of a more extensive study covering various aspects of the biology of this species (Martens, 1983).

Material and methods

Animals and water used for the experiments were collected from Lake Bathurst (N.S.W., Australia) on March 31, 1982. The salinity of the lake water at that time was 11.0 g · l^{-1}. Waters of lower salinities were obtained from the original Lake Bathurst water by diluting it with deionised water. Higher salinity waters were obtained by evaporating the lake water. The latter procedure is described in Martens (1983). Salinities were in both cases prepared to integer values, using the formula of Williams (1966). The following salinities were used: 2 types of distilled water (deionised water and glass distilled water) and 0.5, 4.0, 8.0, 15.0, 20.0, 25.0, 30.0, 35.0, 40.0 g · l^{-1}. Four temperatures were used: 10 ± 0.5 ° C; 15 ± 1.0 ° C; 20 ± 2.0 ° C and 25 ± 0.5 ° C. Results of the chemical analyses of the lake water and of the different solutions used in the experiments are given in Martens (1983). For all solutions, pH ranged between 7.85 and 9.80. The reasons behind the relatively wide range of pH are not obvious, but discussing this is outside the scope of the present paper.

Adults of the ostracod *M. henricae* were subjected to combinations of the 11 salinities and the 4 temperatures, resulting in a total of 44 treatments. Each treatment involved 10 animals and was carried out twice. Adults were picked out at random from the original stock and no distinction was made between sexes. They were transferred to a 25 ml vial filled with 20 ml of the desired solution. Each animal was transferred to a separate vial. Pieces of the halophyte *Ruppia* were added as food. The vials were kept in constant temperature rooms and randomly arranged. Survival was checked daily for 3 days.

Survival response was analysed in 2 different ways. The first (non-parametric) type of analysis

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investigates the association between various combinations of treatments and the distribution of survival times. It is known as the *proportional hazards model*. The theoretical backgrounds of this method are discussed by Cunningham *et al.* (1981). The second type of analysis assesses the effects of different treatments after a set time interval. It is known as the *logit linear model*. Both methods analyse the results, using values of N, the number of specimens subjected to a certain treatment, and R, the number of responses. The probabilities for all these responses thus show a binomial distribution. For both analyses, the results are presented as analysis of deviance. This is a chi-square value expressing the significance of the different sources of variation: temperature, salinity and temperature × salinity (Table 1 & 2).

The second type of analysis uses the following function of treatments:

$$\hat{P}_{ij} = \frac{e^{(\mu + T_i + S_j)}}{1 + e^{(\mu + T_i + S_j)}}$$

$\hat{P}_{ij}$ is the estimated probability of survival after a set period of time, μ is a constant calculated for the set of treatments for which the specific effects have been set to zero and T_i and S_j refer to the effects of a temperature treatment (i) and a salinity treatment (j), respectively. Apart from the analysis of deviance, this model also returns a value for μ and a T_i and S_j-value for each temperature and salinity used in the experiments. These figures were then used to calculate the probabilities of survival after 3 days, applying the above formula (Fig. 1).

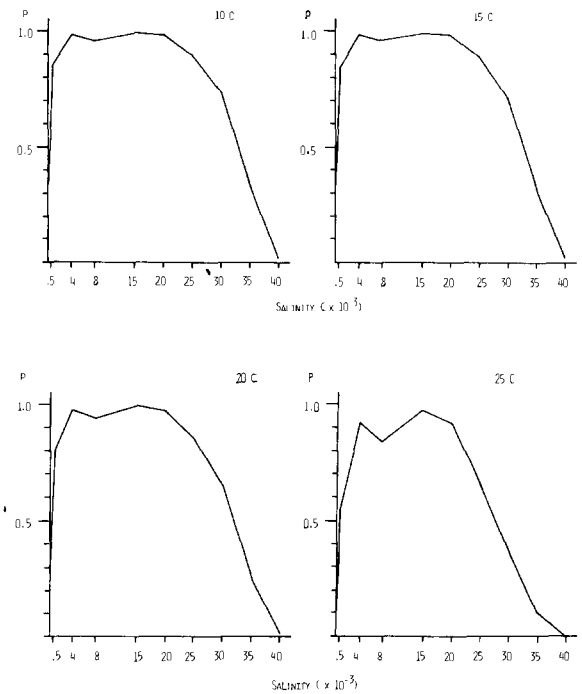

Fig. 1. Probabilities of survival (P) of adults *M. henricae* at 4 temperatures and 11 salinities, calculated with the logit linear model.

Table 1. Analysis of deviance on survival of adults *M. henricae* in direct transfer experiments, using the proportional hazards model. Df = degrees of freedom, signif. = level of significance, NS = not significant.

Source	Df	chi-square	signif.
temperature	3	53.1	$P \leqslant 0.001$
salinity	10	610.2	$P \leqslant 0.001$
temp. × sal.	30	22.2	NS

Table 2. Analysis of deviance of survival of adults *M. henricae* in direct transfer experiments after 3 days, using the logit linear model. (Abbreviations as in Table 1).

Source	Df	chi-square	signif.
temperature	3	35.8	$P \leqslant 0.001$
salinity	10	561.0	$P \leqslant 0.001$
temp. × sal.	30	28.0	NS

Results and discussion

The results of the analyses of deviance (Tables 1 and 2) are in good agreement with one another. They show that both temperature and salinity have a highly significant effect on the survival of animals, but that the interaction between temperature and salinity is not significant. This requires further explanation. At first it seems apparent that higher salinities are less well tolerated at higher temperatures. This would suggest that the species' tolerance of high salinities is affected by high temperatures, or in other words that there would be an *interaction* between salinity and temperature. The analyses, however, reveal that the low survivals in treatments with high salinities and high temperatures are caused separately by salinity and temperature, but

which are *combined* in one treatment. The same can be seen from the distribution of the probabilities of survival in different salinities (Fig. 1), which have a different position in the four temperatures, but retain the same shape and run approximately parallel to each other.

The lower and upper field salinity tolerance limits of *M. henricae* are 3.0 g · l^{-1} and 20.0 g · l^{-1}, respectively (De Deckker, 1981; Williams, 1981). The tolerance range is much narrower in the field than in the laboratory (Fig. 1) and especially the discrepancy between the two lower tolerance limits is apparent. According to the results from the experiments, *M. henricae* can easily tolerate freshwater (salinity $\leqslant$3.0 g · l^{-1}) conditions, yet the species is rarely reported from waters of such salinities. This phenomenon remains as yet unexplained. It might be related to preferential hatching in higher salinities (see discussion in De Deckker, 1983b; Martens, 1983) or to predation by fish (De Deckker, 1983a), but there is not enough hard evidence to support either hypothesis.

M. henricae is probably an essential freshwater form that is salt tolerant. Such species are thought to have their upper salinity tolerance limit around 30.0 g · l^{-1} (Bayly, 1972) and are probably unable to hypo-osmotically regulate. The latter was shown in *Megalocypris ingens* (Tones, 1983).

The ranges of temperature used in the present experiments are not wide enough to show the actual temperature tolerance limits of *M. henricae*. While studying the life cycle of this species in Lake Bathurst (New South Wales), however, it was shown that both adults and larvae were present throughout the year in Lake Bathurst (N.S.W.) while temperature at 50 cm depth in this lake ranged from 4 °C to 29 °C between September 1982 and June 1983 (Martens *et al.*, in press). Although these extremes were tolerated without a significant effect on the structure of the population (e.g. differential mortality of certain lifestages), it appears from results of postembryonic ontogeny experiments in the laboratory that a constant temperature of 25 °C is too high for a succesful completion of the life cycle because all animals died before they reached stage 7 (Martens, in press). These results are supported by those of the present experiments, where mortality is highest at 25 °C.

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