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On Biology of Two Sympatric Species of Hermit Crab (Crustacea, Decapoda, Paguridae) at St. Chads, Newfoundland

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Abstract

Two sympatric species of Hermit Crab, *Pagurus acadianus* and *P. arcuatus*, from the sublittoral near St. Chads, Newfoundland, have many similarities in their life history. These are expressed in their feeding, maturities of females (both species hatching eggs in early spring, extruding eggs in late autumn and carrying eggs through the winter), finding shells plentiful at small sizes but scarce at large sizes, and availability at a sublittoral station throughout the year. Differences seen were low rate of parasitization with *Peltogaster paguri* in *P. acadianus*: only one in almost five hundred specimens, while there were about 18% in *P. arcuatus*; and in the former slightly higher fecundity, longer period of male maturity, somewhat larger size, and, as shown earlier, lower frequency in plankton from the area. Percent of ectocommensal protozoans on gills was low in *P. acadianus* but high in *P. arcuatus*, while those on setae of maxillule were high in both species.

Key words: Crustacea, ectocommensal protozoa, fecundity, feeding, hermit crabs, maturity, Newfoundland, *Pagurus acadianus*, *P. arcuatus*, *Peltogaster* parasite

Introduction

While hermit crabs are not likely to be of commercial importance like snow crabs, lobsters and shrimps in Newfoundland waters, they belong to the same group of crustaceans, and they contribute appreciably to the mass of planktonic organisms in coastal waters that help to feed the young of these commercial species.

Like many other invertebrate coastal species in the Newfoundland area they produce a lot of eggs each summer and, when these hatch, the larvae spend several weeks in the plankton where they are preyed on by many other species (Squires *et al*, 1997). Hermit crabs are benthic and live close to a primary level of feeding, making use of minute algae and other organisms on rocks, sand and mud on the bottom mostly in shallow areas. The two species studied in this paper are *Pagurus acadianus* Benedict, 1901, and *P. arcuatus* Squires, 1964, anomuran decapods of the Family Paguridae (McLaughlin, 1974). They are both found only in the Northwest Atlantic and not much farther north than the Straits of Belle Isle in our records, although the northerly range of *P. arcuatus* is said to be Greenland (Williams, 1984). Both species extend as far south as Virginia, USA. There is only one other species of hermit crab in this general area, *P. pubescens* Krøyer, 1848, but it is found in deeper water here and also found in the Arctic and in Greenland and northern Europe (Squires, 1990, 1993). However it is reported as a sympatric species with *P. acadianus* from the sublittoral of Maine, USA (Grant and Ulmer, 1974).

Work on the biology and ecology of hermit crabs mainly in Europe and the Americas has been extensively reviewed by Elwood and Neil (1992). Hermit crab biology in the Northwest Atlantic area has been mentioned briefly by Squires (1957, 1962, 1963, 1967 and 1990).

The present paper deals with a sublittoral collection of hermit crabs from St. Chads, Newfoundland, taken monthly by scuba diving. They were included in collections of benthiic decapod crustaceans during a study of larvae of lobster (*Homarus americanus)* and other decapod larvae in coastal plankton. Data on both species include sizes of males and females, their use of gastropod shells, monthly maturity, fecundity, stomach contents, and parasitization. These allow for comparisons between the two species. Decapod crustacean species in plankton from the area are noted in Squires (1996) and Squires *et al.*, (1997).

Materials and Methods

A total of about 1 500 specimens of hermit crabs was collected by hand in mostly one sampling period each month from April 1971 to March 1972, by scuba diving at St. Chads, northeastern Newfoundland (Fig. 1), at 4 sites near shore about 10 m deep. Some details of collecting and annual seawater temperatures at the site are noted in Squires *et al.* (2000).

The samples of hermit crabs in their shells were preserved in 7% formalin in seawater. They were later removed from their shells and measured and maturities assessed. During this process the eggs carried by females were first removed and preserved in Gilson's fluid. Later the clutches of eggs were dried to constant weight and put in vials. Some of these were weighed with a precision balance and the egg numbers calculated from calibrating counts. However the numbers of eggs in most clutches were later given actual counts for this paper.

Counting the eggs was done by pouring the hardened eggs from a vial into a petri dish that had been coated peripherally with a thin ribbon of vegetable oil. Some eggs attached to remnants of pleopods were removed with needle probes in the oil. Eggs were then counted under magnification with a dissecting microscope, moving them into groups of 100 eggs in the oil, the hundreds recorded as counted on a calculator and the number less than one hundred added at the end.

The gastropod shells the hermit crabs were extracted from were kept separate for each month's sample and species, and the greatest height of each measured with vernier calipers to nearest 1.0 mm, estimating full height where spires were encrusted or eroded.

The length of the anterior shield (including short rostrum) of the carapace of each hermit crab was measured with vernier calipers under low power of dissecting microscope to the nearest 0.5 mm.

For maturity of each female, ova (from ovaries at posterior abdomen) were measured to nearest 0.1 mm on a stage millimeter grid under low power (about 40X). Small ova were 0.1–0.2 mm and large ova 0.3–0.4 mm in diameter. Eggs on pleopods were designated as eyed or not eyed according to embryonic development. Eggs were 0.5–0.6 mm in diameter. Male maturity was estimated from appearance of spermatophores in the vasa deferentia dissected out at the anterior abdomen dorsally.

Stomach contents were spread in water on a glass slide, covered with cover slip and examined at 100X and/or 420X power of a light microscope to recognize ingested organisms from fragments or the whole organism.

Drawings of each separate species of microscopic filamentous algae were made to estimate the number of species.

All specimens of both species were examined later for incidence of protozoan ectocommensals on gills and tips of setae of the coxal endite of the maxillule.

Results

Shield lengths

As in general with hermit crabs, in both species the males reached a greater length than the females (Fig. 2 and 3), while the females were in greater numbers at small sizes in all samples. There were no apparent seasonal differences in lengths, although many small females were collected in autumn and winter in both species. Two major modal groups were apparent only in males (5 and 8 mm in *P. arcuatus*) and more clearly in *P. acadianus* (6 and 9 mm) than in *P. arcuatus*. Sizes were quite similar in both species, but some *P. acadianus* reached a greater length than *P. arcuatus* (Fig. 2 and 3).

Gastropod Shells

Shells used by the two species of hermit crab included *Buccinum undatum, Littorina littorea* and *Thais (Nucella) lapillus*. There was an overlap in size of these shells but *Buccinum* was the largest and *Thais* almost the same size as *Littorina* (Fig. 4 and 5). The

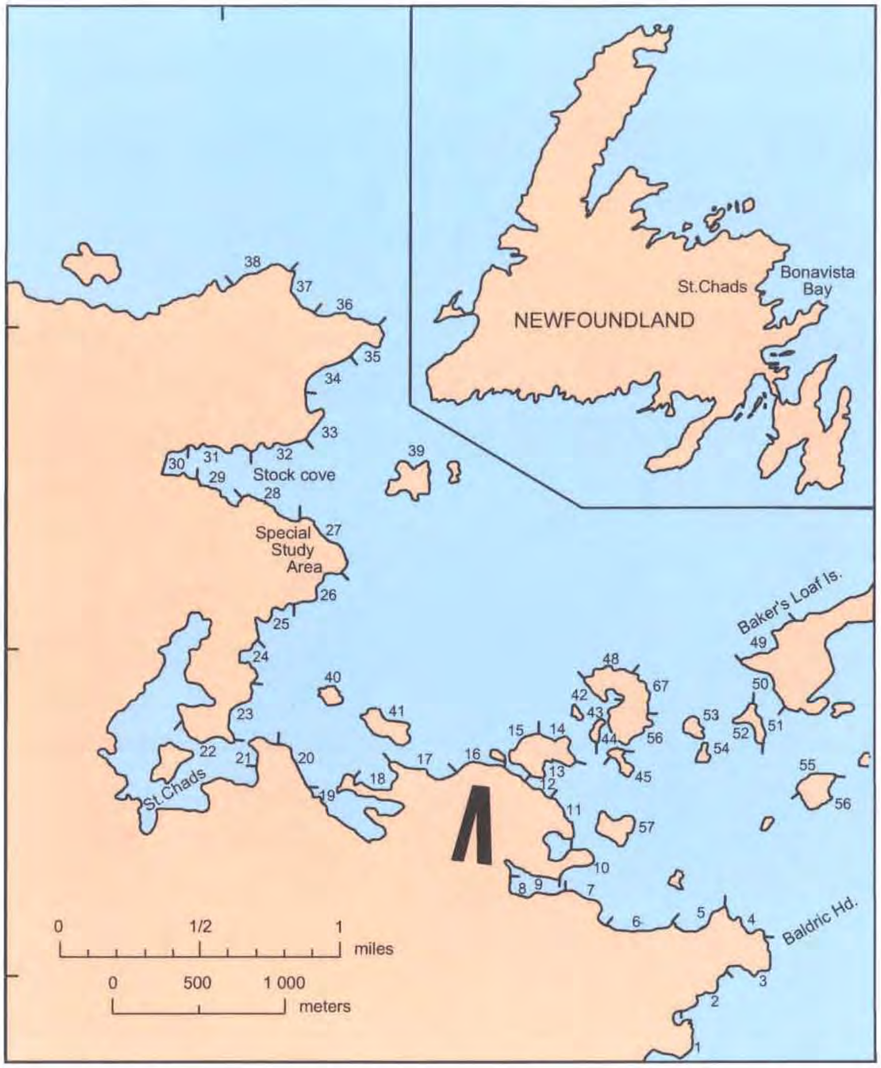

Fig. 1. Map of St. Chads, Bonavista Bay, Newfoundland showing area of sampling of hermit crabs, *Pagurus acadianus* and *P. arcuatus*, (from Squires *et al*, 1997).

shells collected with the hermit crabs were apparently very old, and may have been used over many years by succeeding generations of hermit crabs. Where size of hermit crabs is aligned with size of shells, the small shells seem to be in sufficient numbers for the small hermits but large shells appear to be mostly in short supply for the larger ones (Fig. 6 and 7).

Heights of shells from *P. acadianus* were as follows: *Thais* mode 26 mm, range 18–32 mm (112 specimens); *Littorina* mode 26 mm, range 16–36 mm (148 specimens); and *Buccinum* mode 56 mm, range 32–74 mm (314 specimens) (Fig. 4).

Heights of shells from *P. arcuatus*, were as follows: *Thais* mode 24 mm, range 16–32 mm (402 specimens), *Littorina* mode 24 mm, range 16–40 mm (240 specimens); and *Buccinum* mode 52 mm, range 22–66 mm (140 specimens) (Fig. 5).

Maturity

The seasonal pattern of maturity of females was similar in both species (Fig. 8 and 9). The spring samples had eggs that were eyed mostly, and the ova in the ovaries were small (0.1–0.2 mm) except for a few individuals with large ova (0.3–0.4 mm). The latter would probably produce a second batch of eggs after

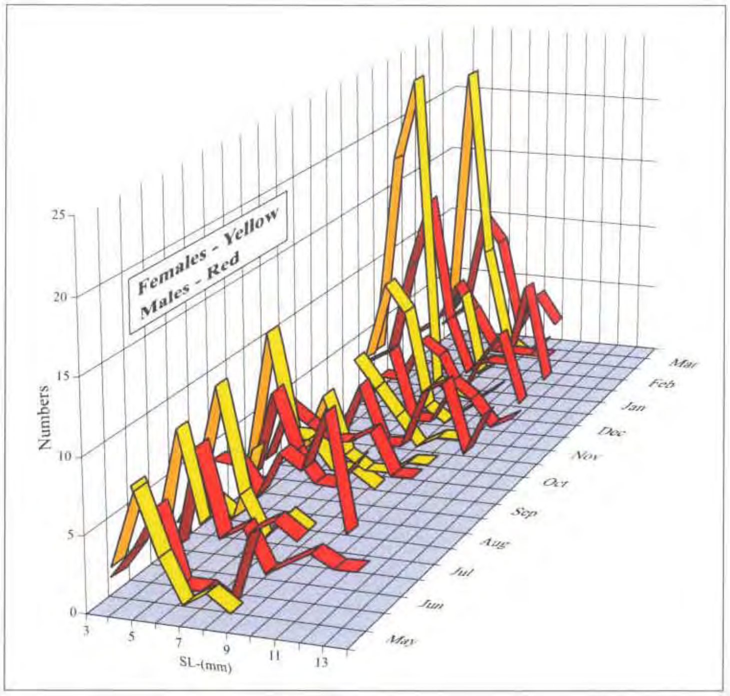

Fig. 2. Shield lengths of female and male *P. acadianus* at each month sampled from May 1971, to March 1972, at St. Chads, Newfoundland.

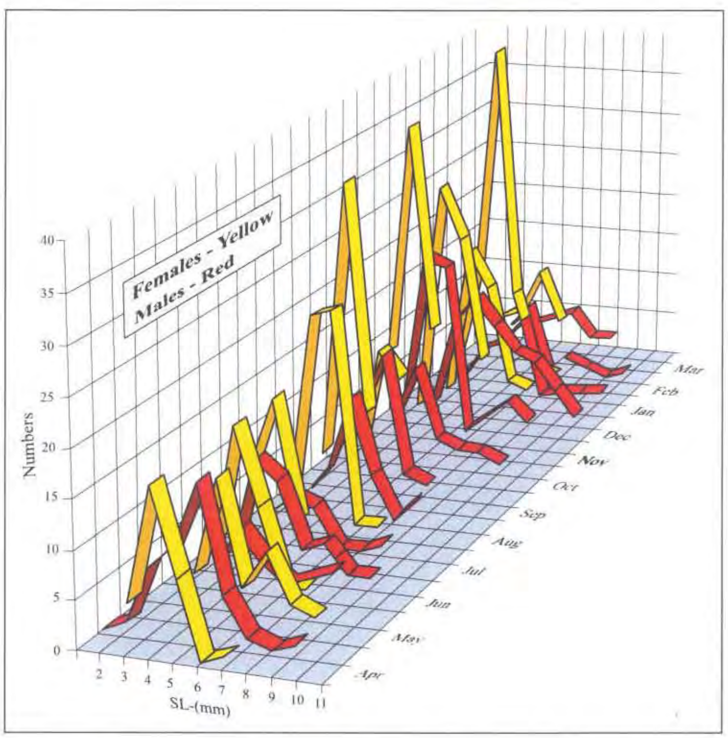

Fig. 3. Shield lengths of female and male *P. arcuatus* at each month sampled from April 1971 to March 1972 at St. Chads, Newfoundland.

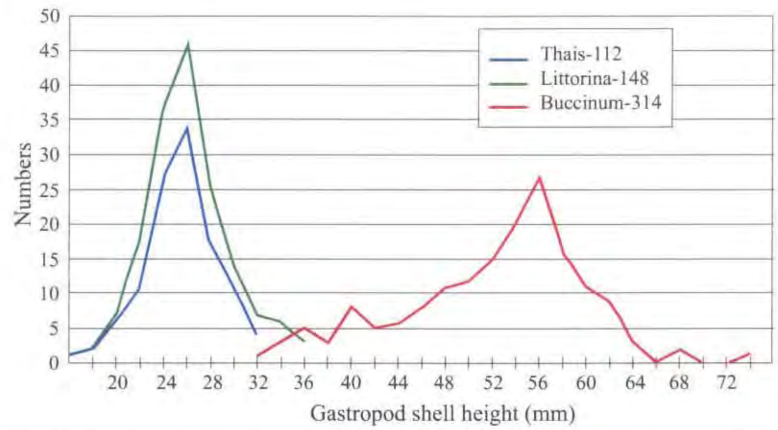

Fig. 4. Heights of gastropod shells *Thais, Littorina* and *Buccinum* occupied by *P. acadianus* from samples collected at St. Chads, Newfoundland, in 1971–72.

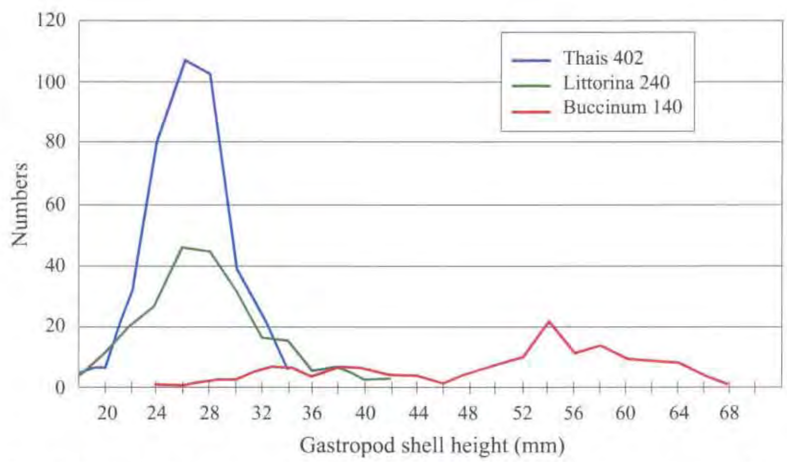

Fig. 5. Heights of gastropod shells *Thais, Littorina* and *Buccinum* occupied by *P. arcuatus* from samples collected at St. Chads, Newfoundland, in 1971–72.

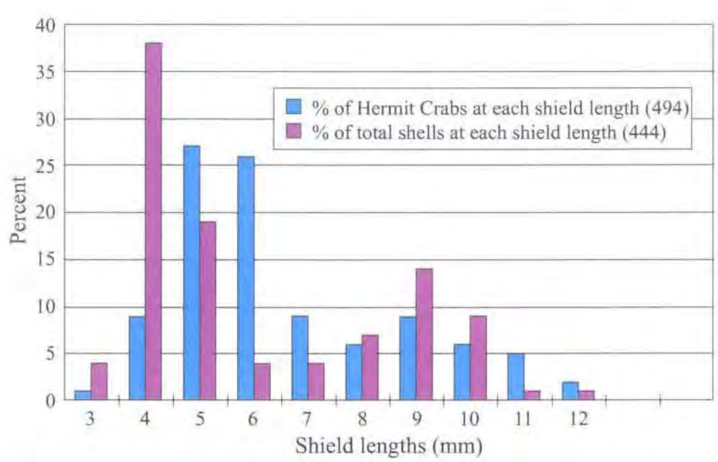

Fig. 6. Percent of gastropod shells at shield lengths of *P. acadianus* collected at St. Chads, Newfoundland.

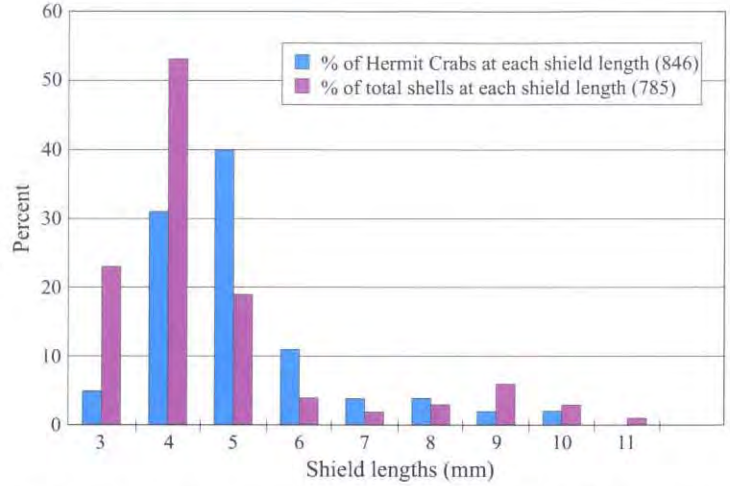

Fig. 7. Percent of gastropod shells at shield lengths of *P. arcuatus* collected at St. Chads, Newfoundland.

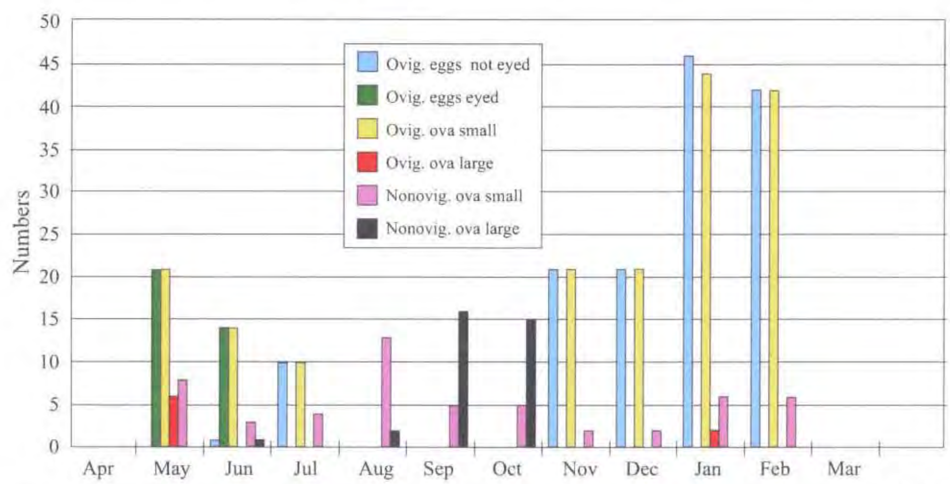

Fig. 8. Monthly maturity of female *P. acadianus* (N = 218) from April 1971 to March 1972, collected at St. Chads, Newfoundland.

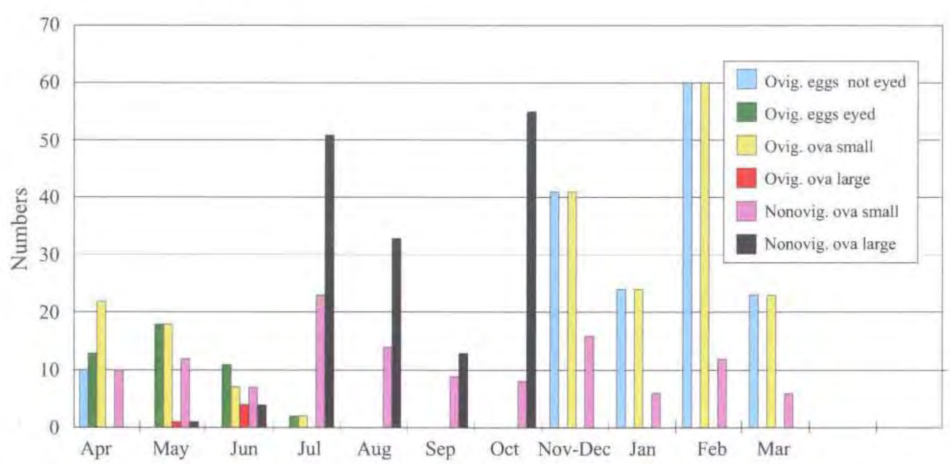

Fig. 9. Monthly maturity of female *P. arcuatus* (N = 453) from April 1971 to March 1972, collected at St. Chads, Newfoundland.

the ones carried had hatched. During the summer months (July and August) the eggs hatched, and ova were small. With the approach of autumn (August to October) numbers with small ova decreased while those with large ova increased and eggs were extruded in November. Most females carried eggs through the winter with no sign of embryonic development until early spring (April). Females were first mature at 3 mm shield length in *P. arcuatus* and 4 mm in *P. acadianus* (no specimens taken at less than 4 mm in the latter).

Male maturity was different in the two species. In *P. acadianus* males had a high percentage mature (the vasa deferentia full of ripe spermatophores) throughout the year (Fig. 10). In *P. arcuatus* the percentage mature was greater during April to October than later in the year (Fig. 11). In both species males were first mature at 4 mm shield length. Specimens at 2 and 3 mm were immature in *P. arcuatus*.

Fecundity

P. acadianus appeared to produce more eggs than *P. arcuatus* (Fig. 12). Average numbers of eggs per hermit crab in the former were about 2 500 at an average shield length of 6 mm, while in the latter the average was about 1 500 eggs.

Greatest numbers of eggs at a shield length of about 9 mm was about 14 000 in the former and 8 000 in the latter.

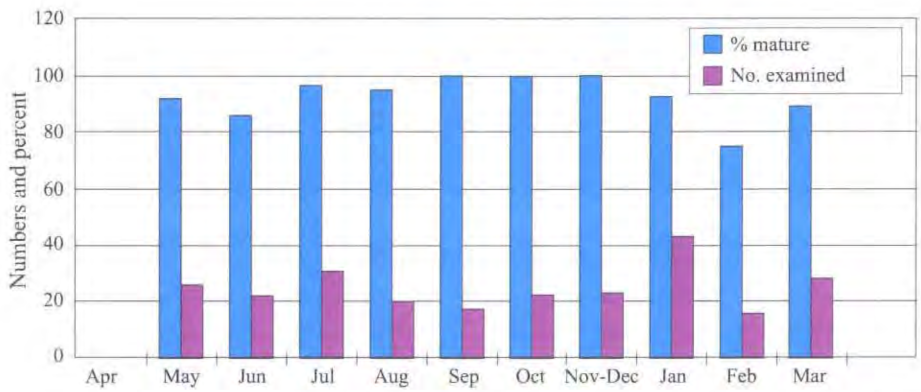

Fig. 10. Monthly maturity of male *P. acadianus* (N = 251) from April 1971 to March 1972, collected at St. Chads, Newfoundland.

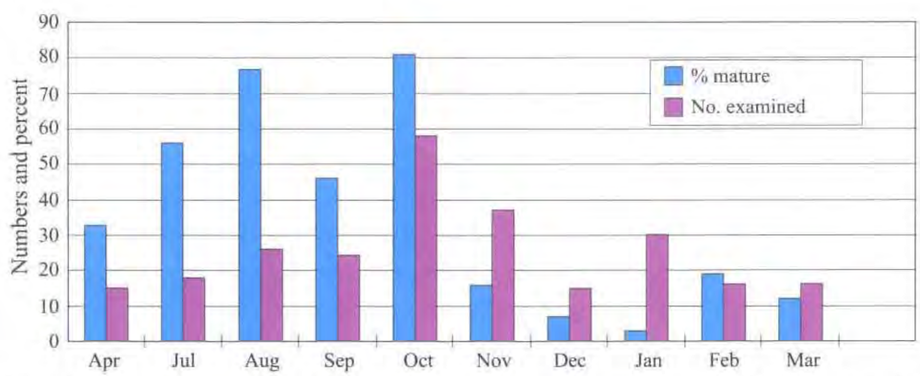

Fig. 11. Monthly maturity of male *P. arcuatus* (N = 379) from April 1971 to March 1972, collected at St. Chads, Newfoundland.

Equations for conversion from shield length to egg numbers were apparently polynomial (quadratic) and are approximate at sizes of 3–7 mm shield length. Trend lines were curved but not really representative since larger sizes of females were not present in samples. They were not included in the scatter diagram of egg numbers at each shield length (Fig. 12). The equations are:

for *P. acadianus* $y = 29.37x^2 - 7.29x + 842.35$
and *P. arcuatus* $y = 9.57x^2 + 386.65x - 345.73$

Feeding

For the most part hermit crabs are scavenging detritivores (Elwood and Neil, 1992). In the present area both species, *P. acadianus* and *P. arcuatus*, fed primarily on sponges (these are spread matlike – greenish and with occasional ostia – over rocks and bottom areas), filamentous algae (at least 15 microscopic species), small crustaceans (mostly harpacticoid copepods), polychaetes (apparently tubeworm heads and anterior parts are pinched or bitten off), settling stages of bivalves and gastropods (the latter appearing first in early autumn samples), pieces of kelp and hydroids, and detritus which included foraminiferans and diatoms (centric and pennate). Almost every stomach had many sponge spicules, mostly monaxon but some triaxon, indicating that the sponges were calcareous. The pattern of feeding was similar in both species of hermit crab (Fig. 13 and 14).

About 250 stomachs from each species were examined.

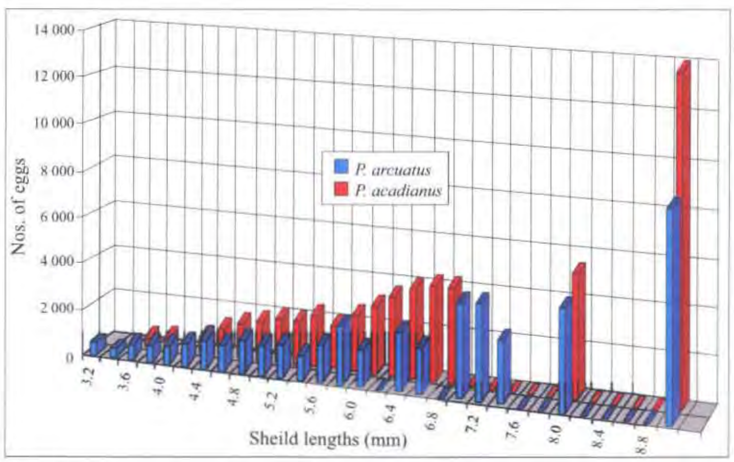

Fig. 12. Average numbers of eggs produced by *P. acadianus* (red) ($N = 68$) (fecundity equation $y = 9.57\,x^2 + 386.65x - 345.73$) and *P. arcuatus* (blue) ($N = 70$) (fecundity equation $y = 9.37\,x^2 - 7.29x + 842.35$) at each shield length from samples at St. Chads, Newfoundland.

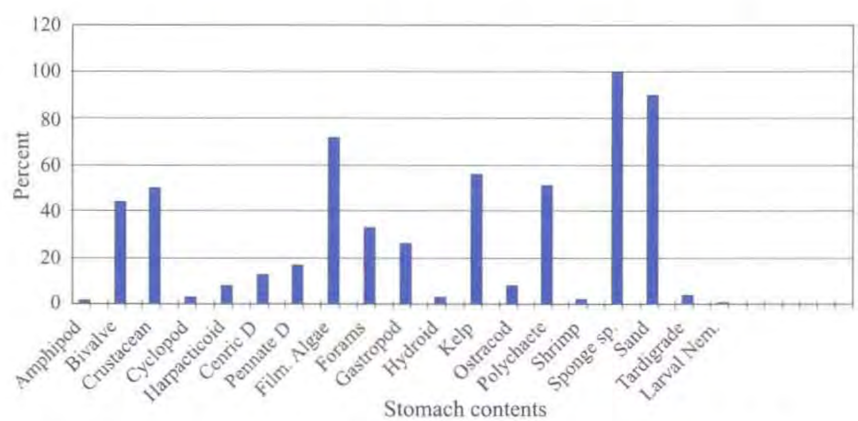

Fig. 13. Stomach contents of *P. acadianus* ($N = 254$) collected at St. Chads, Newfoundland.

Parasitization

About 18% of both female and male *P. arcuatus* were parasitized by the cirripede *Peltogaster (Clistosaccus) paguri* (Total females 453 and males 379 examined). According to size those males and females at 4–6 mm shield lengths had the highest percentages parasitized (Fig. 15).

Only one specimen of *P. acadianus* (1 male at 4 mm shield length, out of a total of 212 females and 262 males examined) carried the parasite.

Because the hermit crabs had been removed from the shells before they were examined by us, a search for symbionts was not done. However, Squires (1963) mentioned the occurrence of male and female amphipods, *Podoceropsis* sp., frequently in shells with *P. arcuatus* from the Newfoundland area. It has also been reported from hermit crabs in European waters (Vader, 1971).

Ectocommensal protozoans

A greenish protozoan was attached to filaments of gills of a high percentage (about 30%) of *P. arcuatus*, while in *P. arcadianus* the percentage was low (less than 5%). However, a brownish protozoan attached to tips of setae of the coxal endite of the maxillule was present in most specimens of both species.

White flocculant material in abdomen

In some specimens the abdomen was distended with white flocculent material. This occurred in 15 females and 28 males of *P. arcuatus* (totals examined

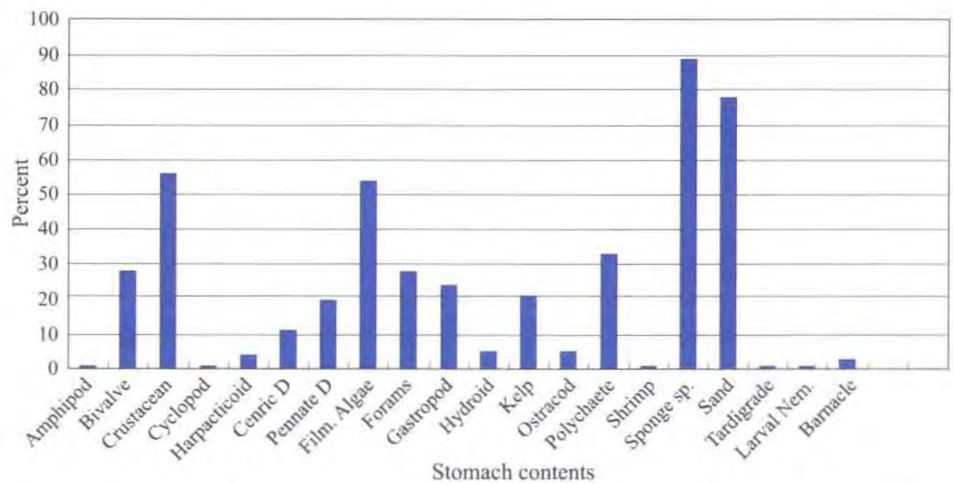

Fig. 14. Stomach contents of *P. arcuatus* ($N = 287$) collected at St. Chads, Newfoundland.

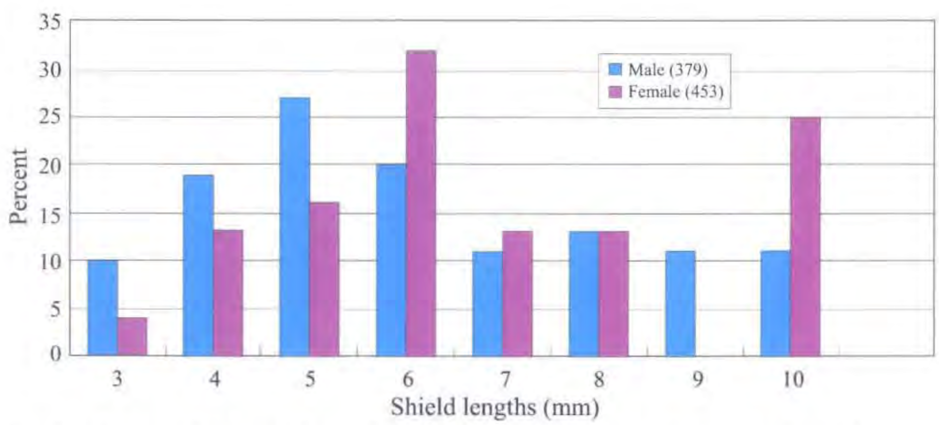

Fig. 15. Percent of male and female *P. arcuatus* at each shield length parasitized by *Peltogaster paguri* from samples (females 453, males 379) collected at St. Chads, Newfoundland.

453 females, 379 males). Only 4 females and 8 males of these were also carrying a parasite. It was also in *P. acadianus* in 1 female and 3 males (totals examined 212 females, 262 males).

Discussion

Since all specimens of hermit crabs seen were collected in the limited time available when scuba diving, the numbers taken indicate that slightly fewer *Pagurus acadianus* than *P. arcuatus* were present in the area. This was also shown in the comparative numbers of both species in the plankton (Squires, 1996 and Squires *et al.*, 1997). Also no megalopas of *P. acadianus* appeared in the plankton, indicating that they might have settled earlier or outside the area of plankton tows where the other species was collected. The advantage of *P. acadianus* with greater egg production at each size would give expected larger numbers of larvae in the plankton.

The pattern of associated shell sizes with hermit crab sizes is the same in both species. The graphs show that possibly at the smaller sizes shells were not in short supply. The shortage of larger shells could indicate interspecies as well as intraspecies competition (see also Elwood and Neil, 1992) with possibly *P. acadianus* having the advantage because of its larger size. Since gastropod shells are limited in number where hermit crabs live, and small shells are apparently more abundant, population strategy has evolved for females to put more energy into egg production than growth (Elwood and Neil, 1992). This leaves more large shells for males, which are less impeded in growth as a consequence. Our data support this conclusion.

The extreme difference in rates of parasitization could perhaps be explained on some subtle differences in body chemistry, which would make *P. acadianus* less attractive than *P. arcuatus* to the parasite that so completely invades its host. The parasite in its planktonic phase settles on the abdomen of the hermit crab and injects its body contents into the body fluids of the host (Høeg and Lutzen, 1985).

The pattern of maturity in male *P. arcuatus* is different from that of *P. acadianus* (Fig. 10 and 11). There may be an adaptation for conservation of resources (where spermatophores are not needed after all the females are carrying fertilized eggs) in *P. arcuatus*. Also, this might be an adaptation of *P. arcuatus* because it is a more northerly species than *P. acadianus*. It has been reported from just north of the Straits of Belle Isle in our records (Squires, 1990), farther north than the latter.

Although the range of depths given for both species of hermit crabs is from low water mark to 270 and 485 m (Williams, 1984), the niche occupied by those from the present collection suggests abundance to be in shallow coastal waters. My field experience has indicated their presence in many areas around the coast of Newfoundland.

Acknowledgements

We thank Dr. Craig Squires for reading a draft of this paper with suggestions for its improvement. Dr. R. A. Khan of the Marine Sciences Institute of MUN indicated that the ectocommensals were protozoans, and they were later examined by Dr. D. H. Lynn of the University of Guelph.

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