Tube epifauna of the Polychaete *Phyllochaetopterus socialis* Claparède

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Animals greater than 1 mm, found among tangled tubes of *Phyllochaetopterus socialis* (Chaetopteridae) from Araçá Beach, São Sebastião district, Brazil, were studied for 1 year, with four samples in each of four seasons. They comprised 10 338 individuals in 1722·7 g dry weight of polychaete tubes, with Echinodermata, Polychaeta (not identified to species) and Crustacea as the dominant taxa. The Shannon–Wiener diversity index did not vary seasonally, only two species (a holothurian and a pycnogonid) showing seasonal variation. *Ophiactis savignyi* was the dominant species, providing 45·5% of individuals. Three other ophiuroids, the holothurian *Synaptula hidriformis*, the crustaceans *Leptochelia savignyi*, *Megalobrachium soriatum* and *Synalpheus fritzmuelleri*, the sipunculan *Themiste alutacea* and the bivalve *Hiatella arctica* were all abundant, but most of the 68 species recorded occurred sparsely. The assemblage associated with *P. socialis* was similar to the endofauna of the sponge *Zygomycale parishii* and the bryozoan *Schizoporella unicornis*, and to the epifauna of seaweed *Sargassum cymosum*, all of which occurred nearby.

Introduction

Epibiotic communities living in intertidal rocky shores are known to be substratum-limited (Connell, 1961; Dayton, 1971). The provision of spatial refuges is an important aspect in the organization of tropical communities (Menge & Lubchenco, 1981). Species diversity may be directly related to spatial heterogeneity (MacArthur & MacArthur, 1961) and the presence of refugia and food resources may increase the number of species (Abele, 1974).

Many intertidal organisms modify rock or sand substrata, creating new structures which facilitate the colonization of other species. For example, seagrasses (Heck & Wetstone, 1977; Stoner, 1980; Nelson *et al.*, 1982; Leber, 1985; Howard, 1987; Lewis, 1987; Virnstein & Howard, 1987*a,b*; Schneider & Mann, 1991*a,b*), seaweed

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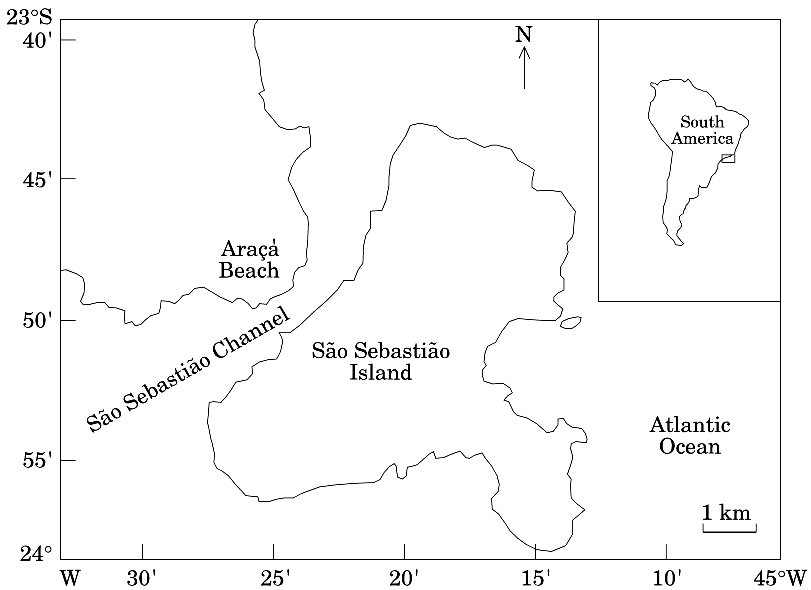

Figure 1. Geographical position of Araçá Beach.

(Montouchet, 1979; McKenzie & Moore, 1981; Choat & Kingett, 1982; Price & Hylleberg, 1982; Kitching, 1987; Gibbons, 1988; Russo, 1989), sponges (Peattie & Hoare, 1981; Westinga & Hoetjes, 1981; Voultsiadou-Koukoura *et al.*, 1987), polychaetes (Bell & Coen, 1982), molluscs (Jacobi, 1987), bryozoans (Lindberg & Stanton, 1988) and corals (Reed *et al.*, 1982; Reed & Mikelsen, 1987; Scott, 1987) provide structural complexity due to their intricate architectural forms. These organisms provide food and/or shelter from predators for numerous species of marine invertebrates and fishes, besides acting as a nursery for many larval and juvenile forms (McKenzie & Moore, 1981; Lewis & Hollingworth, 1982). Morphological differences in the host species may be accompanied by differences in the faunal assemblages (Virnstein & Howard, 1987*a*), although host species with similar architectures have similar faunal assemblages (Virnstein & Howard, 1987*b*).

This study describes the epibiotic macrofaunal (animals greater than 1 mm) assemblage associated with tubes of the polychaete *Phyllochaetopterus socialis*. The tangled matrix of tubes of this species provides a microhabitat exploited by several species of benthic organisms.

Study area

Araçá Beach, in São Sebastião district (23°48′S and 45°23′W) opens on São Sebastião Channel (Brazil). This beach has a silty bottom and a rocky shore that harbours a great diversity of seaweeds and sessile animals (Figure 1).

Early in 1980, a population of *P. socialis* was observed colonizing the rocky shore of Araçá Beach. The population increased following an oil spill that affected the local flora and fauna in May 1981. Bare patches were quickly colonized by *P. socialis*. This polychaete normally occurs in the infralittoral fringe, prior to colonization by the seaweed *Acanthophora spicifera* (Vahl).

Plate 1. Fragment of *P. socialis* sample, collected in Araçá Beach.

Materials and methods

Four samples were collected in each season of the year, from early June 1981 to March 1982. The samples were collected by hand at random points along the Araçá Beach, at low water of spring tides.

Each sample (Plate 1) was enclosed in a plastic bag and transferred to the laboratory where its volume was measured by water displacement. Then the polychaete tubes were carefully separated, and the epifauna were sorted and fixed. Decapods were frozen before being fixed. Other crustaceans were put directly in 70% alcohol. Other taxa were anaesthetized in isotonic magnesium chloride solution and then put into 70% alcohol (following Pantin, 1964).

Species diversity was calculated as the Shannon–Wiener index (Pielou, 1977). The biological index value (BIV), was calculated with 20 points for the most numerous species of each sample, 19 points for the second, etc. (McCloskey, 1970). The BIV for each species is a sum of the points that it received in all samples.

TABLE 1. Volume, dry weight and number of individuals of *P. socialis* in samples collected in Araçá Beach, São Sebastião Channel

Season	Sample	Volume (ml)	Dry weight (g)	Number of individuals	Date
Spring	I	240	169·91	469	28 November 1981
	II	360	146·56	489	28 November 1981
	III	260	107·55	234	29 November 1981
	IV	400	157·98	795	29 November 1981
Summer	I	230	54·77	1158	5 March 1982
	II	220	61·75	551	5 March 1982
	III	310	103·87	734	5 March 1982
	IV	340	97·61	409	5 March 1982
Autumn	I	360	117·87	764	13 June 1981
	II	220	52·83	523	13 June 1981
	III	220	46·85	331	13 June 1981
	IV	370	79·00	721	13 June 1981
Winter	I	270	89·65	692	28 July 1981
	II	420	144·79	976	28 July 1981
	III	570	198·29	922	29 July 1981
	IV	210	93·42	570	29 July 1981
	Total	5000	1722·7	10 338	

TABLE 2. Percentage of polychaete families (in relation to total number of individuals) found among the tubes of *P. socialis*, collected in Araçá Beach

Terebellidae	7·04	Nereidae	0·21
Syllidae	3·50	Flabelligeridae	0·13
Eunicidae	1·82	Chrysopetallidae	0·12
Lumbrineridae	1·56	Dorvilleidae	0·07
Cirratulidae	1·43	Capitellidae	0·06
Sabelidae	1·23	Amphinomidae	0·02
Polynoidae	1·11	Paraonidae	0·01
Hesionidae	0·74	Spionidae	0·01
Phyllodocidae	0·30	Lysaretidae	0·01
Sabellariidae	0·23	Total	19·60

Results

The 16 samples of *P. socialis* tube matrix represented a total sample volume of 5000 ml and a dry weight of 1722·7 g (Table 1). The samples yielded 10 338 individuals, belonging to the following taxa: Echinodermata, 58·71%; Polychaeta, 19·60%; Crustacea, 13·47%; Sipuncula, 3·68%; Mollusca, 3·59%; Pycnogonida, 0·57%; Nemertinea, 0·26%; Cnidaria, 0·12%; Pisces, 0·01%. Excluding polychaetes, which were identified only to family, 68 species were identified. Of these, 32 were crustaceans, 23 molluscs, six echinoderms, three sipunculans, one nemertean, one cnidarian, one pycnogonid and one fish. Among the 19 Polychaeta families found, Terebellidae, Syllidae, Cirratulidae, Lumbrineridae, Eunicidae and Polynoidae were the most abundant (Table 2).

The ophiuroid *Ophiactis savignyi* (Muller & Troschel) was the dominant species of the community comprising 45·51% of the individuals. The other three ophiuroids, *O. lymani*

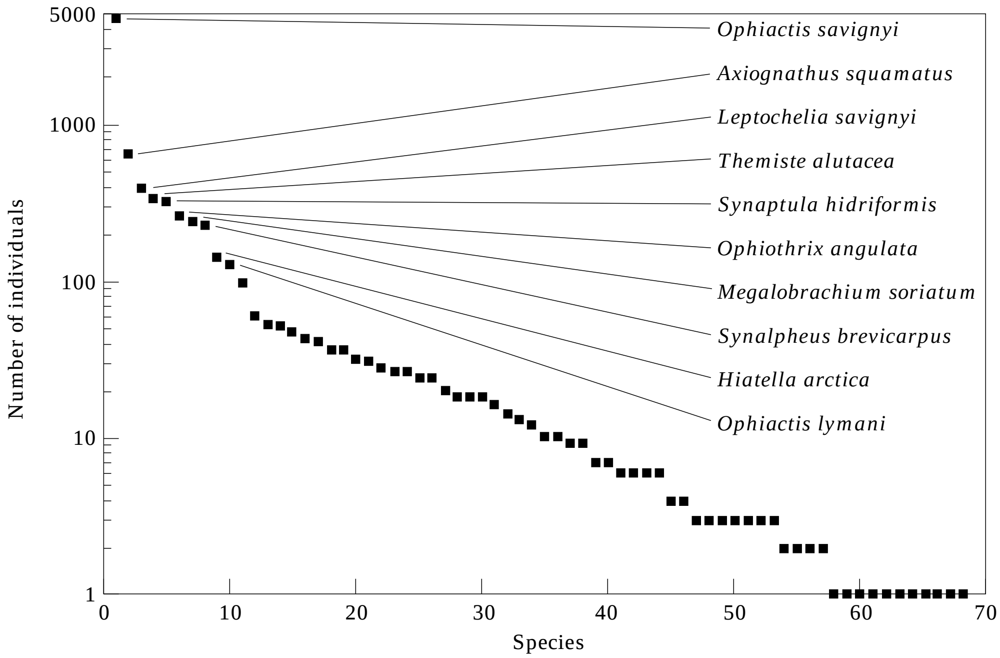

Figure 2. Number of individuals of each of the 68 species found in the samples of *P. socialis*.

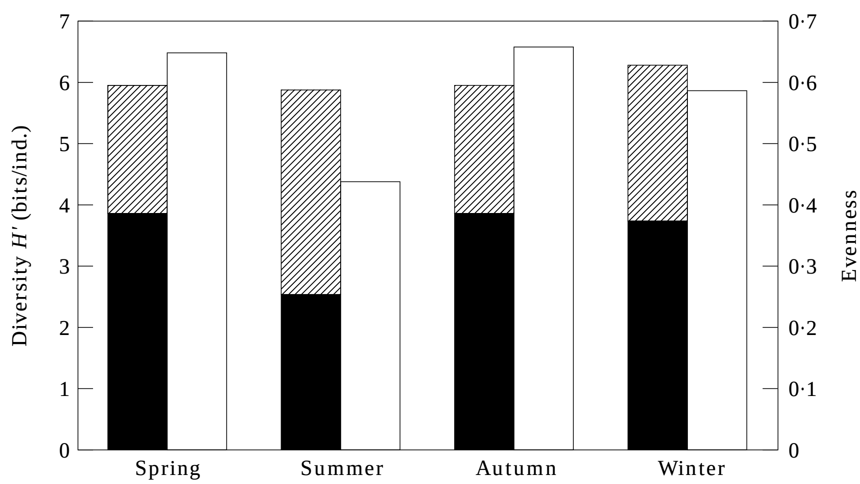

Figure 3. Diversity of the tube epifauna of the polychaetous *P. socialis*, in each season, in bits by individuals (■), maximal possible diversity (▨) and evenness (□).

Ljungman, *Ophiothrix angulata* (Say) and *Axiognathus squamatus* (Delle Chiaje) were also present in all samples, as was the bivalve *Hiatella arctica* (L.), the crustaceans *Leptochelia savignyi* (Kroyer) and *Synalpheus brevicarpus* (Herrick), and the sipunculan *Themiste alutacea* (Grube) (Figure 2).

TABLE 3. Biological index value (BIV) of the macrofauna associated with *P. socialis* tubes and their known association with other substrata (numbers indicate references cited)

Species	Taxa	BIV	Reference
Ophiactis savignyi (Mull & Troschel)	E	320	1–3
Axiognathus squamatus (Delle Chiaje)	E	279	1–3
Leptochelia savignyi (Kroyer)	C	256	—
Themiste alutacea (Grube)	S	255	3
Synalpheus brevicarpus (Herrick)	C	240	2,3
Ophiothrix angulata (Say)	E	228	1–3
Megalobrachium soriatum (Say)	C	224	2–4
Synaptula hidriformis (Lesueur)	E	195	2,5
Hiatella arctica (L.)	M	194	2, 3, 6–9
Ophiactis lymani Ljungman	E	188	1–3, 5
Modiolus carvalhoi Klappenbach	M	174	7,10
Synalpheus fritzmuelleri Coutière	C	145	3, 4, 11, 12
Amothella sp.	P	121	—
Lysianassa sp.	C	115	—
Erichsonella filiformes (Say)	C	101	—
Cymadusa filosa Savigny	C	100	13
Paracerceis sculpta (Holmes)	C	99	—
Bittium varium (Pfeiffer)	M	94	2, 5, 14–16
Hyale media (Dana)	C	91	—
Pilumnus dasypodus Kingsley	C	89	2–4, 12
Clibanarius antillensis Stimpson	C	86	—
Baseodiscus curtus (Hubrecht)	N	84	—
Leucothoe alata J. L. Barnard	C	84	—
Elasmopus rapax Costa	C	77	—
Epiautus brasiliensis Dana	C	73	2, 3, 5
Golphingia confusa (Sluiter)	S	70	2
Microphrix bicornutus (Latreille)	C	67	2, 3
Pilumnus floridanus Stimpson	C	64	2, 3
Cyathura sp.	C	61	—
Costoanachis sparsa (Reeve)	M	57	2, 3, 5, 8
Columbela mercatoria (L.)	M	57	17
Phascolosoma sp.	S	52	—
Caprella scaura Templeton	C	46	—
Anachis lyrata Sowerby	M	45	—
Cnidaria	A	44	—
Morula nodulosa (C. B. Adams)	M	43	3,5
Cirolana parva (Hansen)	C	41	—
Mitrela argus (Orbigny)	M	39	—
Synalpheus apioceros Coutière	C	36	2, 3
Arca imbricata Bruguiere	M	34	3, 5, 8
Pachycheles maginanus Milne Edwards	C	31	2, 3
Lembos sp.	C	30	—
Chlamys tehuelchus (Orbigny)	M	30	2
Hexapanopeus paulensis Rathbun	C	27	2, 3
Ludovigorthuria grisea (Selenka)	E	19	—
Tricolia affinis (C. B. Adams)	M	18	3, 5, 8
Leucothoe spinicarpa (Abildgaard)	C	16	9, 13, 18. 19
Amphithoe ramondi Audouin	C	15	9, 13
Podochela risei Stimpson	C	15	2, 3
Typton gnathophylloides Holthuis	C	15	2, 3
Thais haemastoma (L.)	M	14	5, 8
Petrolisthes galathinus (Box)	C	14	2, 3, 11, 12, 20
Menippe nodifrons Stimpson	C	13	2, 3

Continued

TABLE 3. *Continued*

Species	Taxa	BIV	Reference
Alpheus sp.	C	13	—
Pinctata imbricata Roding	M	13	—
Doris verrucosa Cuvier	M	9	2
Erichthonius brasiliensis (Dana)	C	9	7, 9, 16, 18
Modiolus americanus (Leach)	M	9	—
Rissoina catesbyana Orbigny	M	8	—
Aplysia brasiliana Rang	M	7	—
Alpheidae	C	6	—
Berthella tupala Marcus	M	6	—
Perna perna (L.)	M	6	—
Chaetopleura asperrima (Gould)	M	6	—
Ischnochiton striolatus (Gray)	M	6	5
Syngnathus dunckeri Metzelaar	Pi	6	5
Seila adamsi (H. C. Lea)	M	5	2, 3, 8
Musculus lateralis (Say)	M	4	2, 3, 5, 8

A, Anthozoa; C, Crustacea; E, Echinodermata; M, Mollusca; N, Nemertinea; P, Pycnogonida; Pi, Pisces; S, Sipuncula. 1, Boffi (1972); 2, Duarte (1980); 3, Morgado (1980); 4, McCloskey (1970); 5, Montouchet (1979); 6, Kitching (1987); 7, McKenzie & Moore (1981); 8, Reed & Mikkelsen (1987); 9, Voultsiadou-Koukoura *et al*. (1987); 10, Peattie & Hoare (1981); 11, Lindberg & Stanton (1988); 12, Reed *et al*. (1982); 13, Russo (1989); 14, Howard (1987); 15, Virnstein & Howard (1987*a*); 16, Virnstein & Howard (1987*b*); 17, Lewis & Hollingworth (1982); 18, Lewis (1987); 19, Westinga & Hoetjes (1981): 20, Heck & Wetstone (1977).

Most species were represented by only few individuals and occurred in low frequencies. Forty species occurred in less than 50% of the samples. Among the molluscs, 20 occurred in less than 50% of the samples and 10 occurred with only one individual in all the samples.

Diversity varied little between the seasons (Figure 3), in spite of some species such as *Synaptula hidriformis* (Lesueur) and *Amothella* sp., being seasonal. The 10 species with the highest BIV values included five echinoderms of which four were ophiuroids and one was a holothurian. Crustaceans were also a significant component of the community, with 18 of the 30 species with highest BIV values (Table 3).

No correlation was found between the sample dry weight and the number of individuals ($r = 0{\cdot}20$, $P = 0{\cdot}778$; Table 1).

Discussion

None of the species associated with *P. socialis* was restricted to it. Of the 68 species identified, 41 were also found in other substrata such as sponge, seaweed, seagrass, coral reef or bryozoan colonies (Table 3). All the ophiuroids were common in other substrata, although in different densities: *Ophiactis savignyi* was the dominant species on *P. socialis* tubes and in the sponge *Zygomycale parishii* (Duarte, 1980); it was also common amongst the bryozoan *Schizoporella unicornis* (Morgado, 1980). *Ophiactis lymani* occurred in low densities on *P. socialis* tubes, but was very abundant on seaweed (Boffi, 1972; Montouchet, 1979) and bryozoans (Morgado, 1980). The other two species of ophiuroids, *Axiognathus squamatus* and *Ophiothrix angulata*, were also found on these substrata. The holothurian *Synaptula hidriformis* has been recorded on sponge (Duarte, 1980) and seaweeds (Montouchet, 1979).

With the exception of *Clibanarius antillensis*, the decapods have also been found among bryozoan (Morgado, 1980; Lindberg & Stanton, 1988), seaweed (Heck & Wetstone, 1977; Montouchet, 1979), sponge (Duarte, 1980) and coral reef (McCloskey, 1970; Reed *et al*., 1982) assemblages.

Among the amphipods, many species, such as *Erichthonius brasiliensis*, *Leucothoe spinicarpa*, *Amphithoe ramondi*, *Cymadusa filosa*, have also been recorded from seaweed (McKenzie & Moore, 1981; Lewis, 1987; Virnstein & Howard, 1987*b*), algal reef (Russo, 1989), and sponge (Westinga & Hoetjes, 1981; Voultisiadou-Koukoura *et al*., 1987).

Fifteen of the 23 species of molluscs have also been recorded from other substrata like seaweed (Montouchet, 1979; McKenzie & Moore, 1981; Virnstein & Howard, 1987*a*,*b*), seagrass (Lewis & Hollingworth, 1982; Howard, 1987), sponge (Duarte, 1980; Peattie & Hoare, 1981; Voultsiadou-Koukoura *et al*., 1987), coral reef (Reed & Mikkelsen, 1987) and bryozoan (Morgado, 1980) matrices.

Many workers have observed that such associations of species are facultative and include phylogenetically distant taxa (sponges, bryozoans and seaweeds) utilizing similar structural complexities of their environment (Crocker & Reiswig, 1981; Peattie & Hoare, 1981; Lindberg & Stanton, 1989). Virnstein & Howard (1987*b*) found 75% of species in common among three seagrasses *Halodule wrightii*, *Thalassia testudinum*, *Syringodium filiforme* and one seaweed *Gracilaria* sp.; the authors claimed that plant architecture played an important role in determining community composition.

The intricate structure of tubes of *P. socialis* causes the accumulation of organic material, favouring the establishment of detritivores such as *Ophiactis savignyi*, *O. lymani* and *Ophiothrix angulata*, and attracting predators such as *Hexapanopeus* and *Pilumnus* (Boffi, 1972). Many species of herbivorous amphipods shelter among the polychaete tubes, eating seaweeds that grow over the tubes.

Among the polychaetes, predaceous families represent 9% of the total community (Syllidae, Eunicidae, Lumbrineridae, Polynoidae, Hesionidae and Phyllodocidae), detritivorous families 8·5% (Terebellidae and Cirratulidae) and filter-feeders 1·5% (Sabellidae and Sabellariidae). The presence of organisms from different trophic levels suggests the existence of a complex food-web harboured among the tubes of *P. socialis*, as happens with other substrates such as sponges (Peattie & Hoare, 1981).

The role of living structures as shelters has special importance to young forms of many marine organisms. Many workers emphasize the importance of structural complexity as providing shelter against predation. Nelson (1979) and Edgar (1983) showed that phytal amphipods are less preyed upon by fishes in branching and morphologically complex seaweeds than in structurally simple ones.

Ban and Nelson (1987), studying the infauna associated with the tubes of the polychaete *Diopatra*, suggested that there may be a minimum density of tubes for the establishment of an effective refuge. In their experiments, the predation of *Mulinia lateralis* by *Callinectes* was significantly lower in treatments with 10 tubes per 0·01 m^2 than with four or zero. Although we have not conducted experiments to prove lower predation in the epibiont fauna of *P. socialis*, the structural complexity and the large number of young individuals in the assemblage suggests that *P. socialis* may be a refuge against predators.

The qualitative analysis of *P. socialis* community infauna reveals great similarity to endobiotic fauna of sponges like *Zygomycale parishii* (Duarte, 1980). Some similarity is also evident with endobiotic fauna of the bryozoan *Schizoporella unicornis* (Morgado,

1980) and with the epibiotic fauna of the seaweed *Sargassum cymosum* (Montouchet, 1979). The proximity of sites where these studies were conducted may be the cause of the similarities. Adjacent assemblages facilitate recruitment to each other, as has been observed in other substrata (Sogard, 1989).

These similarities may also be explained by the occurrence of sponges and seaweeds among the polychaete tubes, as well as by the fact that this kind of assemblage is characteristic of sheltered habitats. The occurrence in *P. socialis* assemblages of organisms typically associated with seaweed, sponges and muddy substrata may be related to the presence of such substrata among the *P. socialis* tubes.

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