ミツクリハマアミ Acanthomysis mitsukurii の生存、成長、再生産に及ぼす低塩分の影響

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Effects of low salinity on survival, growth and reproduction of *Acanthomysis mitsukurii* (Crustacea: Mysidacea)\(^1\).\(^2\)

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Abstract

The effects of low salinity on the survival, growth and reproduction of *Acanthomysis mitsukurii*, the natural distribution of which is restricted to areas where the salinity is above or around 30 PSU, were examined under laboratory conditions at 20°C. The survival rates were obviously lower when the salinity was \(\leq 20\) PSU in experiments without acclimation (experiment length: 24 h) and with acclimation (40 d). Growth rates up until Day 40 at 20 PSU were lower than those at higher salinities. Both the ratio of breeding females and the number of cumulative offspring at salinities \(\leq 27\) PSU were lower than those at higher salinities. Also, the percentage of stillborn offspring at low salinities was high, so the number of viable offspring at salinities \(\leq 27\) PSU was extremely small. Therefore, it is concluded that low salinity has a greater impact on reproduction than on survival and growth of the post-embryonic stage. These experiments revealed that *A. mitsukurii* is a stenohaline species and suggest that the occurrence of low salinity regimes at \(< 30\) PSU may play an important role in determining the distribution and population strength of *A. mitsukurii*.

Key words: mysidacea, survival, growth, reproduction, salinity

Many mysid species have restricted distribution patterns, occurring only within a particular salinity range (e.g. Heubach 1969, Mauchline 1980, Williams & Collins 1984, Imabayashi & Endo 1986). The restricted distribution of mysids has been explained by their osmoregulatory ability (McLusky & Heard 1971, De Lisle & Roberts 1987) and the effects of salinity on their survival (Murano 1966, Vlasblom & Elgershuizen 1977, McLusky 1979, Bhattacharya 1982, Pezzack & Corey 1982, McKenney 1994) or growth (McKenney & Celestial 1995). *Acanthomysis mitsukurii* (Nakazawa) is a dominant species in the Pacific coastal waters of Japan and its distribution is restricted to areas where the salinity is above or around 30 PSU (Yamada et al. 1994, Yamada unpubl.). In order to investigate the cause of the limited distribution of *A. mitsukurii*, we conducted laboratory experiments in order to study the effects of low salinity levels on the survival, growth and reproduction of this species.

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\(^2\) ミクシリハマアミ Acanthomysis mitsukurii の生残、成長、生殖に及ぼす低塩分の影響

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Materials and Methods

Live mysids were collected from Sendai Bay (10-m depth, 18.5°C, 33 PSU) and transferred to the laboratory. Female *Acanthomysis mitsukurii* with young in the marsupium (breeding females) were sorted out and maintained in a 50-liter tank (33 PSU). The water temperature in this tank was increased gradually (0.5°C/d) from the temperature at sampling (18.5°C) to the test temperature of 20°C. The test temperature is the approximate temperature level during autumn in the wild, when the density of *A. mitsukurii* is at its highest (Yamada et al. 1994, Yamada unpubl.). Thus, newly released mysids (offspring) were obtained from a 50-liter tank at 20°C and 33 PSU. All experiments were performed at 20±0.5°C under natural light conditions. Enriched *Artemia* nauplii, containing a high concentration of n-3 HUFA (highly unsaturated fatty acids), were added in excess during the experiments. This has been found to be a suitable diet for the survival, growth and reproduction of *A. mitsukurii* and the details of the feeding methods have been described in our previous paper (Yamada et al. 1995). Filtered sea water (0.5-µm mesh) at a salinity of 33 PSU was diluted with distilled water to obtain the low salinities for the tests.

In Experiment A, mysids which had been reared from Day 0 in a 50-liter tank at 33 PSU, were introduced into 1-liter beakers under six salinity conditions, i.e. 10, 15, 19, 23, 27 and 31 PSU on Day 10 [carapace length (CL) of 1.06±0.02 (mean±SE, n = 20) mm]. All treatments initially included 30 mysids per beaker and were replicated three times. The survival rate was determined after 24 h.

In experiment B, offspring that were collected within 24 h of release from the marsupium [CL: 0.52 ±0.01 (mean±SE, n = 20) mm] were introduced into 10-liter tanks at 33 PSU. The salinity was progressively reduced from 33 PSU (Day 0) in steps of 1 or 2 PSU per day to six final salinity conditions, i.e. 16, 20, 24, 27, 30 and 33 PSU. The period required to reach 16, 20, 24, 27 and 30 PSU was 9, 7, 5, 3 and 2 d, respectively. Seawater in each tank was renewed every third day during the experiment. Each treatment contained 100 mysids per tank at the beginning and was replicated three times, except that the 16, 20 and 33 PSU treatments were not replicated. Experiment B was continued until Day 40, which is close to the average life span in rearing experiments (Yamada et al. 1995). The survival rate was assessed on Days 10, 20, 30 and 40. The cumulative number of offspring and the fraction of stillbirths (stillborn offspring/total offspring) up until Day 40 were also measured. All mysids were fixed and preserved on Day 40 in a 5% neutralized formalin-seawater solution in order to measure CL (length from the base of the eyestalk to the dorsal median posterior edge of the carapace) and the ratio of breeding females to total females. The survival percentages, breeding female percentages and stillbirth percentages were transformed to arcsine values for analysis (Sokal & Rohlf 1981). Parameters were compared between each salinity treatment using one-way ANOVA and Tukey Kramer tests (Sokal & Rohlf 1981).
Results

In Experiment A, all the individuals at salinities of 10 and 15 PSU died within 30 minutes of initiation. The survival rates (% ± SE) after 24 h at 19, 23, 27 and 31 PSU were 70.4 ± 3.9, 96.8 ± 1.7, 96.6 ± 1.7 and 98.7 ± 1.3, respectively. There was a significant difference ($p < 0.01$) between the 19 PSU treatment and the other three treatments.

In Experiment B, most of the mysids at 16 PSU died by Day 10, and the survival rate at 20 PSU was evidently lower than those at 24, 27, 30 and 33 PSU on all dates (Figure 1). Although the survival rates at 24 and 27 PSU were significantly lower ($p < 0.01$) than at 30 PSU on Days 10, 20 and 30, there was no significant difference ($p > 0.05$) between the three treatments on Day 40. The survival rates at 33 PSU approximated that of the 30 PSU treatment. Most of the mortalities at 24 and 27 PSU occurred by Day 10, when the acclimation period of all treatments was finished. The mortality values at 24 and 27 PSU after Day 10 were low, and this corresponded closely to the mortality values at 30 and 33 PSU.

Growth rates were not significantly different ($p > 0.05$) between treatments at ≥ 24 PSU, in which CL was approximately 2.0 mm on Day 40, for both sexes (Table 1). However mysids at 20 PSU were significantly smaller ($p < 0.01$) than those in higher salinity treatments for both sexes.

Reproductive parameters in Experiment B were compared between each salinity treatment (Table 2). All mysids at 20 PSU were unsuccessful at reproduction. Both the ratio of breeding females and the number of cumulative offspring at 24 and

![Graph showing survival rates across different salinities and ages](image)

**Fig. 1.** Effects of salinity on the survival rate of *Acanthomysis mitsukurii* reared in the laboratory. Different letters (a, b) indicate significant differences between salinity treatments ($p < 0.01$) and the vertical bars the SE. Treatments at 16, 20 and 33 PSU were not replicated. Age indicates days after release from the marsupium.
Table 1. Effects of salinity on the growth (CL in mm ± SE) of *Acanthomysis mitsukurii* reared in the laboratory. Comparisons between treatments were made on Day 40 for both sexes. Different letters (a, b) indicate significant differences between salinity treatments \( p < 0.01 \). Values in parentheses indicate the number of individuals measured.

<table>
<thead>
<tr>
<th>Salinity (PSU)</th>
<th>20</th>
<th>24</th>
<th>27</th>
<th>30</th>
<th>33</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.55±0.06b</td>
<td>2.02±0.01a</td>
<td>2.03±0.01a</td>
<td>2.03±0.01a</td>
<td>2.00±0.02a</td>
</tr>
<tr>
<td></td>
<td>(4)</td>
<td>(54)</td>
<td>(55)</td>
<td>(66)</td>
<td>(23)</td>
</tr>
<tr>
<td>Females</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.76±0.04b</td>
<td>2.04±0.01a</td>
<td>2.03±0.02a</td>
<td>2.02±0.01b</td>
<td>2.00±0.01a</td>
</tr>
<tr>
<td></td>
<td>(5)</td>
<td>(52)</td>
<td>(51)</td>
<td>(69)</td>
<td>(25)</td>
</tr>
</tbody>
</table>

27 PSU (particularly at 24 PSU) were lower than those at 30 and 33 PSU. In addition, the ratios of stillborn offspring at 24 and 27 PSU (100 % and 55 %, respectively) were significantly higher \( p < 0.05 \) than those at 30 PSU. Consequently, the number of viable offspring at salinities \( \leq 27 \) PSU was extremely small.

**Discussion**

The survival rates in Experiments A and B and growth rates in Experiment B were obviously lower when salinity was \( \leq 20 \) PSU. In addition, the effect of low salinity at \( \leq 27 \) PSU caused an increase in the mortality of *Acanthomysis mitsukurii* by 10 days after release from the marsupium in Experiment B, although it is uncertain whether the low salinity itself or the rate of salinity decrease caused this mortality increase. Vlasblom & Elgershizen (1977) reported that the young of *Neomysis integer* are more susceptible to low salinity than adults. In contrast, juvenile *Mesopodopsis orientalis*, which inhabit both the estuarine and coastal waters of India, exhibited the best survival rates in the range of 30 to 60 % pure sea water when directly transferred and survived well when transferred from 100 % sea water to fresh water with gradual acclimation (about 3 PSU/d) (Bhattacharya 1982). Another estuarine and coastal mysid *Americamysis bahia* (= *Mysidopsis bahia*; Price et al. 1994) also showed normal survival and growth patterns over a wider salinity range throughout its life cycle than did *A. mitsukurii* (McKenney 1994, McKenney & Celestial 1995). These results indicate that salinity is one of the most important abiotic fac-

Table 2. Effects of salinity on the reproduction of *Acanthomysis mitsukurii* reared in the laboratory. The percentage (mean ± SE) of females with young in the marsupium (breeding females) on Day 40, the cumulative number of offspring released up until Day 40 and the percentage of stillborn offspring to total offspring are compared. Different letters (a, b, c) indicate significant differences between salinity treatments \( p < 0.05 \). Treatments at 20 and 33 PSU were not replicated.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>20</th>
<th>24</th>
<th>27</th>
<th>30</th>
<th>33</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breeding females</td>
<td>0</td>
<td>27.0±17.4</td>
<td>41.5±5.7</td>
<td>75.9±8.4</td>
<td>52.0</td>
</tr>
<tr>
<td>Offspring</td>
<td>0</td>
<td>18.3±6.7b</td>
<td>225.3±125.2</td>
<td>436.3±69.3a</td>
<td>570</td>
</tr>
<tr>
<td>Stillbirths</td>
<td>0</td>
<td>100±0.0b</td>
<td>55.0±18.9b</td>
<td>33±0.5a</td>
<td>13.2</td>
</tr>
</tbody>
</table>
tors affecting habitat suitability for mysids and that A. mitsukurii is a stenohaline species.

In general, the salinity range within which some invertebrates are able to reproduce is usually much narrower than the salinity range which permits the growth of individuals (Kinne 1971). However, there are no ontogenetic studies on the effects of salinity in mysids, particularly with reference to reproduction. Our experiments revealed that A. mitsukurii required salinities > 27 PSU for normal reproduction and that reproduction of this species was more sensitive to low salinity than survival and growth of the post-embryonic stage.

Since the salinity tolerance of mysids is usually affected by temperature (e.g. Vlasblom & Elgershuizen 1977, McLusky 1979, Battacharya 1982, Pezzack & Corey 1982, McKenney 1994), there is a possibility that A. mitsukurii is more tolerant to low salinities at other test temperatures. However, these results on salinity tolerance under test temperatures of 20°C are important for understanding the population dynamics of this species because the wild population is most abundant around this temperature (Yamada et al. 1994, Yamada unpubl.). In conclusion, these experiments have revealed that the occurrence of low salinity levels at < 30 PSU, which are sometimes caused by heavy rain fall in shallow coastal waters, may play an important role in determining the distribution and population strength of A. mitsukurii.

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Literature Cited


