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ENHANCED SURVIVAL OF LARVAL GRASS SHRIMP IN DILUTE SOLUTIONS OF THE SYNTHETIC POLYMER, POLYETHYLENE OXIDE[1]

Small amounts of linear, high molecular weight synthetic polymers when added to liquids can significantly reduce frictional resistance in turbulent pipe and channel flow (Castro and Squire 1967; Peterson et al. 1974). These drag-reducing agents have potential for improving efficiency of sewer, water, and fire-fighting systems (Castro 1972); reducing friction around ships' hulls (Wade 1973); and perhaps increasing water flow and circulation in mariculture operations (Zielinski et al. in press). Such uses may result in the introduction of relatively large quantities of polymers into nearshore marine and estuarine waters or culture tanks.

We report here experiments to evaluate effects of chronic exposure to polyethylene oxide, a very effective friction-reducing additive, on larvae of estuarine grass shrimp, *Palaemonetes vulgaris* and *P. pugio*. This polymer exhibits a very low

[1]Contribution No. 22 from the South Carolina Marine Resources Center. This work is a result of research sponsored by NOAA Office of Sea Grant, under Grant #NG-33-72.

degree of toxicity and is approved for food contact applications and as an additive to some foods (Smyth et al. 1970). *Palaemonetes* shrimp were chosen for this study because of their importance in estuarine food chains (Hedgpeth 1947; Welsh 1973), the ease with which their larvae may be cultured in the laboratory, the general similarity of their larvae to those of *Macrobrachium* shrimp being evaluated for commercial culture, and the known sensitivity of these carideans to a variety of toxic agents (Lowe et al. 1971; Hansen et al. 1973; Redmann 1973; Sandifer and Shealy 1974[2]).

Methods and Materials

Two experiments were conducted with *P. vulgaris*, one with *P. pugio*. Effects of three polyethylene oxide concentrations (25, 50, and 100 wppm—weight parts per million) were tested versus controls in all experiments. Forty *Palaemonetes vulgaris* larvae were reared at each condition in experiments I (10 replicates of 4 animals each in 10.5-cm finger bowls) and II (4 replicates of 10 animals each in 19.1-cm bowls), while 72 *P. pugio* zoeae (4 replicates of 18 each) were maintained at each concentration in experiment III. The *P. pugio* larvae were isolated in compartments of covered plastic boxes. The culture containers were placed in a Percival Model I-35VL incubator[3] (Percival Manufacturing Co., Boone, Iowa) where temperature was held at approximately 25°C in experiment I and 28°C in the subsequent trials. A 14-h light – 10-h dark schedule was maintained in all studies. All animals were transferred to clean containers with fresh, filtered seawater (30‰ salinity) and fed newly hatched nauplii of *Artemia salina* daily.

Fresh stock solutions (200 wppm) of polyethylene oxide (Polyox Coagulant, molecular weight approximately 5×10^6 [Union Carbide Corp.]) in seawater were prepared every 3 or 4 days. Test solutions were prepared by diluting the stock with appropriate volumes of seawater.

Results and Discussion

Addition of small amounts of polyethylene oxide to the culture water significantly enhanced the survival of grass shrimp larvae in static water culture (Figure 1). The polymer affected neither the number of molts to the postlarval stage nor the size of postlarvae produced. However, a slight but definite trend toward increasing development time with increasing polyethylene oxide concentration was apparent in all experiments (Table 1).

Stranding of larvae above the waterline on the walls of the culture containers was a significant cause of mortality in all control cultures, but addition of ≥25-wppm polyethylene oxide virtually eliminated stranding deaths (Figure 1). This effect was probably the result of the reduced surface tension and increased viscosity, lubricity, and stringiness of the treatment solutions. Of course, this type of effect would not be manifested in

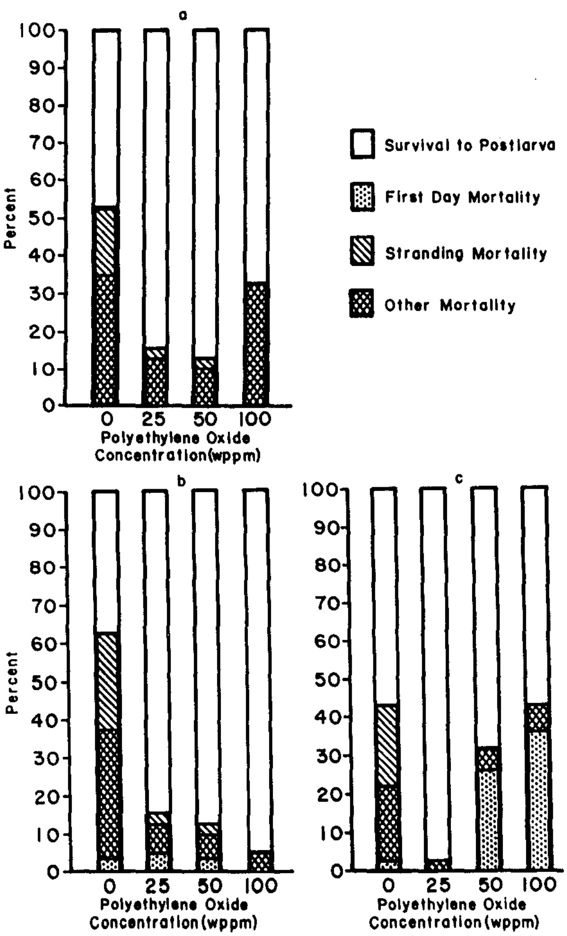

FIGURE 1.—Percentage survival and mortality of *Palaemonetes* larvae reared in polymer and control solutions. (a) *P. vulgaris* experiment I, (b) *P. vulgaris* experiment II, (c) *P. pugio*.

[2]Sandifer, P. A., and M. H. Shealy, Jr. 1974. Some effects of mercury on survival and development of larval grass shrimp, *Palaemonetes vulgaris* (Say). (Unpubl. manuscr.)

[3]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA; NOAA Office of Sea Grant; or the State of South Carolina.

TABLE 1.—Development of *Palaemonetes* larvae exposed to polyethylene oxide solutions (Mean with standard deviation).

Experiment	Species	Polyethylene oxide concentration (wppm) 0	25	50	100
		Development time (days)			
I	*Palaemonetes vulgaris*	19.1 ± 1.5	20.9 ± 2.0	21.3 ± 2.5	22.1 ± 2.8
II	*P. vulgaris*	14.3 ± 0.9	14.6 ± 0.8	14.9 ± 0.9	15.6 ± 1.4
III	*P. pugio*	15.5 ± 1.6	15.5 ± 1.5	16.2 ± 1.4	16.2 ± 2.1
		Molts to postlarva			
III	*P. pugio*	8.0 ± 0.8	8.1 ± 0.9	8.5 ± 0.8	8.3 ± 1.4
		Length of postlarvae (mm)			
II	*P. vulgaris*	6.5 ± 0.6	6.4 ± 0.5	6.4 ± 0.5	6.1 ± 0.5
III	*P. pugio*	6.6 ± 0.6	6.6 ± 0.6	6.6 ± 0.6	6.6 ± 0.5

natural waters, but it may appear in tank culture operations.

First-day mortalities were significant only in the higher treatment concentrations when *P. pugio* larvae were reared in covered plastic boxes (Figure 1c). These deaths apparently were the result of oxygen depletion in the culture water caused by overfeeding and the relatively high biochemical oxygen demand of the polymer solutions (Wade 1973). Other mortalities totaled only 5.6 and 6.9% in the 50- and 100-wppm concentrations, respectively, after the first day.

In all but one instance, larvae in the polymer solutions exhibited a marked reduction in other mortalities (i.e., "natural" deaths) over the controls. Thus, in addition to eliminating stranding, the polyethylene oxide somehow acted to reduce other causes of mortality. The reason for this beneficial effect is unknown, but it is unlikely to be nutritional since, in vertebrates at least, the polymer is poorly absorbed from the gut (Smyth et al. 1970). Further study is needed to examine the reasons for this effect and to evaluate the potential of polyethylene oxide for use in mariculture operations.

Acknowledgments

We thank J. Williams for assistance in the laboratory and E. Myatt for preparing the figure.

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