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On Biology of the Shrimp *Eualus pusiolus* (Krøyer, 1841) (Crustacea, Decapoda) at St. Chad's, Newfoundland

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Abstract

Biology of a population of the shrimp *Eualus pusiolus* was studied from monthly year-round collections by scuba diving at St. Chad's, Bonavista Bay, on the northeast coast of Newfoundland. Lengths of females were larger than in males. Three major modal groups in lengths appeared in males while in females there were four. Females produced about 60–350 eggs according to size. Large ova present in ovaries of most adult females during the winter indicated major spring spawning. Eggs hatched during the summer and none were carried over the winter. About 20% of females produced a second batch of eggs in June and July only, as indicated by large ova in the ovaries of those carrying eyed eggs. Larvae apparently molted to the juvenile stage mostly in September. Indications were that this shrimp lives on a zoophytic calcareous substrate and feeds on small benthic organisms such as foraminiferans, harpacticoid copepods, amphipods, ostracods, polychaetes, sponges and diatoms. About 5% of both males and females were parasitized by the bopyrid, *Hemiarthrus abdominalis*. Other shrimp species present in the collections were *Pandalus montagui* and *Eualus fabricii*.

Key words: biology, bopyrid parasite, *Eualus pusiolus*, fecundity, feeding, Hippolytidae, Newfoundland, *Pandalus montagui*

Introduction

The small shrimp, *Eualus pusiolus*, of the Family Hippolytidae (Chace, 1997), (*sensu stricto* Thoridae, Christofferson, 1987), is found generally in shallow and rocky marine habitats at depths ranging from intertidal to 500 m (Smaldon, 1979) and temperatures ranging from -1.3 to 10.5°C (Williams and Wigley, 1977). In the western Atlantic its distribution is reported from the Straits of Belle Isle, Canada, to Cape Henry, Virginia, USA, and in the eastern Atlantic from Iceland and the Murman coast to the Bay of Biscay (Williams, 1984). This species is also found in the Pacific Ocean where it has been collected at the Priboloff Islands (specimens provided to author through the courtesy of Dr G. C. Jensen, University of Washington at Seattle, USA). It may also be found throughout the northern Pacific, but is not the species found off British Columbia, Canada, referred to by Butler (1980).

Little has been published on the biology of *Eualus pusiolus*. Bull (1939) described its early larval stage, and other larval stages have been described by Pike and Williamson (1961). Occurrences of larval stages at St. Chad's, Newfoundland, have indicated that two broods are produced during the summer (Squires *et al.*, 1997). Biology of other hippolytid shrimps are in papers by Pike (1954), Allen (1962), Ewald (1969) and Oya and Oka (1985).

The objective of the present paper is to present data on sizes of males and females, probable growth rate, maturity, fecundity, stomach contents and parasites of this species from monthly collections carried on throughout the year in St. Chad's, Bonavista Bay, Newfoundland from May 1971 to March 1972.

This study is intended to extend the information base found in other studies on shrimp biology

in the Newfoundland area done by the senior author on *Crangon septemspinosa* in Port au Port Bay and brief reviews on several other species (Squires, 1963, 1966, 1967a and b, 1968a and b, 1990, 1996), by Hadjistephanou (MS 1979) on *Crangon septemspinosa* at Long Pond, Manuels, Conception Bay, by Parsons (MS 1982) on *Pandalus borealis* off Labrador and Parsons *et al*. (MS 1983) on *Pandalus montagui* north of Labrador.

Materials and Methods

About 3 500 specimens of *E. pusiolus* were collected at St. Chad's by monthly sampling at Station 16 (Fig. 1) from May 1971 to March 1972. The collections were by a hand-held suction device ("slurp gun" (Fig. 2)) aimed at shrimp observed about one-third metre from the bottom or around rocks, when SCUBA diving at depths of 5–15 m. The selected bottom area was level with some small boulders and algal coralline encrustations. After each suction the diver surfaced and emptied the contents into a bucket in a small boat accompanying the diver, or into a small net attached to the suction gun. Ovigerous females in addition to those in samples were collected for egg counts during May, July and August only. These female specimens were not from nor included in the regular random

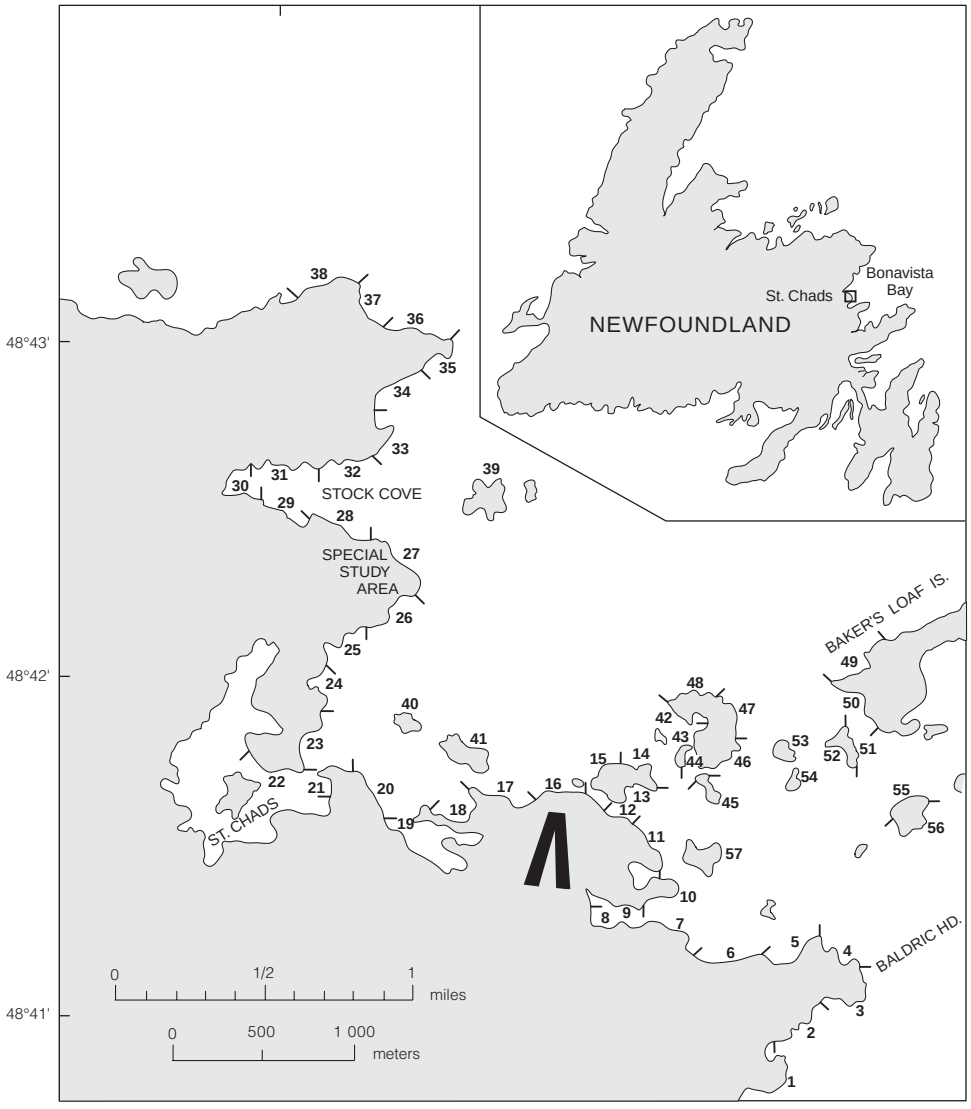

Fig. 1. Map of St. Chad's, Bonavista Bay, Newfoundland, showing Station 16, the sampling site (from Squires *et al*., 1997).

samples of shrimps. During January, February and March the boat was hauled out over the ice at the shore and launched into the sea, but diving was not under the ice, although some ice floes were present. Seawater temperatures at 9 m were recorded throughout the year (Fig. 3). Specimens were preserved in Gilson's fluid.

For detailed laboratory observations, individual specimens were placed in water, and carapace lengths (CL) were measured from ocular notch to end of carapace in midline over a millimeter grid while examined by a dissecting microscope at about 40X magnification. Total lengths were measured from the tip of the rostrum to the tip of the telson. Stomach contents were emptied into a drop of water on a glass slide and examined under cover slip at 100X or 430X magnification. All eggs on ovigerous females were counted. Egg development, and condition of ova in ovaries of females and of testes in males, were recorded.

Results

Size and growth

As in many other caridean shrimps (Allen, 1961), males were appreciably smaller than females: the ranges of CL were 1.5–2.8 mm and 1.5–4.2 mm, respectively. Males were slightly bigger at the same carapace length as shown by trendlines and regression equations of total length *versus* carapace length (Fig. 4). Juveniles were 1.0–1.4 mm in CL, recognized by 1 or 2 rostral spines only and lack of development of the appendix masculina (absent or just a bud) in males. Only a few juveniles were present from June to July and none in August (Fig. 5), but in September they were well-represented in numbers, and exceeded the others during October to March. Molting past the juvenile stage was evident in the November and December length frequencies, but little change was indicated during the cold winter months of January to March.

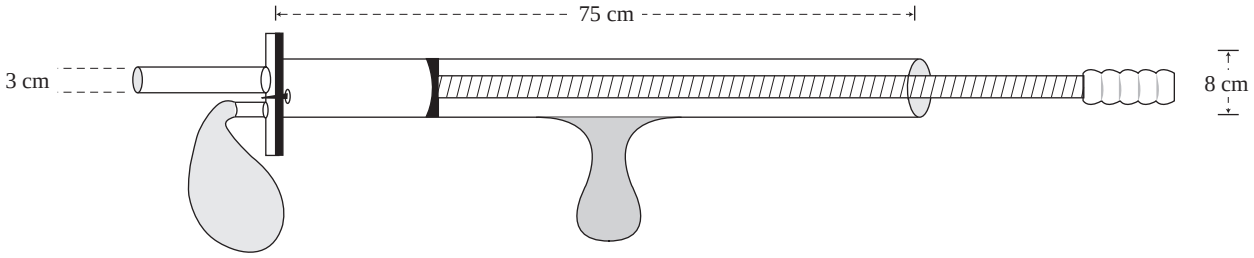

Fig. 2. Diagram of hand-held suction device ("Slurp gun") used to collect specimens when Scuba diving at St. Chad's, Newfoundland (Length of barrel 75 cm., diameter 8 cm.; diameter of nozzle, 3 cm.; made of clear plastic).

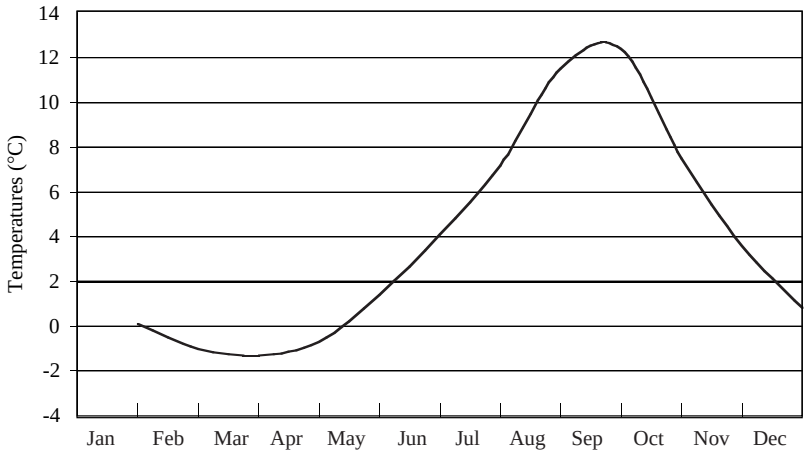

Fig. 3. Average annual temperatures (°C) of seawater at 9 m at St. Chad's, Newfoundland (modified from Ennis *et al.*, 1989).

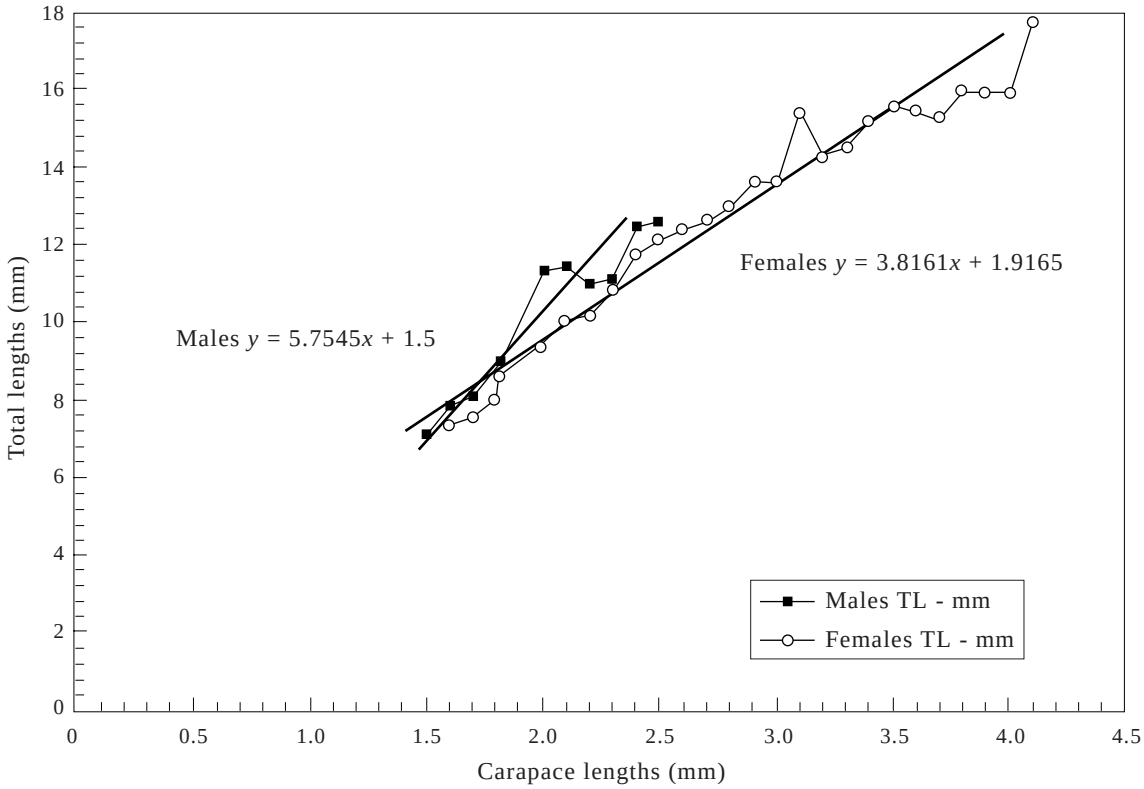

Fig. 4. Total length at each carapace length (mm) of male and female *Eualus pusiolus* at St. Chad's, Newfoundland.

Monthly modal groups of males were around 1.5, 2.0 and 2.3 mm CL or spaced over about 0.8 mm with an average increment of about 0.4 mm. In females the modes were around 2.0, 2.5, 3.0 and 3.5 mm CL, or at an average increment of 0.5 mm. (Fig. 5). Month to month modal shifts were not evident.

Larvae of *E. pusiolus* in this area reached Megalopa Stage in August (Squires *et al.*, 1997) but none were taken in the present collections. In September in the present collections they had apparently molted to the Juvenile Stage which would be to the 0 Group for the year. The few juveniles collected during May–July could be remnants of the over-wintering juveniles most of which would have molted into the smaller males and females.

The 1 Group in both males and females would likely be in the 1.5–2.0 mm CL range and possibly the 2 Group would be 2.0–2.5 mm CL. In females a further modal group appeared in the 2.8 to 4.0 mm range (Fig. 5). According to these premises, the males could reach 2 years of age, and females possibly 3 years. In another hippolytid, *Spirontocaris lilljeborgi*, at the Clyde area, Scotland, females appeared to grow faster than males and to live two to three years, at least six months longer than males (Pike, 1954). Also in *E. sinensis*, in Japan, the females generally grew faster than males (Oya and Oka, 1985) but both sexes left the collection area before their further growth could be determined.

Maturity

Males were first mature at 1.7 mm CL. After maturity male testes remained large irrespective of season.

Females were first ovigerous at 2.3 mm CL, while non-ovigerous females with large ova were at a minimum size of 1.9 mm CL. Only 21% of the females bearing eggs (total 64 specimens) had large ova in the ovaries during June and July (Fig. 6). This indicated that a small proportion of females would produce a second batch of eggs after the first batch of eggs they carried (which showed late embryonic development) had hatched out. There has been similar conditions in other hippolytids as noted

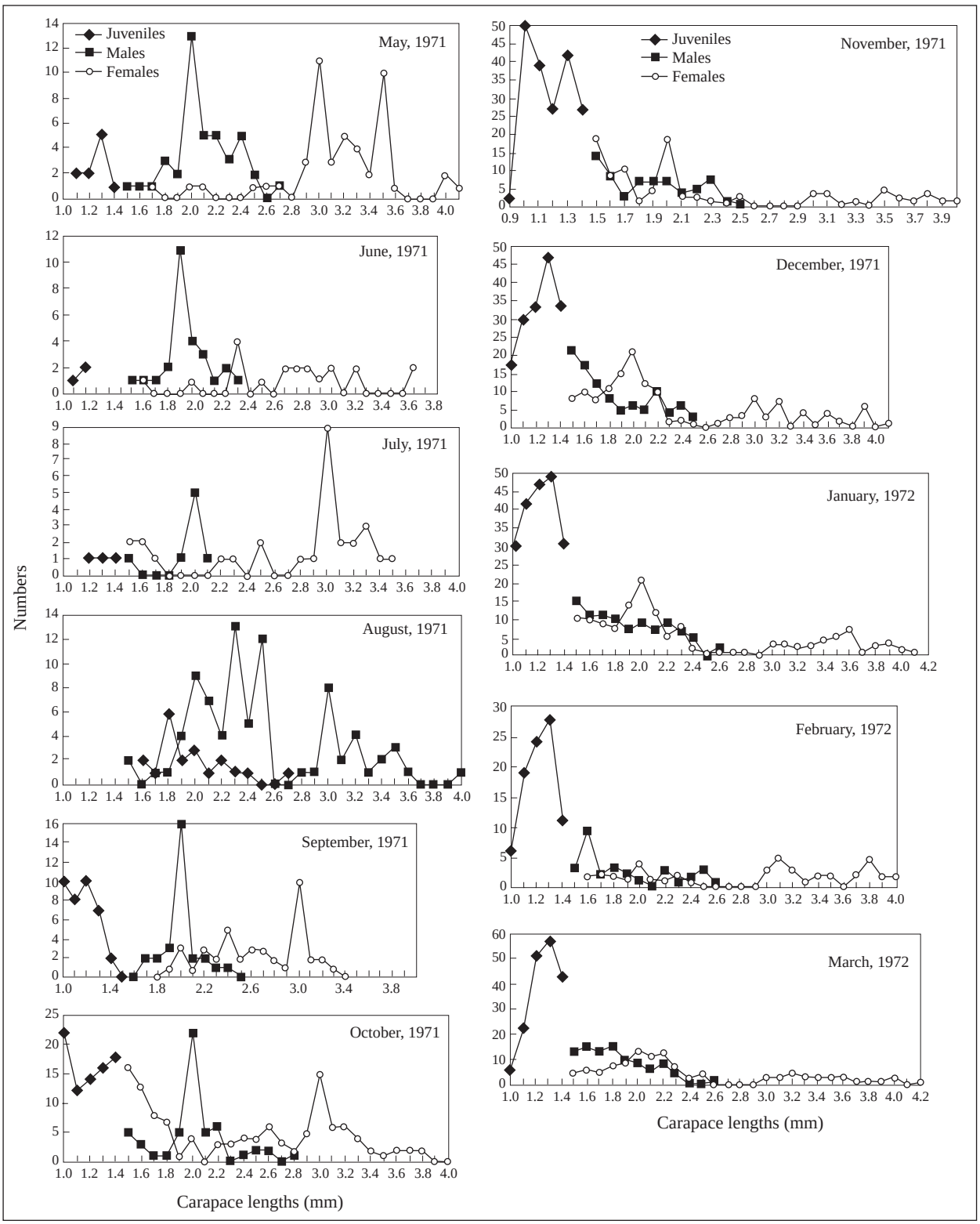

Fig. 5. Length frequencies observed from the selectively collected samples of *Eualus pusiolus* at each month from May 1971 to March 1972, at St. Chad's, Newfoundland.

by Allen (1960, 1961) from studies in Britain, Oya and Oka (1985) from Japan, and as suggested by Squires *et al*. (1997) from occurrences of larvae of *Eualus pusiolus* and of *Crangon septemspinosa* at St. Chad's, the same area as the present study.

About 76% of non-ovigerous females (total 48 specimens) had large ova in May, indicating that the eggs would apparently be extruded in early summer. In the summer months from June to October about 88% of the non-ovigerous adult female shrimps had small ova (Table 1). However, during the winter months from November to March 64% of the non-ovigerous females had large ova (Fig. 6), indicating that a major spawning would occur in the spring or early summer. Apparently eggs were not carried over the winter.

Fecundity

About 60 egg-bearing females were examined for an indication of fecundity by counting the numbers of eggs they carried with the numbers generally showing a size related pattern. The range of egg numbers was 60 at 2.2 mm CL to 426 at 4.0 mm CL (Fig. 7). A regression equation was fitted where y = the number of eggs and x = CL in mm, and the relationships noted were as follows:

polynomial $y = 70.348e^{0.0895x}$

and logarithmic $y = 97.571\text{Ln}(x) - 6.9185$

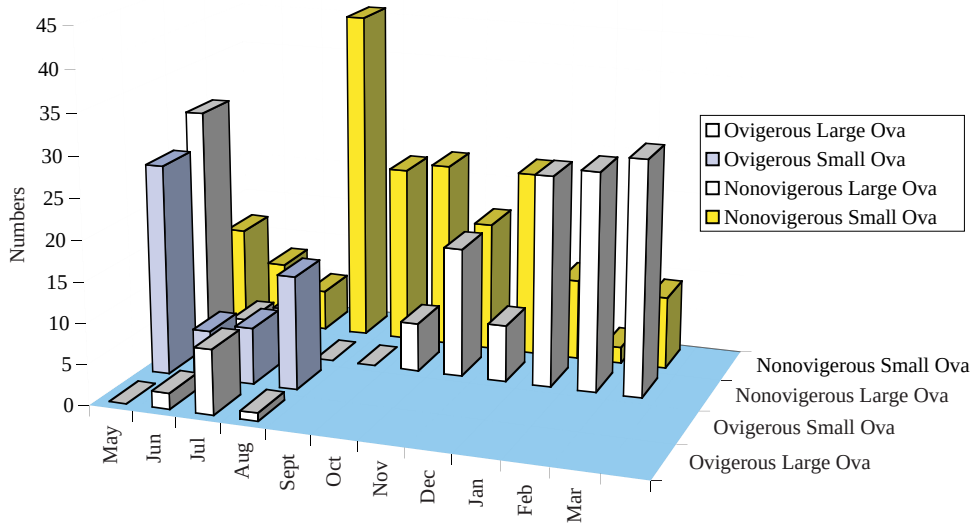

Fig. 6. Maturity of female *Eualus pusiolus* in monthly samples from May 1971 to March 1972 at St. Chad's, Newfoundland.

TABLE 1. Percentage of adult female non-ovigerous *Eualus pusiolus* shrimps with small ova during May, 1971–March, 1972, at St. Chad's, Newfoundland.

Month	Females with small ova (%)	No. of female specimens
May	24	48
Jun, Jul	91	43
Aug–Oct	86	194
Nov–Mar	36	385

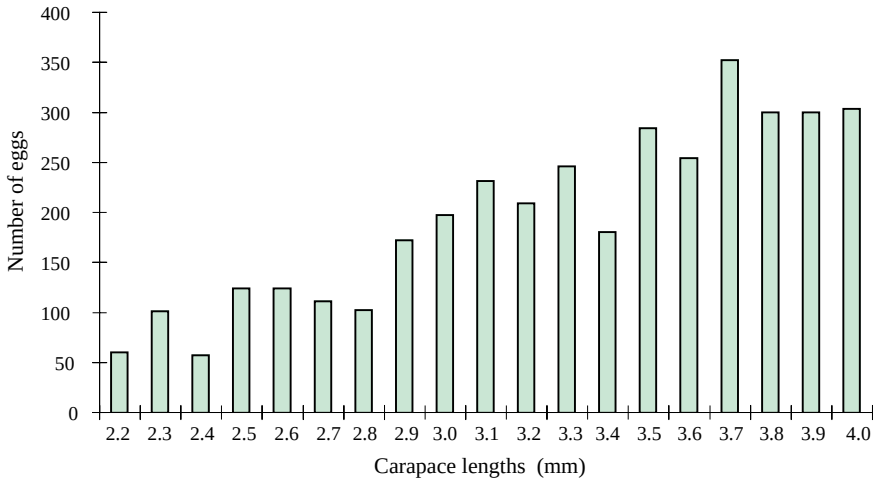

Fig. 7. Average number of eggs carried by female *Eualus pusiolus* at St. Chad's, Newfoundland. Counts from 55 specimens.

Stomach Contents

Stomachs of 1 252 specimens of *E. pusiolus* were examined. Major components were crustacean fragments, foraminiferans, filamentous algae, pennate and centric diatoms, ostracods (*Cypridina* type), harpacticoid copepods (*Tegastes* type), sponge spicules and polychetes (Fig. 8). Length or diameter ranges of some of these components were as follows: foraminiferans, 0.3–0.6 mm; harpacticoid copepods, 0.2–0.7 mm; ostracods, 0.5–0.7 mm; tardigrades, 0.2 mm; amphipods, 0.7 mm; and bivalves 0.4 mm. Feeding differences by size or sex of the shrimps were not evident.

Pieces of the calcareous substrate found in the samples had on them small hydroids, filamentous algae, harpacticoid copepods, amphipods, foraminiferans, ostracods, tardigrades, small polychaetes, diatoms, small brittle stars and small sponges. Apparently foraging on a zoophytic substrate by this species is similar to what other caridean shrimps do in Britain (Allen, 1966). Minute sand grains in stomachs were not always recorded but were almost always present, and in most there were some amorphous partly digested material. Minute spicules, apparently of sponges, were prevalent in the specimens (larger or branched spicules and wheel-like or other structures as in sponges were observed). Sponge spicules were calcareous for the most part, as was confirmed by their disappearance when treated with a mild acid. Only the largest of females showed signs of predation on other shrimp. Fewer crustacean fragments were present during the winter months.

Parasitization

Both male and female *Eualus pusiolus* were parasitized by the bopyrid, *Hemiarthrus abdominalis* (Fig. 9). Of the 558 adult males examined 4%, and of the 1 015 adult females examined 6% infestation occurred. This represented much less infestation than in *Spirontocaris lilljeborgi* in Britain (10–15%: Allen, 1962). The length of the female parasite was slightly greater than the length of its host (the parasite length range was 2.5–4.2 mm on females of CL 2.5–3.8 mm), and they

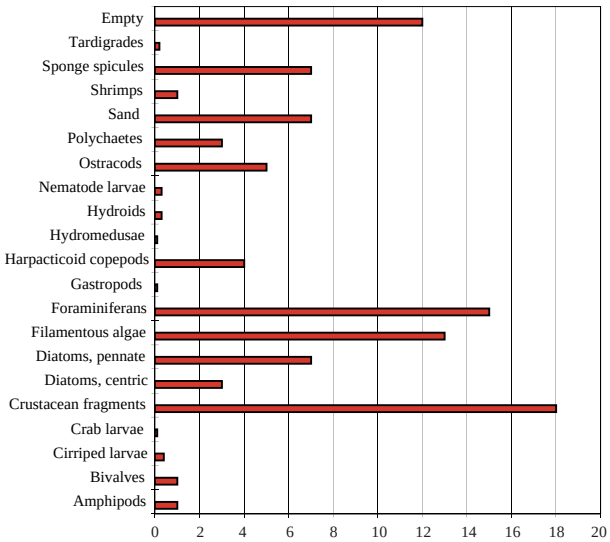

Fig. 8. Stomach contents of *Eualus pusiolus* collected at St. Chad's, Newfoundland. Percentage of 1 252 examined.

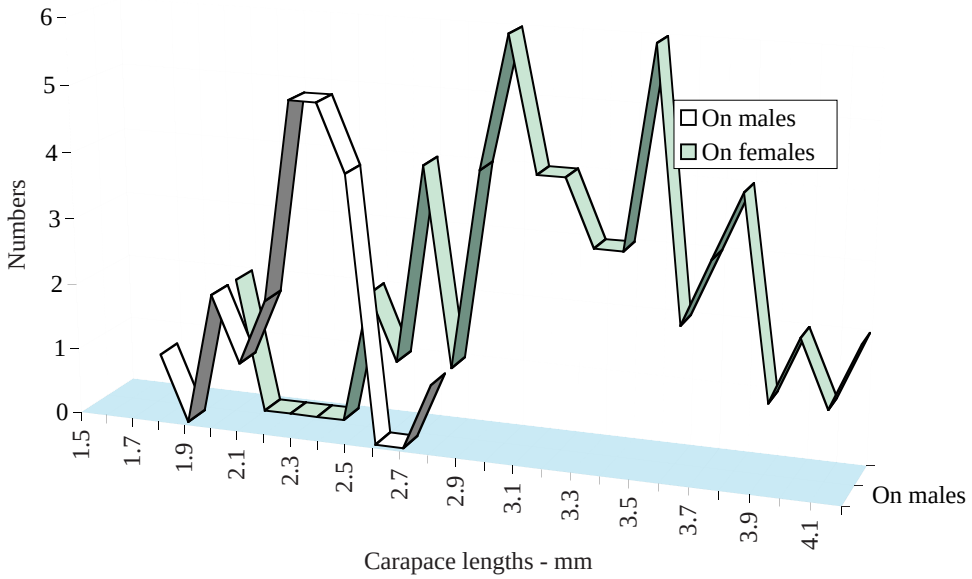

Fig. 9. Numbers of male and female *Eualus pusiolus* parasitized by the bopyrid *Hemiarthrus ab-dominalis* at St. Chad's, Newfoundland. Numbers examined: 558 males, 1 015 females.

were almost as wide as the host when they were full of eggs (eggs in January were 0.2 mm in diameter). Almost all female parasites had a small male (1.5–1.8 mm) attached. It has been reported that in smaller hosts some male parasites become attached and develop into females (Pike, 1960). The point of attachment by the female parasite was not distinct: it seemed to be enwrapped by the pleopods of the host and would easily fall out or be easily removed.

Sample numbers

The numbers in samples of *E. pusiolus* were much larger late in the season, reaching 756 in November and always more than 100 except in June and July (42 and 27). Apparently smaller specimens of *E. pusiolus* were more easily captured than the larger ones by the method used. Also it is possible that some of the larger ones had migrated into deeper water, as is characteristic of other members of this family (Allen, 1966).

Associated shrimp species

Pandalus montagui and *Eualus fabricii* were collected from the same niche occupied by *Eualus pusiolus*. *Eualus fabricii*, a species slightly larger than *E. pusiolus*, was in small numbers: only 8 and 3 in May and June, respectively. *Pandalus montagui* occurred in all months from May 1971 to January 1972, and most were collected in September 1971 with numbers decreasing as winter approached: numbers in each month were 17, 14, 15, 24, 38, 18, 4, 3 and 1, respectively.

All *P. montagui* were juvenile males, 3–9 mm in CL. Stomach contents were similar to those of *E. pusiolus*. Biology of this species has been described by Mistikidis (1957), Allen (1963), Couture and Trudel (1969a and b), Parsons *et al.* (MS 1983) and summarized by Simpson *et al.* (1970).

The biology of *Eualus fabricii* has been briefly described by Squires (1957, 1962, 1967a and b, 1968a and b, 1969 and 1996). It is a colder water species extending farther in distribution into the Arctic than *E. pusiolus* which is not found north of the Straits of Belle Isle in the western Atlantic.

Discussion

Eualus pusiolus is the smallest shrimp found in the Newfoundland area and will not likely become commercially exploited, although it could be used as bait for small fish such as trout. It is apparently a prey species for cod and other fishes (a specimen was obtained from the stomach of cod on the Grand Banks (Squires, 1996)).

The niche occupied by this species at St. Chad's in Bonavista Bay could possibly be repeated in other areas along the Newfoundland coast except perhaps in the area from Pistolet Bay to White Bay, where water temperatures are appreciably lower than in other parts of the area, but investigation would be necessary to confirm this.

Since only one limited inshore area was sampled from during the eleven months of the years 1971 and 1972, the extent of the population over the larger area of Bonavista Bay is not known. The presence of the species at St. Chad's throughout the year, however, indicates that there is little migration. The smaller sizes of the species predominated in the samples, especially during the winter months. This may reflect the observation that some of the larger shrimps may move into deeper water (cf. Allen, 1966).

Apparently egg extrusion occurred early in spring, and larvae were hatched in early summer when at least some females produced a second batch of eggs. The larvae are planktonic (see Squires *et al*., 1997) and apparently considerable numbers molted into the Juvenile Stage in September. No larval stages were among the present collections, relating to the sampling method which did not target plankton. The first evidence of molting past the Juvenile Stage was observed in the length frequencies for October–December (Fig. 5). The subsequent low temperatures of winter (below 0°C in January-March as shown in Fig. 3), seemed to inhibit further molting.

Although only two species of shrimps, *P. montagui* and *E. fabricii*, were collected with *E. pusiolus*, larvae of these and other decapods indicate that *Pandalus borealis, Crangon septemspinosa* and *Caridion gordoni* as well as the crab species *Cancer irroratus, Chionoecetes opilio, Hyas araneus,* and *H. coarctatus,* and the hermit crabs, *Pagurus arcuatus* and *P. acadianus* may also be present in the area (Squires *et al*., 1997), although not collected from the same substrate or by the method used.

Acknowledgments

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