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CONTROLLED REARING OF DUNGENESS CRAB LARVAE AND THE INFLUENCE OF ENVIRONMENTAL CONDITIONS ON THEIR SURVIVAL

July 1, 1967 to June 30, 1968

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INTRODUCTION

Culture methods for Dungeness crab larvae and the effects of temperature and salinity on larval survival and growth were covered in previous progress reports (Reed, 1966 and 1967). This report covers studies conducted from July 1, 1967, through June 30, 1968, to determine the effects of various laboratory diets and diet concentrations on survival and growth of Dungeness crab larvae.

MATERIALS AND METHODS

All rearing was conducted in Erlenmeyer flasks placed in a constant temperature bath (11 C, ±0.5 C). Salt water was filtered, treated with ultraviolet light and adjusted to 30°/oo (±0.5°/oo) with distilled water from a glass-lined still. Larvae were exposed to 16 hours of fluorescent light each day. Salt water was changed, larvae were fed and data were recorded three times a week.

Several organisms were cultured and one was ground up for diet study foods (Table 1). Small Utah brine shrimp were hatched by 24 hours at 27 C and were immediately fed to crab larvae held in 11 C water. The lower temperature delayed molting to the larger second nauplius for at least 24 hours. Large Utah brine shrimp nauplii were obtained by hatching eggs in 27 C salt water with salinities above 30°/oo and were cultured for an additional 18 hours at 27 C after hatching to obtain the second nauplius. San Francisco brine shrimp culture was identical to small Utah brine shrimp culture. Barnacle nauplii were collected from gravid adults and held for 24 hours at 11 C and 30°/oo before they were used for food. Mussel larvae were obtained for food by using

Table 1. Size of Dungeness crab larvae and food items used in diet studies

Species	Size range	Average size	Remarks
Dungeness crab (*Cancer magister*) larvae	2.0-2.3 mm	2.1 mm	First zoea, tip of dorsal to tip of rostral spine
Utah brine shrimp (*Artemia salina*) nauplii-large	466-891 u	761 u	Body length
Utah brine shrimp (*Artemia salina*) nauplii-small	421-524 u	479 u	Body length
San Francisco brine shrimp (*Artemia salina*)	365-454 u	405 u	Body length
Barnacle (*Balamus glandula*) nauplii	354-445 u	417 u	Body length
Bay mussel (*Mylilus edulis*) larvae	86-106 u	95 u	Greatest diameter
Prepared diet, ground basket cockles (*Clinocardium nutalli*)	155-354 u	—	Screened for size

0.03 M KCL to induce adults to spawn, gametes were then fertilized and embryos were cultured to the shell stage. Basket cockles were ground up with a blender. Particles that passed through a 354 u screen and were retained by a 155 u screen were fed to crab larvae immediately.

Desired concentrations of food organisms were achieved by counting all organisms in five 2 ml. samples of a culture (Figure 1). Concentrations were volumetrically adjusted to desired levels based on the average of the five samples.

RESULTS

A study of different diet types was undertaken to determine the best food organism (or organisms) for laboratory rearing of Dungeness crab zoea (Figure 2). Crab larvae were fed more food than they could consume between feedings. Food concentrations were uniform on any one day but varied from one feeding to the next. Zoeal concentrations were 15 per 400 mls. of rearing water. Five single organism diets and six combination diets were studied (Figure 3). A control group of unfed zoea was maintained to provide a reference point for the different diets.

All zoea in the control group died by the fourteenth day. A diet of small Utah brine shrimp resulted in 100% survival after 24 days of rearing. Furthermore, any combination diet containing small Utah brine shrimp resulted in good survival (64 to 91%). Large Utah brine shrimp resulted in poorer survival (31%). No other single or combination diet compared favorably with any of the above brine shrimp groups. The fact that zoea fed barnacles did not survive for the duration of the study is perplexing. Previous work with barnacles resulted in 68 to 88% survival through zoeal development (over 80 days at 10 C). The concentration of barnacles was suspected to be lower than that for previous work.

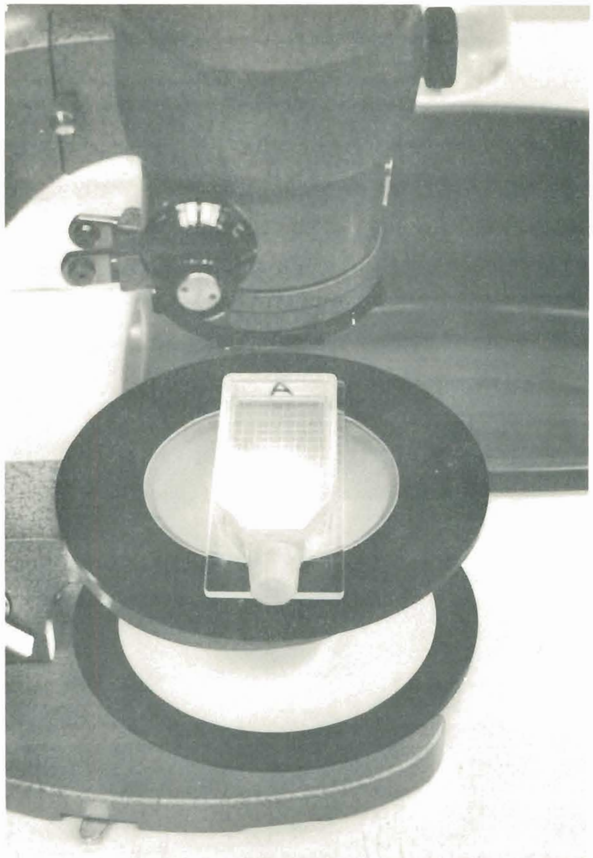

Figure 1. Method of counting food organisms for concentration adjustment.

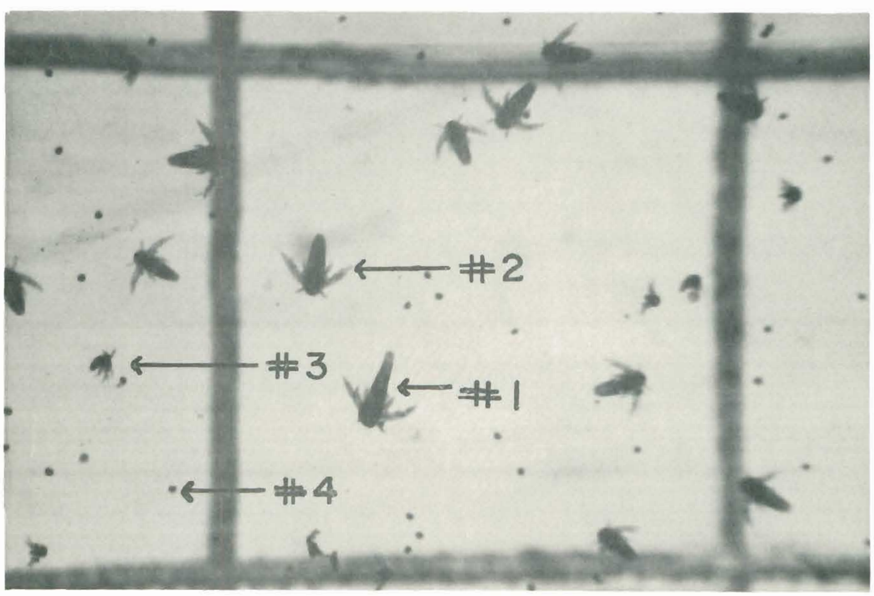

Figure 2. Food organisms used for the diet study. #1- large brine shrimp, #2- small brine shrimp, #3- barnacle nauplii, #4- mussel larvae. The prepared diet was omitted.

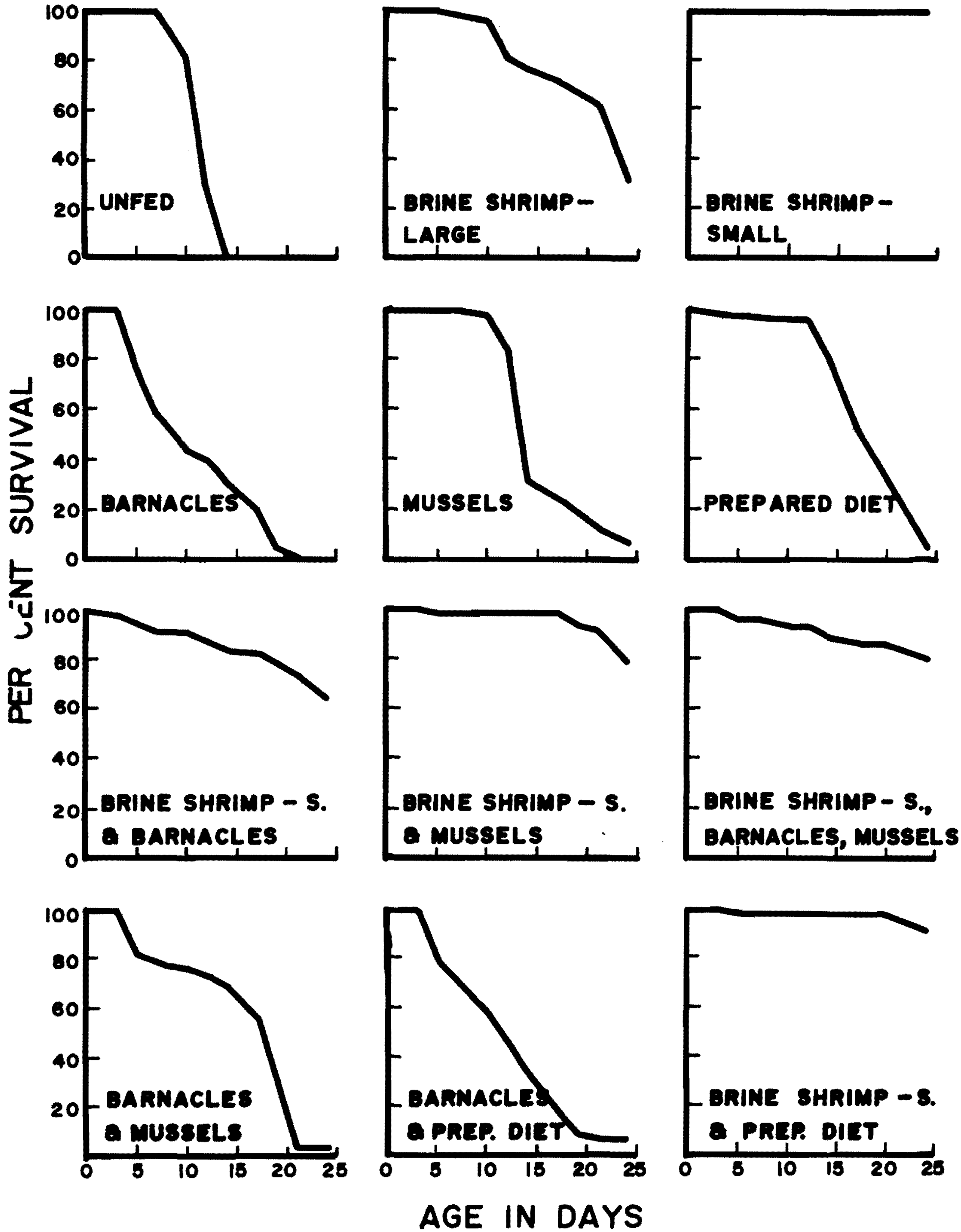

Figure 3. Survival of Dungeness crab zoea fed different diets. (All brine shrimp were of Utah origin.)

A study was conducted to determine the best concentration of brine shrimp to feed Dungeness crab zoea and to define the effects of concentration on survival and growth. Barnacles were not included in the study because gravid adults were not available. Biologists have recently reported inconsistent results for other animals reared with Utah brine shrimp. Therefore, Utah and San Francisco brine shrimp were tested at uniform food concentrations of 1 per ml. of rearing water as food for Dungeness crab zoea (Figure 4). San Francisco brine shrimp were also tested as zoeal food at concentrations of 10 and 20 per ml. An unfed group was maintained as a control for comparison with the diet groups. The zoeal concentration was 5 per 200 mls of rearing water.

All zoea in the control group were dead by the twelfth day. After 38 days of rearing survival of zoea fed San Francisco brine shrimp was better (46%) than survival of zoea fed Utah brine shrimp (7%) with identical food concentrations. The best survival (63%) occurred when zoea were fed San Francisco brine shrimp at a concentration of 10 per ml. Survival at a concentration of 20 per ml. was poor (29%).

Growth was noticeably better for San Francisco than Utah brine shrimp (Figure 4). Molting of second zoea was earlier for zoea fed San Francisco brine shrimp. There was no molting of third zoea fed Utah brine shrimp. The time span of molting for three zoea stages was not much different at various concentrations of the San Francisco brine shrimp diet. However, at a San Francisco brine shrimp concentration of 10 per ml. the preponderance of molting of any stage occurred on a single day.

Twelve days after the inception of the diet concentration study, zoea appeared to have a number of attached objects on their exoskeletons (Figure 4). A detailed examination of an exuvae (molted exoskeleton) disclosed the presence of an ecto-commensal protozoan (Figure 5 and 6). This organism was presumed

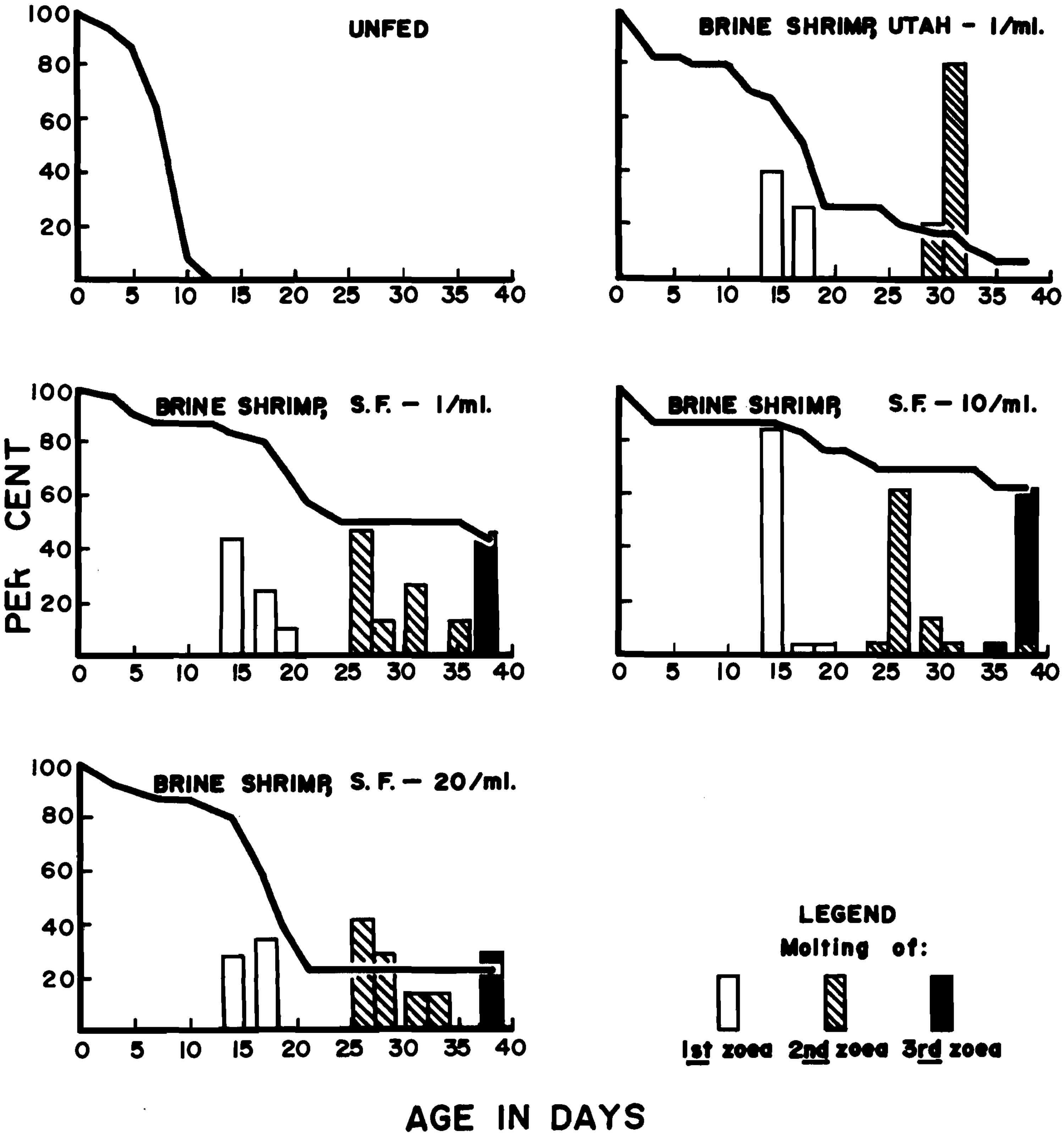

Figure 4. Survival of Dungeness crab zoea (line) and molt of survivors (histogram) at various food concentrations.

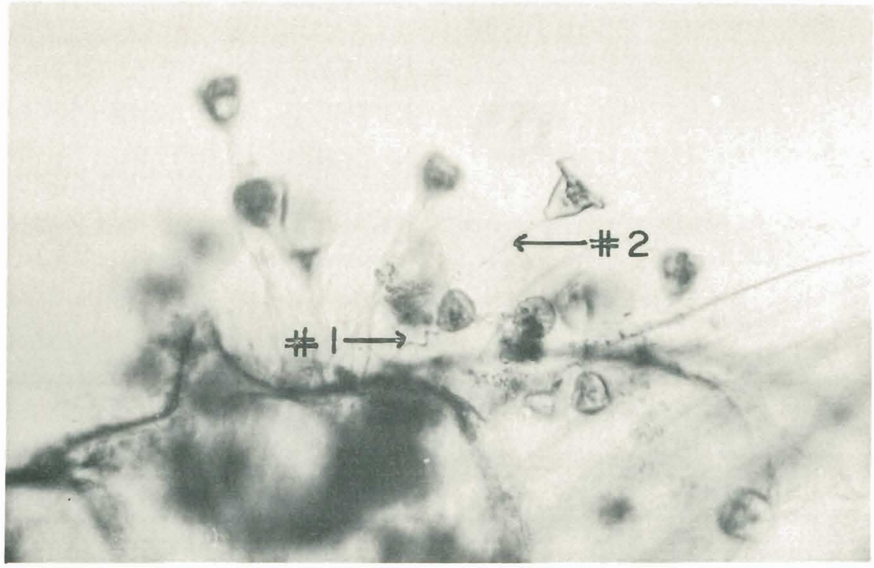

Figure 5. Ecto- commensal Vorticella attached to a crab zoea exuvae. #1- stalk contracted, #2-stalk straight.

Figure 6. Detailed view of Vorticella

to belong to the marine segment of the genera Vorticella based upon possession of a contractile stalk. During the course of the study, 90% of the rearing flasks contained zoea with attached Vorticella. Some mortality was caused by the presence of large numbers of Vorticella on zoea. This nuisance was lost entirely when zoea molting occurred but, in spite of aseptic techniques to eliminate it, generally reappeared before the next molt. The incidence of Vorticella seemed to be lower when most zoeal molting occurred on the same day or within a short time period. Because salt water was filtered and sterilized with ultraviolet light Vorticella was suspected to have originated from the egg mass of the female parent. This is the first time in ten rearing attempts this ecto-commensal has been observed.

DISCUSSION

Criteria for selecting a suitable food organism for Dungeness crab larvae are: high zoea survival potential, uniform zoeal growth potential, ease of handling the food organism, and availability of the food organism. The brine shrimp is well suited as a food organism for Dungeness crab larvae as it meets all of the above requisites. Differences in survival and growth were apparent between San Francisco and Utah shrimp favoring the former organism. This fact and reported inconsistent results with Utah brine shrimp suggest San Francisco brine shrimp are better for rearing Dungeness crab zoea. A food concentration of 10 per ml. resulted in the best zoeal survival and growth.

LITERATURE CITED

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