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The Biology of *Parablennius cornutus* (L.)
and *Scartella emarginata* (Günther)
(Teleostei: Blenniidae) on a Natal Reef

by
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THE BIOLOGY OF *PARABLENNIUS CORNUTUS* (L.) AND *SCARTELLA EMARGINATA* (GÜNTHER) (TELEOSTEI: BLENNIIDAE) ON A NATAL REEF

by
ISABEL EYBERG

ABSTRACT

Aspects of the biology of two blenny species were investigated to provide basic data for assessing their role in the ecology of an isolated subtidal reef off Durban, South Africa.

Scartella emarginata breeds throughout the year and *Parablennius cornutus* from May to December. Repetitive spawning occurs although the exact frequency was not established. Maximum brood size in *S. emarginata* was 1421 eggs, approximately twice that of *P. cornutus* (781 eggs).

Both species are opportunistic feeders. *P. cornutus* is more carnivorous, feeding mainly on Mollusca and Crustacea, whereas *S. emarginata* ingests Crustacea and large amounts of algae from which only the epiphytic diatoms appear to be utilized.

Growth in males of both species is rapid and it is estimated that they live about 1.5 years with less than 5% of the population surviving a second year. Females grow more slowly as they direct much of their energy to gonad production rather than to growth.

Blennies constitute approximately 74% of the biomass of the 67 teleost species on the ORI Reef. Total annual production (somatic and gonadal) for *S. emarginata* was 25.44 gm⁻² (707.03 kJ m⁻²) and for *P. cornutus* was 13.95 gm⁻² (395.31 kJ m⁻²). P/B ratios for the males was 2.89 and 2.90 respectively, and for the females 2.79 and 2.15 respectively.

INTRODUCTION

In 1976 the Oceanographic Research Institute, Durban, initiated the Natal Inshore Reef Programme to study the energetics of a shallow infratidal reef community.

Factors pertaining to the characteristics of the reef and the conditions to which its varied fauna and flora are subjected have been extensively described in previous Investigational Reports, notably Smale (1978) and Berry (1982).

Of the 67 species of teleost recorded on the ORI Reef (Berry, *et al.*, 1979), six belong to the family Blenniidae. Two of these, *Scartella emarginata* (Günther, 1861) and *Parablennius cornutus* (Linnaeus, 1758) were found to be the most abundant residents relative to all other teleosts on the basis of daytime counts. As very little is known about these small benthic fish, information on their life histories and trophic relationships within the community was collected. Production rates were determined as part of an attempt to establish the role of blennies in the energetics of the ORI Reef. For this reason the section on growth should not be seen as an exercise on population dynamics, but rather as an attempt to quantify the relative increases in biomass between the two species and sexes under control conditions.

Distribution

Although the majority of the Blenniidae show adaptations to the shallow waters of the littoral zone, some species occur in deeper water (Nikolsky, 1961). Their small size, elongate body shape and lack of a swimbladder allow them to inhabit holes and crevices, thereby avoiding turbulence (Jones & Marshall, 1953).

P. cornutus appears to be endemic to southern Africa, occurring in two distinct regions from False Cape Frio (18°30'S, 12°00'E) to Walvis Bay (22°59'S, 14°31'E) and Doring Bay (31°50'S, 18°17'E) to Durban (29°52'S, 31°01'E) (Penrith & Penrith, 1972). *S. emarginata* is more widely

distributed, being recorded in South West Africa and from Stilbaai (34°22'S, 21°30'E) in South Africa to Inhambane (23°52'S, 35°20'E) in Mozambique (Penrith & Penrith, 1972); the Mediterranean Sea (De Leo *et al.*, 1976); India (Day, 1878); the Tonga Islands (Zander, 1972) and in Bermuda, the Bahamas and from Florida in the USA to the coast of Brazil (Böhlke & Chaplin, 1968).

S. emarginata is locally known as the maned blenny and *P. cornutus* as the horned blenny (Smith, 1975).

METHODS AND SAMPLING TECHNIQUES

Morphology

Approximately 100 fish of each species were sampled monthly from January to December 1978, using a baited round hoopnet with a vertical metal handle. Sexes and species were separated and preserved in a 10% isotonic formaldehyde solution.

In order to establish the relationship between total length and mass, each individual was measured and weighed before the gut contents and gonads were removed for inspection. The wet mass to dry mass ratio was determined by drying the monthly quota of blennies (sexes and species separately) to a constant dry mass at 60°C. The calorific values were then determined using an adiabatic bomb calorimeter.

Catch composition

Total length measurements were taken and grouped into classes of 4 mm.

Reproduction

Excised gonads were weighed and a dissecting microscope was utilized to determine their state of maturity according to the following criteria:

Males

Rathke (1836) was the first to describe the oval, dorsoventrally flattened testes consisting of two areas, an inner opaque dense portion surrounded by a translucent outer area. According to McIntosh and Prince (1980) the outer or convex region is of a firmer texture and more translucent than other parts of the testes, apparently being composed of tubules containing spermatozoa. The whiter opaque region consists of aggregated sperm sacs. In this study the extent to which the outer region was developed was used as a criterion of ripeness in the stages classified as follows:

- Stage 0 (Immature) – testes very thin, threadlike, semitransparent; less than 0.5 mm in diameter.
- Stage 1 (Inactive) – testes just becoming opaque; slightly thicker (0.5 – 1.0 mm). Spermatoocytes present.
- Stage 2 (Active) – outer region forming round the gonad which is slightly swollen; first spermatozoa formed.
- Stage 3 (Ripe) – outer region narrow and very transparent, testes swollen and creamy in colour; spermatozoa released on piercing inner area.
- Stage 4 (Prespawning) – outer region broad with sperm present; very opaque, sperm often present in swollen sperm duct.
- Stage 5 (Spent) – testes very enlarged. No central region present; only a minimal amount of residual sperm left in gonads.

Females

Features used in staging female gonads include ovary and egg size, rigidity of the ovarian membrane and the presence or absence of yolk platelets. Gonads contained oocytes at various stages of development which indicated multiple spawning (Dekhnik *et al.*, 1970). Gonads were,

therefore, classified according to the state of the most advanced eggs, i.e. the forthcoming brood, as follows:

- Stage 0 (Immature) – flat ovaries, paperlike, whitish, only tiny microscopic oogonia present.
- Stage 1 (Inactive) – smallish ovaries; first few primary oocytes visible.
- Stage 2 (Active) – ovaries slightly larger, contain ova not larger than 0.4 mm across the broadest region.
- Stage 3 (Ripe) – ova larger than 0.4 mm; ovarian membrane still tough, taut. Ovaries very swollen, no yolk platelets.
- Stage 4 (Prespawning) – ovarian membranes easily ruptured; ova averaging 0.6 mm in size, numerous yolk platelets visible.
- Stage 5 (Spent) – ovaries flaccid, much larger than in Stage 1, ova either few or absent.

Gonad index

Gonad mass can be used in conjunction with gonad staging to determine reproductive cycles. To counter the effects of variation in body length as well as mean gonad mass, a gonad index was calculated following van der Elst (1976). The "b" exponent in the length/mass relationship (Results. Morphology) was used, hence:

$$\text{gonad index} = \frac{\text{gonad mass in grams} \times 10\,000}{\text{total length in mm}}$$

Only sexually mature fish were included in the calculations.

Brood size

Eggs > 0.4 mm in diameter in ripe and prespawning ovaries were counted to estimate the number of eggs laid at each spawning, i.e. the brood size.

Feeding

The contents of the whole intestine were quantitatively and qualitatively analysed since neither *S. emarginata* nor *P. cornutus* possess a true stomach. Very small amounts of food were involved, thus the wet and dry mass of food components was determined on a seasonal basis by grouping samples. Items containing calcium carbonate were decalcified with 10% nitric acid before mass determinations.

For the qualitative analysis, food items in each blenny were visually ranked in order of dominance by volume in relation to the rest of the items. The dominance method (Hynes, 1950) was applied to the data whereby the number of fish in which a particular food item occurred as the dominant foodstuff, was expressed as a percentage of the total number of fish examined. The Hynes method was also applied to items which were second, third, fourth and fifth in importance to obtain a more comprehensive analysis of the food components.

A non-ionic surfactant was employed to separate multicellular algae and diatoms to facilitate counting the number of digested and undigested diatoms in the fore- and hindgut of *S. emarginata*.

Gut length and total fish length of 101 fresh blennies were measured to establish the relationship between these parameters.

Growth

Two sets of growth studies on fish from preselected size classes over a wide size range were carried out under laboratory conditions. Total length and mass of each fish was recorded every week and plotted graphically. The mean time spent by males and females within a particular

length class was then calculated. The representative growth curves were obtained by cumulatively adding the time required to grow from one size class to the next.

Biomass and Production

Production was assessed using the method developed by Ricker (1971) where $P=GB$; "G" being the instantaneous growth rate and "B" the mean biomass. The instantaneous growth coefficient "G" was estimated by the equation $G=\log_e W_2 - \log_e W_1/t$, where W_1 is the initial mean mass of each size class and W_2 final mass after 't' (3 months). Since these results and catch composition suggest that blennies on the ORI Reef do not survive for much longer than one and a half years, production was estimated on a quarterly basis and summed to give annual production.

Density of the wild population was determined by means of SCUBA divers using a 25×25 cm metal quadrat baited with a crushed mussel. This was placed randomly along the lines of a transect and fish appearing within its borders were rapidly counted to exclude invaders.

The ratio of *S. emarginata* to *P. cornutus*, males to females, and length frequency distributions in monthly samples were applied to density data. Biomass was subsequently determined by multiplying initial mean mass by mean density in each length class. The equation $P=GB$ could then be applied to compute production for each length class, the sums of which provided quarterly production estimates.

RESULTS

Morphology

The length/mass relationship is expressed by the equation $w=a.l^b$, where w =mass and l =length. The exponent b varies with body form, mass varying seasonally and also with stomach content and spawning condition. A "b" value of 3 indicates an unchanging body form and specific gravity (Ricker, 1975).

S. emarginata:

Males:	$w=8.42 \times 10^{-6} \times l^{3.12}$ ($n=551$; length range = 17-96 mm; $r^2 = 0.97$)
Females:	$w=5.97 \times 10^{-6} \times l^{3.22}$ ($n=658$; length range = 17-103 mm; $r^2 = 0.97$)

P. cornutus:

Males:	$w=9.37 \times 10^{-6} \times l^{3.07}$ ($n=550$; length range = 26-87 mm; $r^2 = 0.97$)
Females:	$w=1.54 \times 10^{-5} \times l^{2.98}$ ($n=608$; length range = 16-79 mm; $r^2 = 0.93$)

Wet mass/dry mass is expressed by the linear equation:

$$y = a + b x, \text{ where } y = \text{dry mass and } x = \text{wt mass}$$

S. emarginata: $y=0.01+0.26 x$
($n=50$; range = 39.5-74 mm; $r^2 = 0.98$)

P. cornutus: $y=0.03+0.22 x$
($n=50$; range = 36.5-70 mm; $r^2 = 0.96$)

Since differences between the sexes were negligible, the combined results are presented.

Sex ratio

Although there was a monthly variation in the male to female ratio in both species, the mean ratio for the year was 1:1.1 in *P. cornutus* and 1:1.2 in *S. emarginata*.

Length frequency distribution

No shift of modes through successive months could be followed. Distribution of the length classes during the year was relatively similar although settlement of juvenile male and female *S. emarginata* and female *P. cornutus* in August tended to overshadow the middle age groups to some extent. Recruitment of juvenile male *P. cornutus* during this period was less obvious.

Both sexes of *P. cornutus* cover approximately the same size range whereas the males of *S. emarginata* are, in general, distinctly larger than the females (Fig. 1).

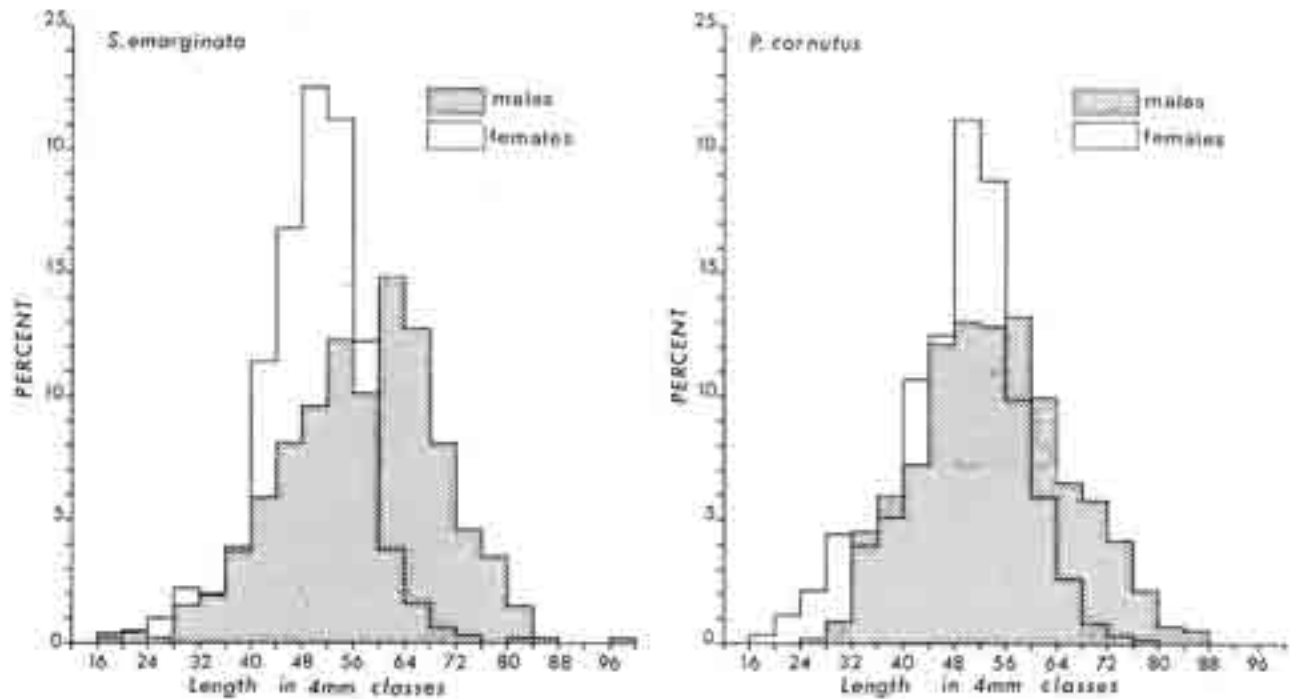


Fig. 1. Annual size frequency distributions for male and female *S. emarginata* and *P. cornutus*.

Reproduction

Breeding cycles as defined by gonad staging and indices.

Both these parameters indicate that *S. emarginata* breeds throughout the year, whereas *P. cornutus* has a more distinct reproductive phase with gonads or the prespawning stage only occurring from May to December. The mean monthly gonad indices are depicted in Figure 2.

Length at sexual maturity

Data from the months of peak reproductive activity were used to compute the length at sexual maturity for it was assumed that fish showing no gonad development were immature. As *S. emarginata* spawned throughout the year, data for the whole of 1978 were used. In *P. cornutus*, only the months June to September were considered.

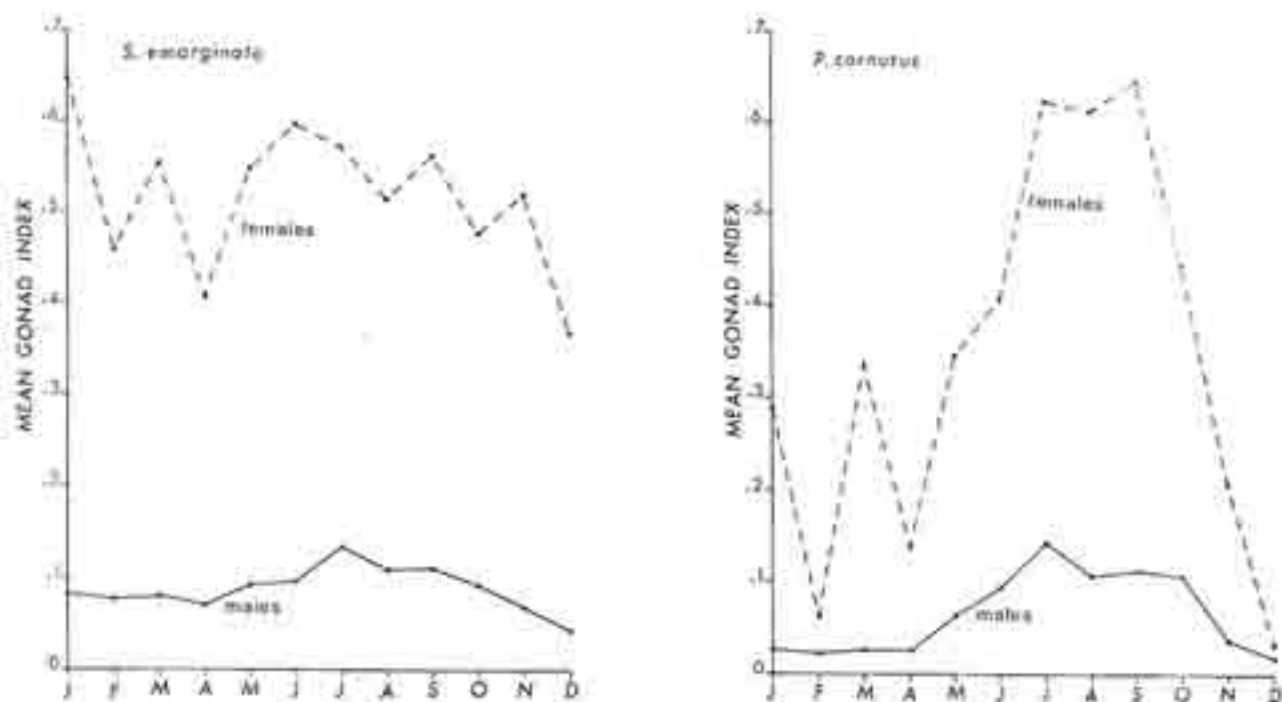


Fig. 2. Monthly gonad indices for male and female *S. emarginata* and *P. cornutus* from the ORI Reef.

The size at which 50% of the population reached sexual maturity was taken to be the mean length at sexual maturity. In *S. emarginata* both sexes reach sexual maturity at 36 mm, whereas in *P. cornutus* the females mature at 40 mm and the males at 44 mm (Table 1).

Table 1. Length at the attainment of sexual maturity.

	<i>S. emarginata</i> length mm		<i>P. cornutus</i> length mm	
	Males	Females	Males	Females
Minimum length	30	35	36	32
50% mature	36	36	44	40
100% mature	56	60	48	48

Brood size

The relationship between the number of ripe and prespawning eggs and *P. cornutus* length was linear ($y = -694.00 + 18.70x$; $r^2 = 0.83$). In *S. emarginata* the situation is less clear. When fish smaller than 64 mm were considered, the relationship was linear; (a): $y = -1384.73 + 38.93x$; $r^2 = 0.71$. However, when fish of all sizes were included in the calculations, the relationship was not clearly linear; (b): $y = 2.84 \times 1.31$ and the goodness of fit close to zero ($r^2 = 0.17$). Five of the six females larger than 64 mm from which counts were obtained had very few ripe or prespawning eggs. The sixth fish had slightly more eggs than estimated from the curve for females smaller than 64 mm. Total number of eggs irrespective of size was determined for *S. emarginata* and a curvilinear relationship was found to exist; $y = 0.21 \times x^{1.17}$; $r^2 = 0.73$. This suggests that

the majority of fish larger than 64 mm were caught when partially spawned and that the small numbers were not as a result of a reduction in brood size, since the total number of ova found in the gonads still showed an increase with length increment.

S. emarginata produced almost twice as many eggs as *P. cornutus*, and their brood size was never less than 216 eggs compared with 95 in the latter species. The maximum number of pre-spawning eggs found in *S. emarginata* was 1421 and in *P. cornutus*, 781.

Feeding

As no sexual differences in feeding habits or preferences were apparent, results for the sexes were combined. The stomach contents were classified into the following groups: Mollusca, Crustacea, Rhodophyta, Chlorophyta, Hydrozoa and Bryozoa. A number of animals such as polychaetes, tunicates and blenny eggs occurred in such small numbers that they could not be weighed accurately and were therefore grouped together under the heading 'miscellaneous animals'. A large fraction of the gut contents (Table 2) was composed of partly digested matter that was finely fragmented and of mixed origin and could not be separated or positively identified. In *S. emarginata* this partly digested matter had an ash-free calorific value ranging from 21.333 to 25.817 kJ g⁻¹ dry mass, and in *P. cornutus* 24.502 to 28.557 kJ g⁻¹ dry mass. The different calorific values were most likely due to differences in the composition of the partly digested matter during the course of the year, and also the extent to which assimilation of the nutrients had occurred.

Digested matter comprised more than 80% of the mass of the gut contents in both species (Table 2).

Table 2. Seasonal and annual dry weights of food components of *S. emarginata* and *P. cornutus*. Calorific values for the various food items are also given.

	JAN-MAR		APR-JUN		JUL-SEP		OCT-DEC		ANNUAL		Calorific Values kJ g ⁻¹	
	g	%	g	%	g	%	g	%	g	%		
<i>S. emarginata</i>	Mollusca	0.0138	0.33	0.0189	0.46	0.0249	0.37	0.0104	0.29	0.0650	0.42	26 291
	Crustacea	0.0419	1.01	0.1113	3.23	0.0606	1.38	0.0788	2.21	0.2926	1.88	25 162
	Rhodophyta	0.1775	4.26	0.1281	3.72	0.1258	2.66	0.2498	7.00	0.6812	4.37	19 902 (3)
	Chlorophyta	0.0476	1.14	0.0432	1.25	0.0393	0.89	0.0467	1.31	0.1768	1.13	19 594 (3)
	Hydrozoa and Bryozoa	0.0013	0.03	0.0025	0.07	0.0444	1.01	0.1511	4.23	0.1993	1.28	22 131 (1) & (2)
	Miscellaneous animals	0.0195	0.47	0.0103	0.30	0.0445	1.01	0.0602	1.69	0.1245	0.86	22 855 (1)
	Partly digested matter	3.8667	92.76	3.1329	90.97	4.0571	92.28	2.9710	83.27	14.0277	90.05	23 575
	TOTAL	4.1683		3.4442		4.3966		3.5680		15.5771		
<i>P. cornutus</i>	Mollusca	0.0225	2.89	0.0427	2.91	0.0231	1.90	0.0042	0.34	0.0925	2.15	26 291
	Crustacea	0.0138	1.77	0.0891	6.07	0.0228	1.85	0.0177	2.27	0.1432	3.33	25 162
	Rhodophyta	0.0004	0.05	0.0212	1.44	0.0039	0.73	0.0087	0.73	0.0812	1.89	19 902 (3)
	Chlorophyta	0.0112	1.44	0.0068	0.46	0.0030	0.25	0.0010	0.13	0.0220	0.51	19 594 (3)
	Hydrozoa and Bryozoa	0.0029	0.37	0.0021	0.14	0.0328	2.69	0.0121	1.68	0.0509	1.38	22 131 (1) & (2)
	Miscellaneous animals	0.0058	0.74	0.0198	1.35	0.0257	2.11	0.0245	3.14	0.0758	1.76	22 855 (1)
	Partly digested matter	0.7228	92.74	1.2865	87.63	1.1074	90.88	0.7143	91.51	3.8310	89.16	26 529
	TOTAL	0.7794		1.4682		1.2185		0.7805		4.2966		

(1) Atkinson & Wacasey (1976) - Canadian Arctic

(2) Cummins (1967)

(3) Joubert & Hanekom (1979) - ORI Reef.

It is possible that *P. cornutus* accidentally ingested algae with Crustacea and the other animals since the multicellular algae were apparently unaffected by the digestive enzymes, and few diatoms were present on the algae.

S. emarginata consumed large amounts of multicellular algae which were unaffected by digestion, unlike the many diatoms found in association with the algae. It became evident from a survey of the foregut that 19.4% of the diatoms were empty (n=340) compared with 18.3% (n=142) empty frustules on fresh multicellular algae, whereas in the hindgut this increased to

59.4% (n=286). Thus in the hindgut there was a threefold increase in the percentage of diatoms without cytoplasm, indicating digestion by *S. emarginata*.

The qualitative analysis (Tables 3 & 4) provides a more detailed breakdown of food organisms in the various subdivisions. Of the Mollusca, *Perna perna* L. was most abundant, while *Anomura Porcellana dehaanii* (Kr.) in *S. emarginata* and Gammaridea in *P. cornutus* were the predominant Crustacea. On one occasion, both species were observed tearing flesh from the inside of a dead *Panulirus homarus* L. indicating that they are also scavengers. Polychaeta were the most common 'miscellaneous animals'. The hydroid *Obelia dichotoma* (L.) was often present, but not in very large quantities.

Table 3. Food components of *S. emarginata*. Figures presented are percentages in which items were ranked in 1-5 in importance in stomach contents.

	PERCENTAGE				
	1st	2nd	3rd	4th	5th
ALGAE					
Chlorophyta & Rhodophyta + diatoms (equal amounts)	3.80	16.58	5.99	2.20	0.81
Chlorophyta + diatoms	1.74	7.93	4.88	2.40	0.81
Rhodophyta + diatoms	9.26	35.43	14.86	5.19	4.88
HYDROZOA					
<i>Obelia dichotoma</i>	5.05	6.90	27.16	27.94	22.76
<i>Pennaria disticha</i>	-	0.08	0.89	0.40	-
<i>Amphisbeta</i> sp.	-	-	-	0.20	-
BRYOZOA					
<i>Bicellariella ciliata</i>	-	0.08	1.44	0.80	1.63
MOLLUSCA					
<i>Perna perna</i>	2.23	2.78	4.54	8.39	22.70
Gastropoda	0.17	0.08	0.55	1.20	2.44
<i>Crassostrea cucullata</i>	-	0.08	0.11	0.40	-
Gastropoda eggs	-	-	0.22	0.20	-
CRUSTACEA					
Unidentified	0.08	0.42	2.33	3.19	-
Caprellidae	-	0.51	2.77	4.99	4.08
Gammaridae	0.58	2.95	12.64	22.55	17.89
Copepoda	-	-	0.22	0.20	-
Cirripedia	0.25	2.27	6.87	7.36	5.69
Anomura	1.16	3.03	2.55	0.88	0.81
Caprellidea & Gammaridea (equal amounts)	0.08	0.42	0.67	0.60	1.63
Isopoda	-	0.17	0.11	0.40	-
Tanaidacea	0.08	-	-	0.40	-
Macrura	-	-	0.11	-	-
DIGESTED MATTER	74.36	18.02	2.12	0.60	-
MISCELLANEOUS	0.17	0.08	1.11	1.20	0.81
Porifera	-	-	0.44	-	-
Polychaeta	0.58	1.44	5.43	4.39	6.50
Cestoda	-	0.25	0.11	1.20	2.44
Blenny eggs	0.25	0.08	0.67	0.40	-
Echinodermata	-	0.17	0.44	0.20	-
<i>Pyura stolonifera</i>	-	0.25	0.22	0.40	0.81
Sipunculida	0.08	-	-	-	-
Actinaria	0.08	-	0.33	0.20	0.81
Chironomidae (larvae)	-	-	0.11	0.60	0.44
Gelatinous film with faecal pellets	-	-	0.11	1.00	-
	100%	100%	100%	100%	100%

Table 4. Food components of *P. cornutus*. Figures presented are percentages in which items were ranked in 1-5 in importance in stomach contents.

	PERCENTAGE				
	1st	2nd	3rd	4th	5th
ALGAE					
Chlorophyta & Rhodophyta + diatoms (equal amounts)	0.54	11.30	6.17	4.82	4.96
Chlorophyta + diatoms	1.88	9.23	6.70	10.12	9.09
Rhodophyta + diatoms	1.70	22.59	16.09	11.81	14.05
HYDROZOA					
<i>Obelia dichotoma</i>	1.97	16.70	34.18	23.61	21.49
<i>Pennaria disticha</i>	0.09	0.29	0.40	0.48	-
<i>Amphisbetia</i> sp.	-	0.10	-	0.24	-
BRYOZOA					
<i>Bicellariella ciliata</i>	-	-	0.29	0.24	-
MOLLUSCA					
<i>Perna perna</i>	8.40	5.11	6.57	10.30	19.01
Gastropoda	0.09	0.10	0.13	1.45	-
<i>Crassostrea cucullata</i>	-	0.29	0.27	0.72	-
Gastropoda eggs	-	-	0.54	0.24	-
CRUSTACEA					
Unidentified	0.68	0.49	0.80	1.20	0.83
Caprellidae	0.71	1.08	2.55	6.99	4.10
Gammaridae	2.95	7.86	9.92	11.33	9.92
Copepoda	-	-	-	-	-
Cirripedia	0.45	5.21	6.97	9.88	6.61
Anomura	2.14	1.96	1.61	0.24	-
Caprellidea & Gammaridea (equal amounts)	0.18	0.29	0.40	0.48	-
Isopoda	-	-	0.13	0.24	-
Tanaidacea	0.09	-	0.13	0.24	-
Macrura	-	0.10	-	-	-
DIGESTED MATTER	76.60	11.79	1.33	-	0.83
MISCELLANEOUS	0.18	0.49	0.27	0.24	0.83
Porifera	-	0.10	1.07	0.24	-
Polychaeta	0.63	3.24	2.01	2.43	3.31
Cestoda	-	0.10	0.27	0.48	0.83
Blenny eggs	0.63	0.79	0.27	0.48	1.65
Echinodermata	-	-	-	0.24	-
<i>Pyura stolonifera</i>	-	-	0.54	0.24	0.83
Sipunculida	-	-	-	-	-
Actinaria	-	0.39	0.13	0.24	0.83
Chironomidae (larvae)	-	0.10	0.13	0.48	0.83
Gelatinous film with faecal pellets	-	0.30	0.13	0.24	-
	100%	100%	100%	100%	100%

Growth

In laboratory experiments male *S. emarginata* grew considerably faster than the females. On average males took 180 days to grow from the 28-31 mm size class to the 76-79 mm class whereas the female took 319 days to grow the same amount; that is an extra 139 days. This means that a female within the 76-79 mm class is approximately 4.5 months older than a male of equal size (Fig. 3A).

Both sexes of *P. cornutus* increase in total length at the same rate until they reach a class of 44–47 mm. Thereafter a male requires a further 155 days to reach the 76–79 mm size class while the female takes as many as 322 days to reach the same size class. This means that in this species a female of 76–79 mm is 167 days or 5.5 months older than the males (Fig. 3B).

P. cornutus females had a higher growth rate than *S. emarginata* females until they reached the 64–67 mm size class, after which the rate dropped off considerably. From 28–31 mm to 36–39 mm, *P. cornutus* males grew faster than did male *S. emarginata*. In the largest size classes, male *S. emarginata* appeared to reach a greater maximum length (96–99 mm) compared to 87–90 mm for male *P. cornutus*.

A possible explanation for the considerable differences in growth rates between males and females of both sexes is given in the discussion.

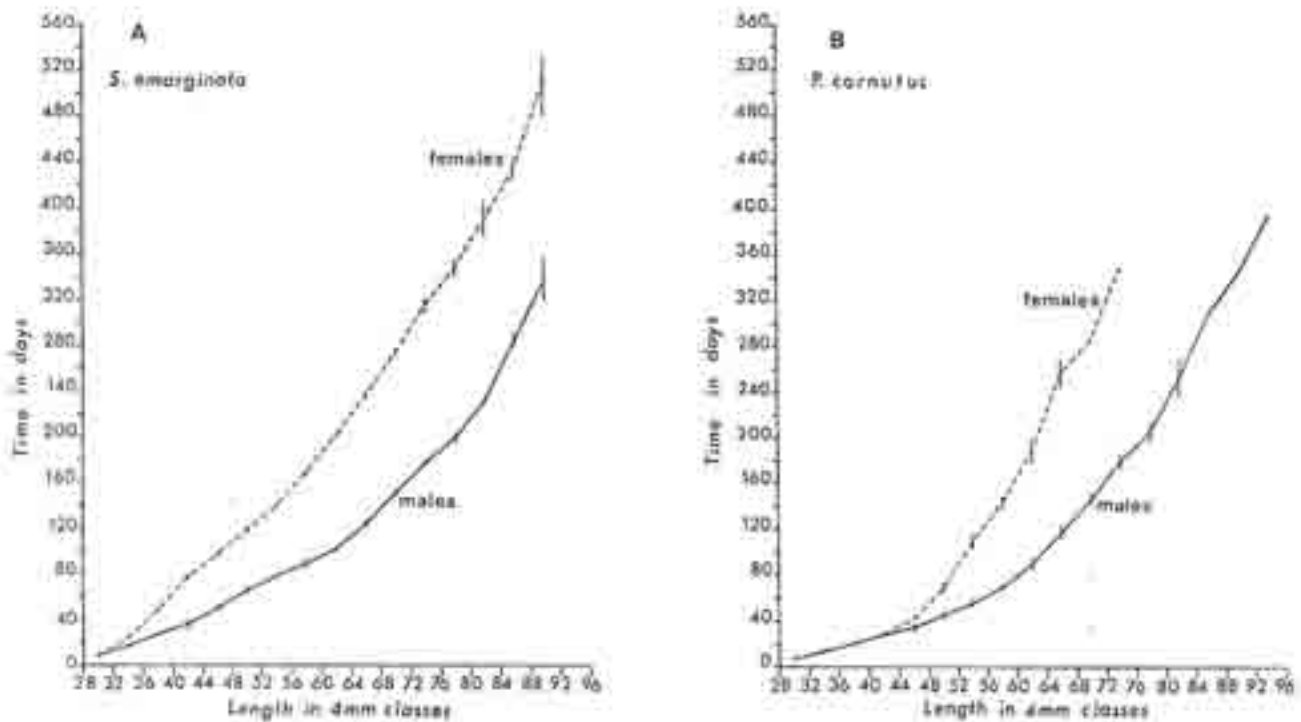


Fig. 3. Growth in male and female *S. emarginata* and *P. cornutus* in captivity.

Biomass and Production

Mean density as determined by underwater quadrat surveys was used to calculate the total numbers of each species (by sexes) on the whole reef which had a total area of 1 646 m² (Berry, 1982) (Table 5). Mean biomass and annual production estimates for the ORI Reef are presented in Table 6. In the smallest and largest length classes, instantaneous growth rate and therefore production could not be determined from the growth curves (indicated by an asterisk), thus the given estimate of production without the input from these size classes is an underestimate. Production of gonadal material (Pg) was estimated separately from somatic production. However, although the number of eggs released per spawning could be estimated for blennies of a given length and converted to mass, the number of broods produced was unknown. It was, therefore, not possible to obtain direct values for female gonad production. An

alternative method was then employed whereby production of somatic tissue in females was calculated using male growth rates, and it was assumed that the difference in growth, i.e. slower growth in females, approximates the energy directed into egg production. This assumption is based on the fact that growth rates of juvenile males and females were found to be very similar until length at sexual maturity was reached. Total annual production of *S. emarginata* was 25.44 g m⁻² (707.03 kJ m⁻²) compared to 13.95 g m⁻² (395.31 kJ m⁻²) for *P. cornutus*. Total and annual production includes both somatic and the estimated female gonadal production.

With respect to annual somatic production, the P/B ratios of *S. emarginata* and *P. cornutus* males are very similar. On the other hand *S. emarginata* females have a much higher P/B ratio compared to similar sized *P. cornutus* females as a result of their much greater body mass to length ratios.

Table 5. Mean density and estimated total number of blemmes on the ORI Reef, as well as calorific values in kJ g⁻¹ dry, ash-free weight.

Months		<i>S. emarginata</i>			<i>P. cornutus</i>		
		Mean density m ⁻²	Mean number on reef	Calorific values kJ g ⁻¹	Mean density m ⁻²	Mean number on reef	Calorific values kJ g ⁻¹
MALES	Jan - Mar	7.20	11 851.20	27.724	6.69	11 011.74	29.480
	Apr - Jun	3.71	6 106.66	27.899	6.07	9 991.22	28.036
	Jul - Sep	4.76	7 834.96	28.149	3.64	5 991.44	28.034
	Oct - Dec	6.97	11 472.62	27.235	5.83	9 596.18	27.912
FEMALES	Jan - Mar	8.95	14 731.70	27.620	5.50	9 053.00	29.135
	Apr - Jun	4.20	6 913.20	28.007	7.13	11 735.98	28.402
	Jul - Sep	6.26	10 303.96	27.925	7.30	12 015.80	27.988
	Oct - Dec	7.64	12 575.44	27.758	4.11	6 765.06	27.708

Table 6. Mean biomass, annual production and P/B ratios for *S. emarginata* and *P. cornutus*. Female production (B) was estimated at male growth rates to obtain an estimate of female gonadal production, by subtraction.

		MALES			FEMALES				
		Mean biomass (g dry Wt)	Somatic* production	P/B ratios	Mean biomass (g dry Wt)	Somatic production at female growth rates (A)	P/B ratios	Somatic production at male growth rates (B)	Production (A-B)
<i>S. emarginata</i>	Whole reef (g y ⁻¹)	6 564.07	19 001.89	2.89	5 388.36	15 044.05	2.79	22 872.78	7 828.73
	gm ² y ⁻¹		11.54			9.14		13.89	4.76
	kJm ² y ⁻¹		320.26			154.32		386.49	132.45
<i>P. cornutus</i>	Whole reef (g y ⁻¹)	4 253.48	12 335.55	2.90	1 994.55	4 295.97	2.15	10 629.09	6 333.12
	gm ² y ⁻¹		7.49			2.61		6.46	3.85
	kJm ² y ⁻¹		212.45			73.88		182.87	108.98

*Production of male gametes was considered negligible.

DISCUSSION

Some blenny species deposit their eggs in crevices e.g. *Halmablennius lineatus* (Val.) (Lee & Chang 1977), under stones e.g. *Acanthoclinus quadridactylus* (B. & S.) (Jillett 1968) or on rocky ground e.g. *Tripterygion tripteronotus* (Risso) (Abel 1955). In *S. emarginata* and *P. cornutus* the males choose the breeding site which invariably is an empty mussel or oyster shell (Gibson 1969); the eggs being deposited on the clean inner surface. Ova are not bound together by threads as in *A. quadridactylus* (Jillett 1968), but appear to be glued individually to the surface. Champy and Gley (1922) suggest that this is achieved by a lipoidal secretion from an accessory gland on the testis whose function is to cause an increase in the adhesive properties of the egg. The males guard the eggs against fish of their own and other species. Brood care includes rubbing their bodies over the eggs, keeping them free of fungal infections (Qasim 1956).

A male *P. cornutus* in the laboratory was observed to attend the nest continuously for a period of six months. Although deposition of ova by females was never observed, the length of attendance by this male and the apparently continuous presence of ova suggested that the brood was regularly supplemented by fresh ova deposition.

The variation in egg size in ovaries indicates multiple spawning in *S. emarginata* and *P. cornutus*, but the exact frequency has not been determined.

Shackley and King's (1977) aquarium stock of *Blennius pholis* L. produced a maximum of 200 eggs at each spawning although they had calculated a total of 1 000 to be available at any one time. Jillett (1968) found egg masses of *A. quadridactylus* with counts varying between 7 500 and 8 200. He did not state whether an egg mass was produced by one female only (this species spawns only once a year). If one female produces this mass of eggs, then one spawning is probably equivalent to all the spawnings of *S. emarginata* and *P. cornutus* during their life time. Shackley and King (1977) estimated that *B. pholis* spawned at least eight times in one breeding season. Because the breeding period continues throughout the year as in the case of *S. emarginata*, factors other than photoperiod and temperature must play a role in the regulation of spawning.

In this study, the first eggs hatched in the laboratory seven days after laying, whereas others from the same cluster hatched several days later. Newly hatched larvae were well developed and at a mean length of 3.5 mm weighed approximately 0.23 mg.

During the planktonic phase immediately after hatching, blenny larvae are found drifting out to sea (Gibson 1969). It is thought that this phase is instrumental in the distribution of the species since the adults are apparently confined to the reef once settlement has occurred at approximately 16 mm, for no blennies were seen moving across the sand on either side of the reef.

When considering the sex ratio of *S. emarginata*, Penrith and Penrith (1972) stated that females were always in the majority. On the other hand Smith (1959) observed that the majority of this blenny caught off South Africa's coast were males. These contradictory observations and the fact that, in the present study, there was a drop in number of males during the autumn-winter period particularly in the case of *P. cornutus*, could be as a result of their increased activity in guarding eggs. It is, therefore, concluded that the sex ratio is essentially 1:1, the monthly ratio being influenced by the time of capture rather than actual differences in the abundance of either of the sexes.

"In a typical brood the fish vary considerably in size at the end of the first growing season, partly because of differences in time of hatching, partly from congenital physiological differences and partly from differences in environment" (Ricker 1975). This apparently is also true of the two blenny species studied. Individuals which were initially the same size could differ in length by about 10% at the end of the seven and a half month study period, even though kept in the same tank.

Growth and ageing data found in the literature relate entirely to temperate species of blennies with long life cycles. The males and females of *T. tripteronotus* in the Black Sea have an almost identical rate of growth in their first year of life (Gordina *et al.* 1970) and at the age of

1+ the size and mass difference is insignificant. At the age of 2+ the mass and length of the males exceeds that of the females. Unfortunately no mention is made of the way in which their age was determined, nor the age or size at sexual maturity.

The ORI Reef blennies have a short life span (fewer than 5% survived a second winter). In addition, large variations in growth rates occurred, resulting in considerable overlap in size between adjacent age classes. It was not possible, therefore, to obtain satisfactory estimates of growth rates or age by using the Petersen method (Tesch 1971) which follows modal progressions in the analysis of monthly size frequency polygons.

From the growth rates and maximum lengths of fish caught on the ORI Reef, it would appear that these blennies do not live for more than one and a half years (at the most two years in *S. emarginata* females) even if the planktonic phase from hatching to recruitment into the adult population lasts approximately two months as suggested by Gibson (1969) for temperate species. Attempts to raise larvae were unsuccessful. The longest that these planktonic larvae were kept alive was three days.

No growth equation has been fitted to the data obtained from the growth studies since length increments in larvae and juveniles smaller than 28–31 mm size class have not been measured. Thus the absolute age of individuals was not known. It was not possible to establish how the growth curves obtained from the laboratory animals compared with those of wild blenny populations on the ORI Reef. Nevertheless, it is thought that the mean curves derived from a wide range of growth rates would be representative of that of wild specimens.

The males and females of both species appear to grow at a similar rate until they start to mature sexually (Fig. 3). Thereafter the females grow at a much slower rate. A reasonable explanation for this is that at about 32–35 mm in *S. emarginata* and 44–47 mm in *P. cornutus* the females commence to channel much of their energy into the production of eggs. It would, therefore, appear that about 34.3% of the energy of a female is diverted towards the production of eggs. It was not possible to determine the mass of sperm released by the male, but compared with that of eggs it is thought to be negligible.

With respect to annual somatic production, the P/B ratios of *S. emarginata* and *P. cornutus* males were very similar, unlike that of the females. The P/B ratios of 2.89 and 2.79 for *S. emarginata* males and females and 2.90 and 2.15 for *P. cornutus* males and females is comparable with that of *Octopus vulgaris* males (2.78) and females (3.33) (Smale & Buchan 1981) and considerably higher than the 0.42 for *Panulirus homarus* (Berry & Smale 1980) studied on the same reef. From examination of the ovaries, repetitive breeding was evident. If the number of broods had been known and the time interval between broods, it would have been possible to determine with greater accuracy the mass of eggs released during a quarter. According to Le Cren (1962), gonad production of older, slower-growing fish may be as much as somatic production, and in species such as the stickleback *Gasterosteus aculeatus* L. which lay a succession of egg batches, may be much larger (Wootton 1973).

Blennies are the only truly resident fish species of the ORI Reef with the possible exception of *Epinephelus andersoni* Boulenger which is resident while juvenile and subadult. Semi-resident species which are present for a few weeks or up to several months include *Abudefduf saxatilis*, *Pomadasys olivaceum* Day, *Sarpa salpa* (L.) and *Diplodus sargus* L. (Berry *et al.* 1979).

The diet of both *S. emarginata* and *P. cornutus* comprises a wide variety of animals (and diatoms in the case of the former species). *P. cornutus* possess well developed canines used for tearing flesh from *Perna perna*, and have a short intestine. *S. emarginata* differs from *P. cornutus* in that the canines are more reduced and the alimentary canal is much longer, a characteristic feature associated with fish having herbivorous tendencies. However, they do not have special adaptations restricting them to one source of food only, as in *H. lineatus* (Lee & Chang 1977). *S. emarginata* is the more omnivorous species and together with herbivores such as *A. saxatilis* (L.) and *Acanthurus lineatus* (L.) (Joubert & Hanekom 1980) keep the multicellular algae closely cropped, although it appears to utilize only the diatoms on them. In this way the algal material is made available to the detrital pool.

The high calorific values of partly digested matter in *P. cornutus* suggests that it is largely of animal origin rather than plant matter. In the case of *S. emarginata* the lower calorific value of the partly digested matter was probably indicative of a higher proportion of plant to animal matter.

Both species are highly opportunistic, and although there is some overlap in their choice of food items, no aggression between *S. emarginata* and *P. cornutus* was apparent from observations on the ORI Reef. These opportunistic feeding habits are particularly advantageous to populations inhabiting a continually changing intertidal environment. Factors such as silting up of the reef may lead to mass mortalities in *P. perna* and *Pyura stolonifera* (Heller) (Berry 1979), so that any species solely dependent on them as food would themselves suffer mass mortalities.

The total mean biomass of the 67 species of teleost recorded on the ORI Reef was 15.45 g m⁻² dry mass (Berry *et al.* 1979) of which *S. emarginata* and *P. cornutus*, with their greater density and residency, comprised 74%.

The blennies have the highest production rates of the ORI Reef teleosts recorded. They constituted about 50% of the gut contents of *E. andersoni* Boulenger and were less frequently preyed upon by *P. olivaceum* Day and *O. vulgaris* Cuv. (Joubert & Hanekom 1980). The Cape cormorant *Phalacrocorax capensis* (Sparrrman) was recorded as consuming on average one blenny every 105 seconds, and spending an estimated one and a half hours per day on the reef over the six or seven months that they are in Natal, an approximate but perhaps conservative estimate (Berry *et al.*, in press).

No night-time observations were carried out thus the possibility of heavy exploitation of this rich food source by nocturnal feeders cannot be excluded.

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