The effect of temperature-salinity combinations on survival and growth of juvenile *Patiriella pseudoexigua* (Echinodermata: Asteroidea)

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**Abstract.** Adult *Patiriella pseudoexigua* were collected in October 1989 from Wanlitung, Taiwan and then induced to spawn in the laboratory. Post-metamorphosed juvenile *P. pseudoexigua* were reared on a diet of benthic algae *Navicula* sp. at 25 °C and salinity (34‰). Six weeks after metamorphosis, juvenile *P. pseudoexigua* at ca. 400 µm in radius were reared on a diet of benthic algae *Navicula* sp. at different combinations of temperatures (20, 25, 30 °C) and salinities (26, 30, 34‰) for 40 d. Both temperature and salinity had a significant effect on juvenile survival and growth. Juveniles survived best (> 90%) at 25 °C and 34‰ and grew best (to ca. 750 µm in radius) at 30 °C and 34‰. Variation in juvenile size was small immediately after metamorphosis and increased with time.

**Introduction**

Temperature and salinity strongly influence survival and growth of marine organisms (Kinne 1970, 1971, Pechenik 1987, His et al. 1989, Zimmerman and Pechenik 1991). Many marine invertebrates even require specific temperature and salinity at different developmental stages (Pechenik 1987). In echinoderms, which are poikilothermic and typically stenohaline, effects of temperature-salinity combinations have been documented in embryonic cleavage (Cameron et al. 1985), larval development and growth (Watts et al. 1982) and adult activity (Lawrence 1975, Watts and Lawrence 1990 a, b). However, environmental influence on post-metamorphosed juveniles are rare. It is important to know the survival and growth responses of early-staged juveniles to combinations of temperature and salinity to understand the distribution of echinoderms.

The purpose of the present study is to examine the responses of young juvenile *Patiriella pseudoexigua* to combinations of temperature and salinity. Reproductive cycle, larval development, juvenile growth and population dynamics of *P. pseudoexigua* have been documented (Chen and Chen 1992). This seastar occurs abundantly in high intertidal pools of southern Taiwan. The habitat has high levels of physical stress and disturbance, especially in summer, due to the rainy season, high temperature (up to 40 °C at ebb, authors' personal observation) and unpredictable typhoons.

**Materials and methods**

Adult *Patiriella pseudoexigua* Dartnall were collected in October 1989 from Wanlitung (120°41'E; 22°01'N), southern Taiwan. They were kept in an aerated aquarium at ca. 26 °C and 34‰ salinity. Adults spawned in the aquarium on 27 October. Embryos were collected with a plankton net and reared in 250-ml beakers to metamorphosis at 25 °C in continuous dim light. Seawater was changed daily. Larvae were lecithotrophic and did not need to be fed. At ca. 10 d after fertilization, larvae metamorphosed without artificial inducing. After larvae metamorphosed, juveniles were fed benthic algae (*Navicula* sp.) growing on watch glasses.

Six weeks after metamorphosis, juveniles reached an average major radius of 400 µm and were then distributed among various temperature and salinity treatments. A 2 x 3 factorial experimental design was used (temperature: 20, 25, 30 °C; salinity: 26, 30, 34‰), with each treatment triplicated. Thirty juveniles for each replicate were kept in 250-ml glass bowls with filtered seawater. The culture bowls were placed in the incubator to maintain water temperature within 0.1 °C. The salinity of each culture bowl was checked with a refractometer and adjusted within 1‰ with distilled water. The culture bowls were exposed to continuous light (200 Lux). Many tiny air bubbles appeared on the algal surface through algal photosynthesis. Under such a culture system, seawater does not need to be aerated and changed frequently. The seawater was changed only once on Day 20. The benthic algae (*Navicula* sp.) cultured on watch glasses were replaced after 20 d for feeding. The major radii were measured and the number of surviving individuals was counted on Day 20 and Day 40. The juveniles use tube feet to adhere to or move on the bottom. In order to avoid damaging the tube feet while picking the juveniles up for size measurement, the juveniles were narcotized as follows: the seawater in the culture bowls was discarded, then the culture bowls were rinsed briefly with 6 to 7% MgCl₂ in freshwater for ca. 5 min. Juveniles were returned immediately to seawater after measurement. The individuals showed no ill effects caused by this treatment.
Data on survival were adjusted with the arcsine transformation before conducting the ANOVA test. Mean values of major radii in juveniles from each bowl were used for the ANOVA test. The multiple regression equation of size was chosen by using a backward elimination procedure (Sokal and Rohlf 1981). A response surface technique was employed for examining effects of temperature and salinity on juvenile size (Alderdice 1972). Juvenile growth rate was calculated as \((L_{40} - L_0)/40\), where \(L_0\) and \(L_{40}\) are the average major radii of juveniles in three bowls initially or on Day 40, respectively.

### Results

**Effect of temperature and salinity on juvenile survival**

Survival of juvenile *Patiriella pseudoexigua* differed significantly among temperature, salinity and day (Fig. 1, \(p < 0.01\)). The effect of temperature varied with salinity. Maximal survival (96.7%) occurred at 25°C and 34%.

![Fig. 1. Patiriella pseudoexigua. Average survival (%) of juveniles. 6-wk old juveniles reared at different temperature-salinity combinations for 20 and 40 d. Vertical bar indicates 1 standard deviation. Error bars shifted slightly to avoid overlap.](image1)

![Fig. 2. Patiriella pseudoexigua. Size distribution of juveniles. 6-wk old juveniles reared at different temperature-salinity combinations for 20 d. Data averaged from triplicates.](image2)

![Fig. 3. Patiriella pseudoexigua. Average sizes of juveniles. 6-wk old juveniles reared at different temperature-salinity combinations for 20 and 40 d. Vertical bar indicates 1 standard deviation. Error bars shifted slightly to avoid overlap.](image3)