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Earl F. Prentice

Kurt X. Gores

Conrad V. W. Mahnken

and

Herman S. Groninger

Coastal Zone and Estuarine Studies Division
Northwest and Alaska Fisheries Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
2725 Montlake Boulevard East
Seattle, Washington 98112

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ABSTRACT

The genus Pandalus contains the most important commercial shrimp species in the North Pacific. Among them, the spot prawn (P. platyceros) is a promising cultivar because of its large size (254 mm total length), relatively rapid natural growth, and ease of culture. Exploratory research was conducted at the National Marine Fisheries Service Manchester Marine Experimental Station near Manchester, Washington to develop efficient rearing techniques for spot prawn larvae for the purpose of stocking as a companion crop in salmon net-pens, for stock enhancement, and as a bioassay organism. The larval rearing experiments reported here were intended to determine 1) if prepared feeds could be substituted for brine shrimp (Artemia) nauplii; 2) the extent to which larval development could be accelerated using heated water; and 3) aspects of culture that might lead to more efficient rearing systems.

The survival of larvae fed living and prepared food was examined in heated water (14° and 18°C) and water ambient temperatures (9°-12°C). Metamorphosis to post larvae (Stage V) occured in 18 d at 18°C, 22-28 d at 14°C, and 31-42 d at ambient seawater temperatures. Survival was best (75%) at 14°C when fed Artemia. A linear relationship between larval stage of development and temperature units is expressed by TU = 221.3 + 84.3 (S - 3.5), where TU = temperature units (°C) and S = larval stage. Artemia-fed larvae survived better than those fed prepared food containing blue bay mussel, housefly larvae, or chicken egg as major nutrient sources. The use of supplemental fluorescent light during larval culture is discussed as a possible means of reducing stress during ecdysis.

CONTENTS

INTRODUCTION

The spot prawn (Pandalus platyceros), reaching 254 mm total length, is the largest of the commercially important North Pacific pandalids. It is widely distributed in the temperate waters of the North Pacific from off southern California northward to Alaska and off Asia from Korea northward to Siberia. The prawn occurs at depths from 4 to 487 m (Butler 1964).

The spot prawn is fished commercially off North America with pots and trawls. Heavy exploitation of inshore shrimp beds has depleted stocks in some areas, forcing management agencies to reduce the catch through gear restrictions or area closures. Despite declining natural production, market demand has remained high and interest in commercial production has grown. However, biological information to permit large-scale rearing has been lacking.

In the last decade, research was directed toward studies of the nutritional and environmental needs of P. platyceros to facilitate large-scale culture for commercial production. In general, studies showed the spot prawn to be highly adaptable to artificial culture (Forster and Wickens 1972; Wickens 1972; Kelly et al. 1977; Rensel and Prentice 1977, 1979, 1980). In 1972, the National Marine Fisheries Service (NMFS) began studying the technical feasibility of culturing the spot prawn. Research was divided into three phases based on prawn development: larval, postlarval, and adult. Larval rearing was carried out in the laboratory; whereas postlarval, juvenile, and adult work was divided among laboratory facilities, floating seawater net-pens, and benthic seawater cages (Prentice and Rensel 1977; Rensel and Prentice 1977, 1979, 1980). The

larval rearing experiments reported here had the following objectives:

1. Show if a variety of prepared, nonliving feeds could be substituted for Artemia nauplii. It was not our intent to carry out a detailed nutritional study, but rather to describe the success or failure of the diets in our culture system.

2. Determine rearing temperature(s) for optimum survival and the shortest time within any given developmental stage.

3. Identify aspects of culture that might lead to more efficient rearing systems.

METHODS AND MATERIALS

Brood Stock and Larval Collection

Female spot prawns were captured in pots in Hood Canal, Washington during March and April of 1973, 1974, and 1975. Ovigerous prawns were held at the National Marine Fisheries Service (NMFS) Manchester Marine Experimental Station near Manchester, Washington. Raw ambient seawater (9°-12°C, salinity 28°/oo) was continuously supplied to four 75-liter Fiberglass[1/] holding troughs. Up to 12 ovigerous prawns were placed in each trough and fed crushed blue bay mussels (Mytilus edulis).

Eggs started to hatch soon after arrival at the laboratory and continued hatching to the end of April for each collection year. Eggs

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[1/] Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

hatched over a 2- to 4-d period, primarily at night. Larvae were collected with a piece of nylon screen (1-mm mesh) in the form of a scoop. At hatch, the larvae were 6-7 mm total length.

Once collected, the newly hatched larvae were counted and distributed into test containers. The tests were conducted in a laboratory illuminated with cool-white fluorescent light. All larval experiments were carried through to developmental Stage V (Price and Chew 1972) when possible.

1973 Experiments

Initial larval rearing tests were conducted at three water temperatures (ambient, 14°C, and 18°C) from March through June 1973 (Test A). A three compartment water table containing four 1,000-ml glass beakers per compartment was used to evaluate the influence of temperature on larval development. Each beaker contained 1,000 ml of aerated, sand-filtered seawater (salinity 28°/oo). Ten larvae were placed in each beaker. At the start of a test, all compartments were at ambient temperature. The 14° and 18°C compartments were brought up to temperature over 24- and 48-h periods.

Larvae in all beakers were fed live Artemia nauplii. All feeding was to excess, twice daily. The water in the beakers was replaced every fourth day or whenever it became fouled. Larvae were examined daily for developmental stage. Larval stages were identified by morphological characteristics described by Price and Chew (1972). Exuviae and mortalities were counted and removed daily. Other than the identification of larval stages, no growth measurements were made.

1974-75 Experiments

Larval rearing experiments were continued in 1974 (Test B) and 1975 (Test C) at two water temperatures (ambient and 14°C). In these experiments, time to death by starvation in comparison to artemia fed larvae were noted. Larvae were examined and fed in a manner similar to that previously described.

Larvae were reared in perforated (1-mm openings) plastic baskets 15x13x13 cm deep. The baskets were hung from partition walls of two water tables (Fig. 1). Each compartment was aerated with airstones. The water level was adjusted so each basket had a rearing volume of 1 liter. Ten larvae were placed in each basket. Each diet treatment was replicated four to eight times.

A continuous supply of sand-filtered seawater at ambient temperature entered the back of the water tables. Water in one-half of each table was maintained at ambient and the other half at 14°C $\pm$ 1.0°C using submersible heaters and temperature controllers (Fig. 1).

Starvation tests (Test B) at ambient and 14°C were conducted in cylindrical tubes (5 cm diameter x 16 cm length) made of Fiberglass[1/] window screen (1-mm mesh) with a rearing volume of 196 ml; 40 screen tubes with one animal per container prevented cannibalism. In Test C, starvation time (at ambient and 14°C) was determined using four baskets with 10 larvae per basket at each temperature.

In addition to Artemia nauplii, prepared diets containing blue bay mussel, house fly larvae (Musca domestica), or whole chicken egg as major

DIAGRAM OF WATER TABLE

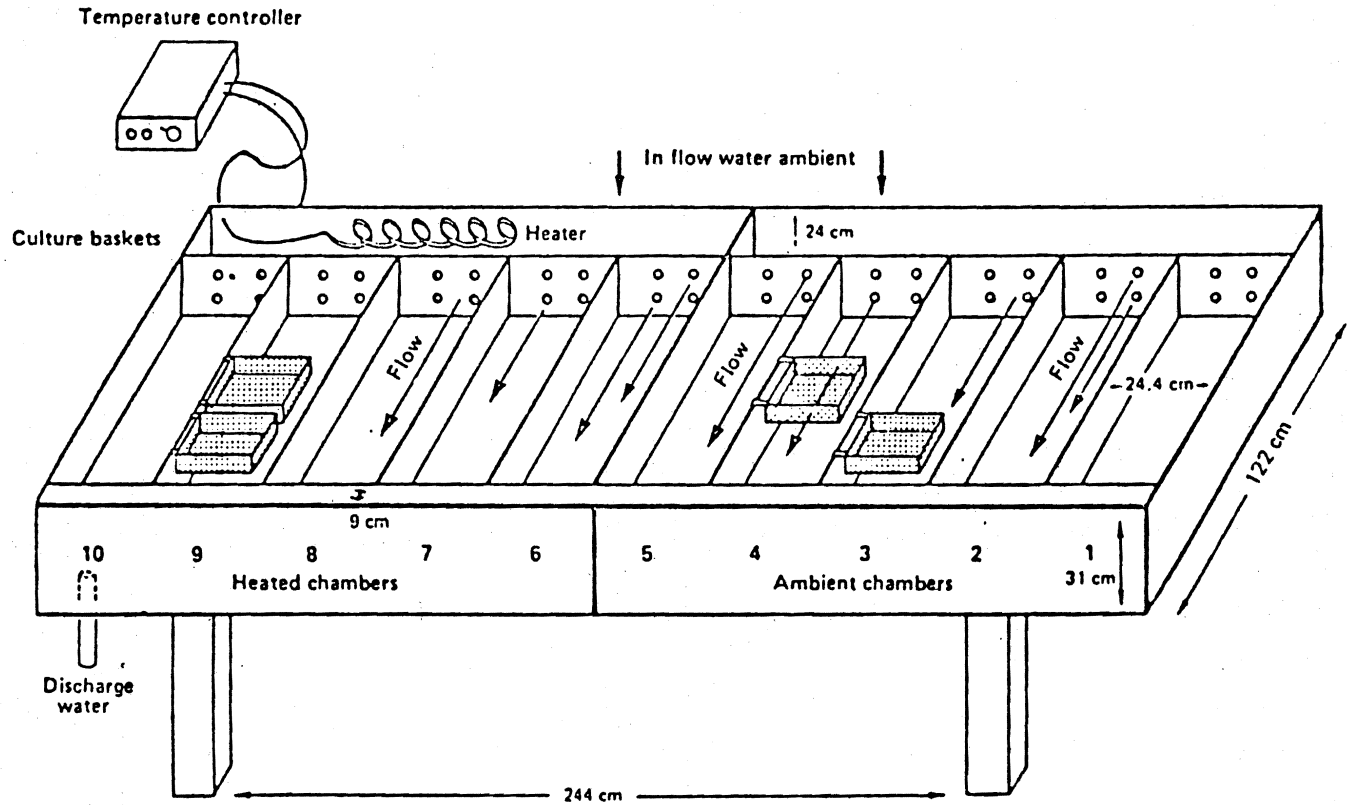

Figure 1.--Water table used in the culture of spot prawn larvae.

nutrient sources were tested as possible larval diets. The biochemical composition and physical properties of these diets are shown in Tables 1 and 2. The prepared diets were formulated by combining ingredients and homogenizing in a blender for up to 1 min at medium to high speed. Distintergrated material was pressed through a 0.180- or 0.425-mm mesh screen. Constituents used in freeze-dried diets were distintergrated in a blender at -80°C.

The effect of temperature and diet on survival of larvae was analyzed for independence using the G^2 statistic (Sokal and Rohlf 1969).

RESULTS AND DISCUSSION

Effects of Temperature

Temperature and diet are key metabolic determinants of the larvae's ability to survive the stress of transition from one developmental stage to the next. In Test A, the effect of rearing temperature on survival of Artemia-fed larvae was evaluated. At larval Stage II there was no significant difference between larvae reared at ambient, 14°C, or 18°C. However, there was a significantly higher survival to Stage V of larvae reared at 14°C than at ambient (Table 3). Further tests showed a trend for the 14°C test groups to have higher survival at larval Stage V (77.5%) than the 18°C groups (65.0%). The 18°C groups showed higher survival (65.0%) than larvae reared at ambient temperature (55.0%), but no statistical differences in survival were observed in either comparison (Table 3).

Table 1.--Estimated composition of diets (dry basis) fed to larvae of *Pandalus platyceros*.

Diet	Major nutrient	Protein %	Fat %	Ash %	Mineral[a] supplement	Vitamin[b] supplement
Artemia	*Artemia*	58.0	19.3	20.6[c]	-	-
Prepared-1	Raw fly larvae	51.3	14.4	11.7	+	+
Prepared-2	Raw fly larvae	61.9	13.6	12.8	+	+
Prepared-3	Raw fly larvae[d]	60.7	13.3	12.5	+	+
Prepared-4	Raw mussel	69.8	7.6	11.9	+	+
Prepared-5	Raw mussel	52.5	8.0	14.4	+	+
Prepared-6	Whole chicken egg	48.8	43.0	2.3	-	+

[a]Mineral supplement contained: 5.7 g K_2HPO_4; 9.4 g KCl; 14.8 g $MgSO_4$; 10.0 g Ca $(H_2PO_4)H_2O$; 1.4 g $FeCl_3$; 0.2 g $MnSO_4 \cdot 7H_2O$; and 25 g $CaCO_3$. Supplement was added at a rate of 6% of total dry ingredients.

[b]The following amounts of vitamins (mg) were added per 100 g of total dry feed ingredients: thiamine-HCl, 10; riboflavin, 80; pyridoxine-HCl, 20; cyanocobalamin, 0.02; nicotinic acid, 150; calcium pantothenate, 100; biotin, 2; inositol, 400; folic acid, 6; choline chloride, 500; p-aminobenzoic acid, 80; menadione, 5; alpha-tocopherol, 50; calcium ascorbate, 1,000; cholesterol, 2,000; vitamin D_3, 20; vitamin A, 2,000,000 USP units.

[c]Gallagher and Brown 1975.

[d]1.0% each of glucosamine and betaine added.

Table 2.--Physical properties of diets fed larvae *Pandalus platyceros*.

Diet	Major nutrient	Binder	Particle size	Diet form
Artemia	*Artemia* nauplii	none	<2.0mm	Live
Prepared-1	Raw fly larvae	4% agar	<0.5mm	Freeze-dried
Prepared-2	Raw fly larvae	14% succinylated protein	<0.5mm	Freeze-dried
Prepared-3	Raw fly larvae	13% succinylated protein	<0.5mm	Freeze-dried
Prepared-4	Raw mussel	17% succinylated protein	<0.5mm	Freeze-dried
Prepared-5	Raw mussel	13% agar	<0.5mm	Freeze-dried
Prepared-6	Whole chicken egg	none	0.180 or 0.425 mm	Moist, frozen

Table 3.--Comparison of larval Pandalus platyceros survival in beakers at different rearing temperatures when fed live Artemia.

Ambient (9°-12°C) vs. 14°C

Stage	Mean % survival Ambient (9°-12°C)	14°C	G^2	df	S or NS[a]
II	82.5	85.0	0.09	1	NS
V	55.0	77.5	4.59	1	S

Ambient (9°-12°C) vs. 18°C

Stage	Mean % survival Ambient (9°-12°C)	18°C	G^2	df	S or NS[a]
II	82.5	80.0	0.08	1	NS
V	55.0	65.0	0.84	1	NS

14°C vs. 18°C

Stage	Mean % survival 14°C	18°C	G^2	df	S or NS[a]
II	85.0	80.0	0.35	1	NS
V	77.5	65.0	1.54	1	NS

[a]S or NS denotes statistical significance or nonsignificance at $P \leq 0.05$.

In Tests B and C, Artemia-fed larvae reared to Stage V in baskets at 14°C showed a significantly higher survival than those reared at ambient temperature (Table 4). Additional larval tests conducted in baskets also showed a significant differences in survival between larvae reared at ambient and 14°C regardless of diet (Table 4). Overall, 14°C was shown to be the best larval rearing temperature of the three temperatures evaluated, ambient (9°-12°C), 14°C, and 18°C. Other investigators have shown 14°-15°C to be a satisfactory rearing temperature for P. platyceros (Wickens 1972; Kelley et al. 1977).

The low survival at ambient temperature was associated with the extended time required for a population of similar aged larvae to pass from one developmental stage to the next (Table 5). Unlike the findings of Kelly et al. (1977) who observed synchronous ecdysis between Stages I and II (rearing temperature 9.5°-12.0°C), we observed no molt synchronies at any of the developmental stages under similar rearing temperatures. In our studies, the lack of synchronization at ambient temperatures resulted in different stages of larvae of similar age within the same population. Cannibalism was prevalent under these conditions.

In subsequent tests, the time required to reach each larval developmental stage was shortened by elevating the culture temperature (Table 5). For example, larvae fed an Artemia diet required 31-42 d to reach first postlarval stage (Stage V) at ambient temperature. Time to reach Stage V was reduced to 22-28 d at 14°C, and 18 d at 18°C. Larvae fed other diets also showed a reduced time to reach each developmental stage.

Table 4.--Comparison of larval *Pandalus platyceros* survival in screen tubes of in baskets at different rearing temperatures when starved or fed live *Artemia* or a prepared diet.

Diet	Rearing container	Stage	Mean % survival Ambient (9°-12°C)	Mean % survival 14°C	Ambient (9°-12°C) vs 14°C G^2	df	Significance[a]
Starved	Baskets	II	7.5	37.5	11.7	1	S
Starved	Screen tubes	II	12.5	32.5	4.72	1	S
Artemia	Baskets	V	42.5	67.5	10.22	1	S
Prepared[b]	Baskets	II	48.2	65.5	16.88	1	S
Prepared egg	Baskets	III	42.5	67.5	5.11	1	S

[a]S or NS denotes statistical significance or nonsignificance at $P \leq 0.05$.

[b]Survival data for prepared diets, blue bay mussel and house fly larvae, showing no statistical difference at ambient ($G^2 = 3.11$, df = 4, $P \leq 0.05$) or 14°C ($G^2 = 5.70$, df = 4, $P \leq 0.05$) rearing temperatures were combined. Specific diets and their composition are shown in Tables 1 and 2.

Table 5.--Larval development time, age, and survival of Pandalus platyceros larvae at developmental Stages I to V at three rearing temperatures.

Rearing container	Test	Temp.(°C)	Diet		Developmental stage I to II	II to III	III to IV	IV to V
Beaker	A	Ambient[a]	Artemia	Development time (days)	11	5	9	6
				Age (days)	11	16	25	31
				% survival	82.5	65.0	57.5	55.0
Beaker	A	14	Artemia	Development time (days)	7	4	7	5
				Age (days)	7	11	18	23
				% survival	85.0	82.5	77.5	77.5
Beaker	A	18	Artemia	Development time (days)	6	4	4	4
				Age (days)	6	10	14	18
				% survival	80.0	67.5	65.0	65.0
Screen tubes	B	Ambient[a]	Starvation	Development time (days)	15	-	-	-
				Age (days)	15	-	-	-
				% survival	12.5	-	-	-
Basket	B	Ambient[a]	Artemia	Development time (days)	10	12	12	6
				Age (days)	10	22	34	40
				% survival	72.5	48.8	45.0	42.5
Basket	B	Ambient[b]	Prepared[b] (combined)	Development time (days)	13	-	-	-
				Age days)	13	-	-	-
				% survival	49.2	-	-	-
Screen tubes	B	14	Starvation	Development time (days)	6	-	-	-
				Age (days)	6	-	-	-
				% survival	32.5	-	-	-
Basket	B	14	Artemia	Development time (days)	6	6	10	6
				Age (days)	6	12	22	28
				% survival	82.5	76.2	71.2	67.5
Basket	B	14	Prepared[b] (combined)	Development time (days)	6	-	-	-
				Age (days)	6	-	-	-
				% survival	66.8	-	-	-

Table 5.--Cont.

Rearing container	Test	Temp.(°C)	Diet		Developmental stage I to II	II to III	III to IV	IV to V
Basket	C	Ambient[a]	Artemia	Development time (days)	10	12	12	8
				Age (days)	10	22	34	42
				% survival	90.0	62.5	55.0	55.0
Basket	C	Ambient[a]	Starvation	Development time (days)	22	-	-	-
				Age (days)	22	-	-	-
				% survival	7.5	-	-	-
Basket	C	Ambient[a]	Prepared egg	Development time (days)	12	18	-	-
				Age (days)	12	30	-	-
				% survival	75.0	42.5	-	-
Basket	C	14	Artemia	Development time (days)	7	3	6	6
				Age (days)	7	10	16	22
				% survival	95.0	87.5	82.5	80.0
Basket	C	14	Starvation	Development time (days)	14	-	-	-
				Age (days)	14	-	-	-
				% survival	37.5	-	-	-
Basket	C	14	Prepared egg	Development time (days)	7	7	12	7
				Age (days)	7	14	26	33
				% survival	82.5	67.5	60.0	55.0

[a]9°-12°C.

[b]Data prepared diets, blue bay mussel, and house fly larvae, showing no statistical differences were combined.

At the elevated rearing temperatures, molt synchronization was observed. This was most evident with larvae reared on Artemia. Cannibalism was substantially reduced, thus partly accounting for the higher survival at rearing temperatures above ambient (9°-12°C). Our results from shortening the developmental period through increasing temperature are in agreement with Price and Chew (1972), who found the larval period to be 35 d at 11°C, and Kelly et al. (1977) who reported the larval period to be 26-35 d at 9° to 12°C. Wickens (1972) reported a larval period of 15-29 d at 14°C.

The advantages gained by increasing the rearing temperature and thus decreasing the larval developmental period were not extended to larvae reared at 18°C. Rearing at 18°C may have been close enough to the upper thermal tolerance of P. platyceros to negatively affect survival. Kelly et al. (1977) noted that larval mortality increased sharply at temperatures above 21°C in 48-h temperature tolerance tests. These tests did not measure the chronic effect of sublethal temperatures in which 18°C may be classified.

Since larval development is affected by rearing temperature, each stage can be described in terms of temperature units. This concept is used to describe and predict stages of embryonic development in fish (Leitritz and Lewis 1976). Applying this to larval development (Stages I to V) of P. platyceros, a relationship was established using our data expressed by the following general equation:

$$TU = 221.3 + 84.3\ (S - 3.5),$$

where TU = temperature units (°C) and S = larval stage (I to V). Since the time to reach each stage of development is temperature dependent, the number of days to the specific developmental stage is expressed by the equation

$$d = \frac{TU}{°C},$$

where d = days to the developmental stage, TU = temperature units, and °C = rearing temperature.

Specific temperature unit equations were established for larval rearing temperatures of 9°-12°C, TU = 232.4 + 88.2 (S - 3.5); 14°C, TU = 214.7 + 84.5 (S - 3.5); and 18°C, TU = 207.6 + 72.0 (S - 3.5). These equations are based on the anabolic developmental time for P. platyceros larvae fed excess Artemia nauplii. These predictive equations are of use in research planning, in mass culture, and for comparison work (e.g., bioassays).

Effects of Diet

Adequate larval diets are necessary to assure good growth and survival. A variety of living and prepared diets have been used to culture prawn larvae with varying results (Wickens 1972; Balazs et al. 1973; Kelly et al. 1977; Barbieri and Cuzon 1980). In Tests B and C of this study, survival of starved larvae was compared to survival of larvae fed Artemia nauplii or a prepared diet.

In the starvation tests, there was a significant difference in survival between Stage II larvae kept at ambient and 14°C (Table 4). The higher survival at 14°C was related to the shorter developmental times

between Stages I and II ($\bar{x}$ = 10 d at 14°C vs. $\bar{x}$ = 18 d at ambient). By Stage III, however, all starved larvae were dead at both rearing temperatures. Starvation tests were not conducted at 18°C.

Artemia nauplii are a commonly used live diet that has proved to be adequate for the culture of P. platyceros larvae (Price and Chew 1972; Wickens 1972). The developmental time to Stage II, in Tests B and C, was up to 12 d shorter for Artemia-fed than for starved larvae (Table 5). There was also a significant difference in survival at Stage II between Artemia-fed and starved larvae at both ambient and 14°C in all tests (Table 6).

In Test B, larvae fed diets containing blue bay mussel or house fly larvae showed poorer survival than Artemia-fed larvae at ambient and 14°C (Table 5). Larvae fed these prepared diets generally did not progress past Stage II at either rearing temperature. Despite the poor performance of larvae reared on prepared diets, those reared at 14°C showed significantly higher survival than those reared at ambient temperature (Table 4). These results are consistent with the other findings of the study.

Of the prepared diets tested, the whole egg diet (Tables 1 and 2) showed the greatest promise as a possible larval diet. Survival for the whole egg diet (Test C) was not significantly different at Stage II from Artemia-fed groups at either ambient or 14°C (Table 6). Under ambient rearing conditions, however, the larvae fed whole egg did not progress past Stage II. At 14°C, the egg-fed larvae required 11 more days to reach

Table 6.--Comparison of larval Pandalus platyceros survival in screen tubes or in baskets when starved or fed live Artemia or prepared diets at one of two temperatures.

Rearing temperature	Test	Diet	Mean % survival	Stage	G^2	df	Significance[a]
Ambient (9°-12°C)	B	Artemia vs. starved	72.5 vs. 12.5	II	41.81	1	S
	C	Artemia vs. starved	90.0 vs. 7.5	II	63.54	1	S
	B	Prepared[b] vs. starved	48.2 vs. 12.5	II	20.54	1	S
	C	Prepared egg vs. starved	75.0 vs. 7.5	II	42.14	1	S
	B	Artemia vs. prepared[b]	72.5 vs. 48.2	II	15.24	1	S
	C	Artemia vs. prepared egg	90.0 vs. 75.0	II	3.20	1	NS
14°C	B	Artemia vs. starved	82.5 vs. 32.5	II	29.47	1	S
	C	Artemia vs. starved	82.5 vs. 37.5	II	33.49	1	S
	B	Prepared[b] vs. starved	65.5 vs. 32.5	II	15.61	1	S
	C	Prepared egg vs. starved	82.5 vs. 37.5	II	17.66	1	S
	B	Artemia vs. prepared[b]	82.5 vs. 65.5	II	9.16	1	S
	C	Artemia vs. prepared egg	95.0 vs. 82.5	II	3.29	1	S
	C	Artemia vs. prepared egg	80.0 vs. 55.0	V	5.82	1	S

[a]S or NS denotes statistical significance or nonsignificance at $P<0.0125$.

[b]Prepared diets of blue bay mussel and house fly larvae were combined since no statistical difference was seen between individual diets at ambient ($G^2 = 3.11$, $df = 4$, $P\leq 0.0125$) or 14°C ($G^2 = 5.70$, $df = 4$, $P\leq 0.0125$) rearing temperatures. Specific diets and their composition are shown in Tables 1 and 2.

Stage V than Artemia-fed larvae; the survival of the egg-fed larvae was also significantly lower (Tables 5 and 6).

All prepared diets were accepted by larvae regardless of stage. The prepared diets were ingested and observed in the digestive tract of the larvae; however, it is not known whether the food was digested or assimilated. Poor survival and prolonged intermolt time at both ambient and 14°C indicate that the prepared diets did not meet the requirements of the larvae. Particle size, form, binder type, or other unknown factor(s) may have contributed to the overall poor performance of the prepared diets. Many studies have been directed at nutritional requirements and crustacean diet formulation with little consistent agreement between investigators (Forster 1972; Balazs et al. 1973; Groninger and Miller 1974; New 1976; Jones et al. 1979; and Barbieri and Cuzon 1980).

The transition between Stage I and II was a critical period (high mortality) for all larvae regardless of diet. This was especially true for those larvae fed prepared diets. A high incidence of cannibalism was noted during molting. Once past Stage II, mortalities usually declined and survivors generally completed development to Stage V (Table 5). Wickens (1972) indicated that the first 10 d of larval life seemed to be the most critical. This period (10 d) is nearly equivalent to the first two stages of larval development.

Other Effects

Our observations on diet and temperature indicate that P. platyceros can be cultured with relative ease on a small scale through larval

metamorphosis in a controlled environment. With Artemia nauplli as food, survival through the larval stages at 14°C ranged from 67.5% to 80% (mean 75%). Maximum survival through controlled nutrition and environment is essential for the successful mass culture of this species.

Recent efforts have been directed toward prawn nutrition (New 1976, 1980) with insufficient attention given to environmental factors. For example, light is a factor known to affect the development of crustacean larvae, although little work has been done to quantify the effect of light on larval crustacean survival (Damkaer et al. 1980, 1981). Damkaer et al. (1980) showed that when P. platyceros larvae (Stage I) were irradiated with high-intensity, filtered, cool-white fluorescent light for 3 h/day, survival was greater than for larvae reared only under laboratory light (low-intensity, indirect fluorescent light). It was postulated that the higher survival was related to greater larval activity and feeding when stimulated by high-intensity visible light. It was further postulated that visible radiation may drive repair mechanisms similar to the photorepair mechanism described by Caldwell (1971) to alleviate some stresses of ecdysis.

To improve survival, supplemental exposure to high intensity, cool-white fluorescent light for 1-3 h/day might be given larvae of P. platyceros. Elevated rearing temperatures coupled with supplemental light exposure would likely enhance survival and growth rates of marine Crustacea artifically cultured for commercial or research programs.

SUMMARY AND CONCLUSIONS

Pandalus platyceros larvae were reared to developmental Stage V in a closed system at ambient temperatures (9°-12°C), 14°C, and 18°C, and in a flow-through system at ambient temperatures (9°-12°C) and 14°C. Artemia nauplii and six prepared diets containing blue bay mussel, house fly larvae, or chicken egg yolk as major nutrient sources were evaluated and compared to a baseline of starvation. No suitable larval food substitute was found for Artemia nauplii. In all tests, Artemia-fed larvae had the best survival and shorter intermolt periods.

Survival to Stage V was related to rearing temperature; survival increased between ambient (50.8%) and 14°C (75.0%) but decreased between 14°C and 18°C (65.0%). Rearing at 18°C may have been close enough to the upper thermal tolerance of P. platyceros to affect survival. Because of limited testing at 18°C, further testing is suggested to confirm decreased survival.

Prawn larval development was accelerated by increasing the rearing temperature from ambient (9°-12°C) to 14°C and 18°C. Metamorphoses to developmental Stage V occurred in 31-42 d at 9°-12°C, 22-28 d at 14°C, and 18 d at 18°C. The developmental time (days) to reach larval Stages I to V was defined with a linear relationship in terms of temperature units.

To improve survival, supplemental exposure to cool-white fluorescent light for 1-3 h/day might be given larvae of P. platyceros and other cultured marine Crustacea. Elevated rearing temperature and supplemental light exposure during the larval stages may improve growth and survival, benefiting future commercial or research rearing programs.

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