



# Ecological review of the Syllidae (Annelida) associated with sponges (Porifera), including the description of a new species from northeastern Brazil

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## ABSTRACT

This study reviews the data published on the ecology of polychaete annelids of the family Syllidae associated with sponges (Porifera) and provides additional empirical data from samples collected at Paiva Beach (northeastern Brazil). This literature review collected data from the Web of Science and Scopus databases, together with additional sources of information, to provide the best possible overview of the available data on the ecological relationships between these organisms. This review identified a total of 76 papers reporting on 68 associations between syllids and sponges, which involved 61 syllid species inhabiting 57 different sponge taxa. Although few studies have provided detailed data on the auto-ecology of the syllids associated with sponges, some information is available on their reproductive patterns, feeding habits, and role in the association. In this study, seven syllid genera were recorded inhabiting sponges of the genus *Cinachyrella* (Porifera: Tetillidae) at Paiva Beach in Pernambuco, northeastern Brazil, where a predominance of syllids of the genus *Branchiosyllis* was recorded. The syllids were found either on the outer surface of the sponges or in their inner channels, and most specimens were females, some of which presented stolons, indicating that they were using the sponges as a reproductive substrate. A new species of the genus *Branchiosyllis* is described based on our collected data. *Branchiosyllis lanai* sp. nov. can be identified by its relatively enlarged anterior region, cirriphore with a collar, and branchiae varying between domed and multilobed. The new species is compared with its morphologically most similar congeners. A synoptic table of the morphological variation found among the individuals of the type series is also provided, as well as an updated key to the identification of the *Branchiosyllis* species found on the Brazilian coast.

**Keywords:** Host, Poriferan, Syllid, New species

## INTRODUCTION

Sponges provide important habitats for many marine animals, and may support whole ecological communities (Westinga and Hoetjcz, 1981; Koukouras et al., 1985; Gherardi et al., 2001). Many different animals can be found attached to the surface of a sponge or inhabiting its canals

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and choanosome. The holes, grooves, chambers, and channels inside a sponge can provide shelter, and the constant filtration of water can provide access to food (suspended or deposited) for both vertebrates and invertebrates (Frith, 1979; Wulff, 2006; Gerovasileiou, 2016; Coppock, 2022). The relationship between these animals and the sponges may be either obligate or opportunistic, and may vary from a specific period to the whole life cycle of the animal, although, in most cases, the exact nature of the relationship between polychaetes and their sponge hosts remains unclear (Wulff, 2006; Goren et al., 2021).

Polychaetes tend to be the predominant group found in association with sponges, whether regarding their species richness, abundance, or biomass (Westinga and Hoetjes, 1981; Koukouras et al., 1992; Çinar et al., 2019). These polychaetes can occur as epifauna, on the surface of the sponge, or infauna, being found in the channels or oscules of the sponge (Pérès 1982; Pérez-Botelho and Simões, 2021), where they reproduce (Lattig and Martin, 2011a.), feed (Magnino and Gaino, 1998; Turon, 2019), or obtain refuge from predators and environmental pressures (Giangrande et al., 2005). The most prominent polychaete taxon found in association with sponges is the family Syllidae Grube, 1850 (Pamungkas et al., 2019; Martin et al., 2021).

The Syllidae comprises 79 genera and almost 1,100 valid species (Martin et al. 2021; Read and Fauchald, 2020) of mostly small-sized polychaetes with diverse feeding habits, including carnivore, herbivore, and detritivore trophic guilds (Fauchald and Jumars 1979; Giangrande et al. 2000). In addition to other animals, syllids may also colonize a number of other substrates, such as mud and sand (Martin and Britayev, 1998; Lopez et al., 2001), and may be found in environments ranging from the intertidal zone to the deep ocean (López et al., 2001; Giangrande et al., 2000). Many syllid species are found in association with other marine organisms, such as hydrozoans, bryozoans, corals, and even other polychaetes, as well as sponges (León-González et al., 2009; San Martín, 2003; San Martín and Worsfold, 2015).

Approximately 150 syllid species have been recorded in Brazil to date, representing 35 genera

(Steiner et al., 2021). While sponge-associated fauna, particularly polychaetes, have been the subject of various studies worldwide, few of these studies have focused specifically on the syllids, although López et al. (2001) compiled a number of hypotheses based on the initial research. This study reviews the published data available on sponge-syllid associations and provides further insights from empirical data collected from the southern coast of Pernambuco, in tropical northeast Brazil. In addition, a new species of *Branchiosyllis* Ehlers, 1887 is described, based on specimens found in association with sponges of the genus *Cinachyrella* Wilson, 1925 (Porifera: Tetillidae), collected from sandstone reefs at Paiva beach, in the state of Pernambuco. This increases the number of known species of sponge-associated polychaetes from the southern Atlantic Ocean.

## METHODS

### LITERATURE SEARCH

The literature search was based on the investigation of published papers, written in English, available in the Web of Science (WoS) and Scopus databases. These two databases were selected due to being generally considered the most comprehensive sources of scientific data for most fields of research (Zhu and Liu, 2020). The Topic Search was based on the terms 'Syllid\* AND Spong\*', which were applied to the title, abstract, and keywords. The asterisks allow for the inclusion of derived words with the same prefix, which ensures the broadest possible approach.

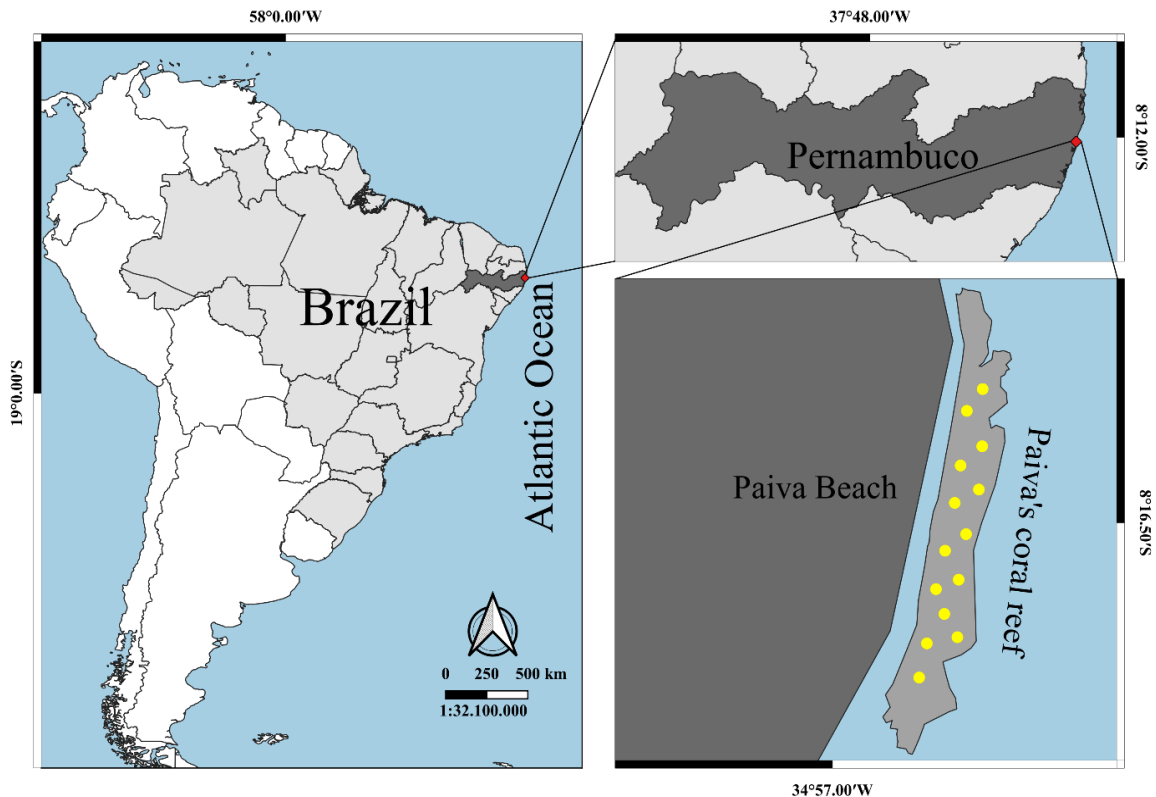
These search terms resulted in 376 results, 43 in the WoS database and 333 in Scopus, of which 35 were duplicates, resulting in a total of 341 articles. However, most of these articles (290) were excluded due to not explicitly referring to the ecological interaction between syllids and sponges, i.e., some articles presented only a study on sponges excluding the presence of syllids and others presented information only on syllids without mentioning their host, leaving 57 articles that aligned with the objectives of this study. Another 19 articles not found on WoS or Scopus were considered relevant to the analysis and added to the database. These 76 articles were

classified according to the decade of publication (1880–2020), the main topic (ecology, taxonomy, autoecology, taxonomy/ecology), and the location of the study.

### BRANCHIOSYLLIS AT PAIVA BEACH

From July 2019 to June 2020, sponges were collected manually (30 sponges randomly selected per month) from the intertidal zone of

reefs at Paiva beach (08°15'76"S, 034°57'30"W) in Pernambuco (northeastern Brazil) (Figure 1). Prior to collection, each sponge was enclosed in a plastic bag to prevent losses of the associated fauna. The sponges were then fixed in a 5% saline formalin. In the laboratory, each sponge was examined under a stereomicroscope to collect the polychaetes encountered in their internal channels and chambers.



**Figure 1.** Map of the reefs at Paiva Beach, Pernambuco. Yellow dots represent locations of the *Cynachirella* collected.

The *Branchiosyllis* specimens were identified to species and measured using an ocular micrometer attached to the microscopes. The length of each specimen was measured from the tip of the palps to the tip of the pygidium, excluding the anal cirri, whereas the width was measured in the proventricular region, excluding the parapodia. Some specimens were also examined using Scanning Electron Microscopy (SEM). The specimens examined and photographed by SEM were first dehydrated in a graded series of increasing concentrations of ethanol (70–100%),

dried to the critical point, and coated with 35 nm of gold prior to analysis at the Technological Platforms Center at FIOCRUZ in Pernambuco.

The sponges were identified based on the examination of the spicules, the standard procedure for the identification of porifera taxa. Type material and voucher specimens are deposited at the Museu de Zoologia da Universidade de São Paulo, São Paulo, Brazil (MZUSP) and at the Museu de Oceanografia Professor Petrônio Alves Coelho da Universidade Federal de Pernambuco, Recife, Brazil (MOUFPE).

## RESULTS

### Taxonomy

Family Syllidae Grube, 1850

Subfamily Syllinae Grube, 1850

Genus Branchiosyllis Ehlers, 1887

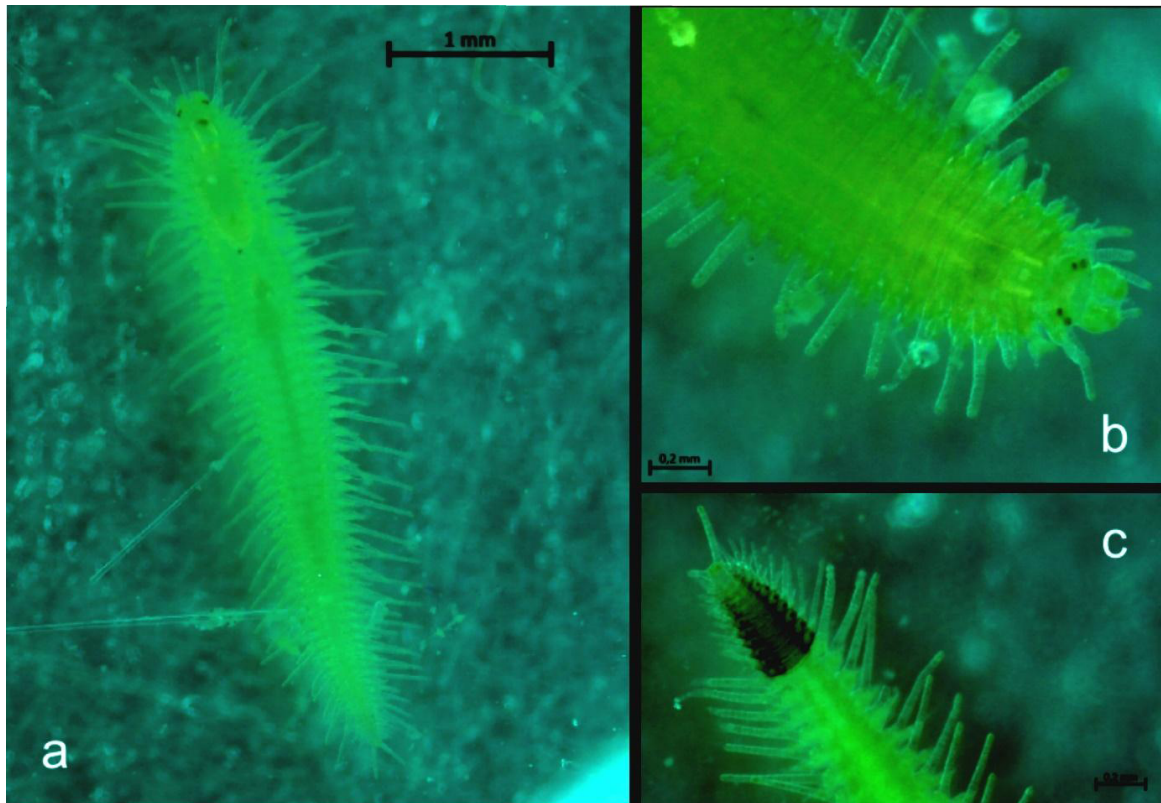
Type species: *Branchiosyllis oculata* Ehlers, 1887

Diagnosis (after San Martín, 2003). Relatively medium- to large-sized body, subcylindrical to dorso-ventrally or, more rarely, laterally flattened. Palps free or fused at bases. Prostomium with four eyes, occasionally with two anterior eyespots, three

antennae, and two palps. Peristomium with two pairs of peristomial cirri. Antennae, peristomial, dorsal, and anal cirri articulated, moniliform. Parapodial lobes sometimes with branchiae. Compound chaetae as falcigers and unguiae, on at least part of the body. Simple chaetae not observed, apparently absent altogether. Pharynx with single anterior tooth; opening surrounded by a crown of approximately 10 soft papillae. Two anal cirri. Proventricle usually with approximately the same length as the pharynx. Reproduction by acephalous stolon.

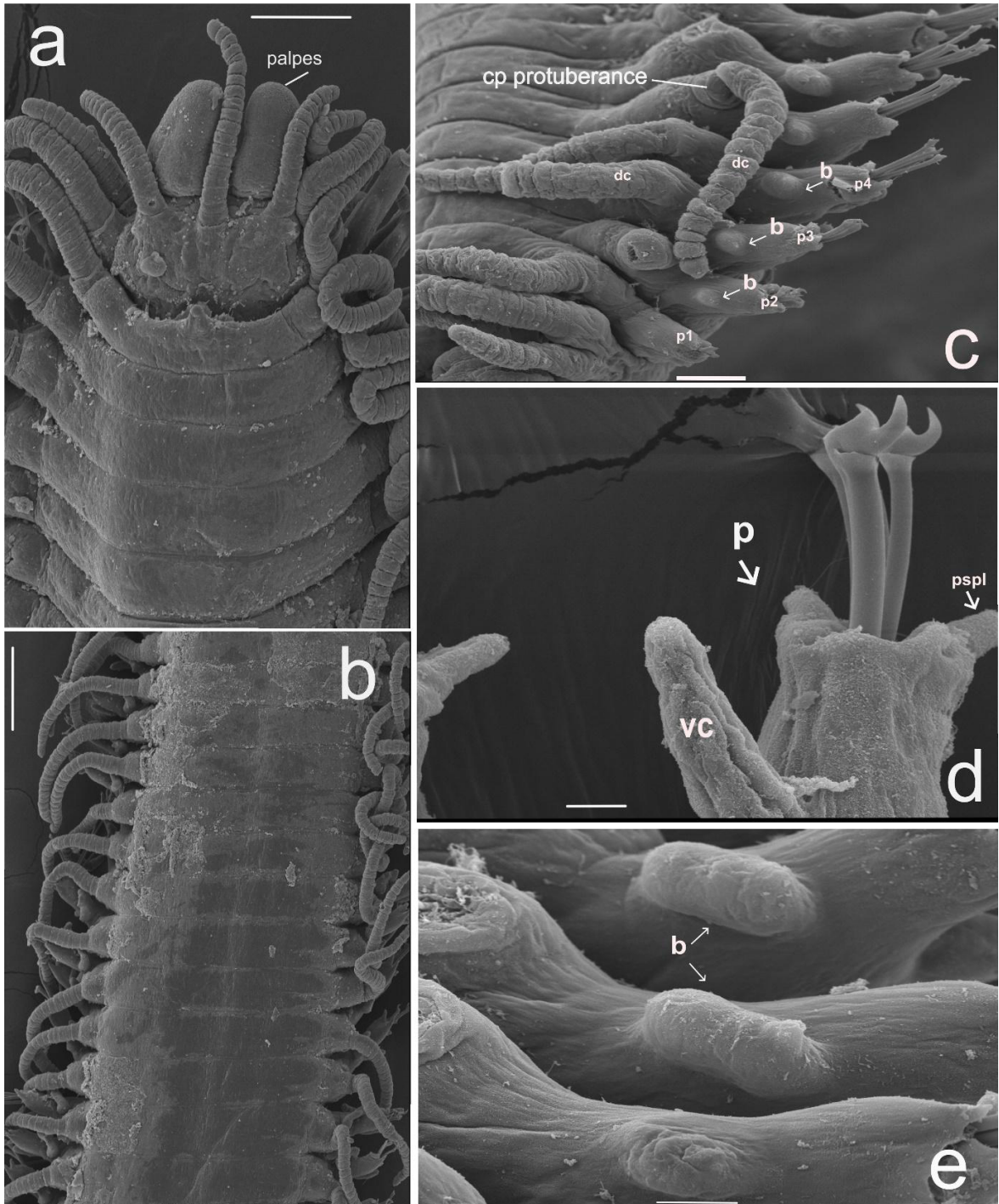
### *Branchiosyllis lanai* sp. nov.

urn:lsid:zoobank.org:pub:DFB1C8BD-6DD2-4A7E-B093-6F4848A91A9F

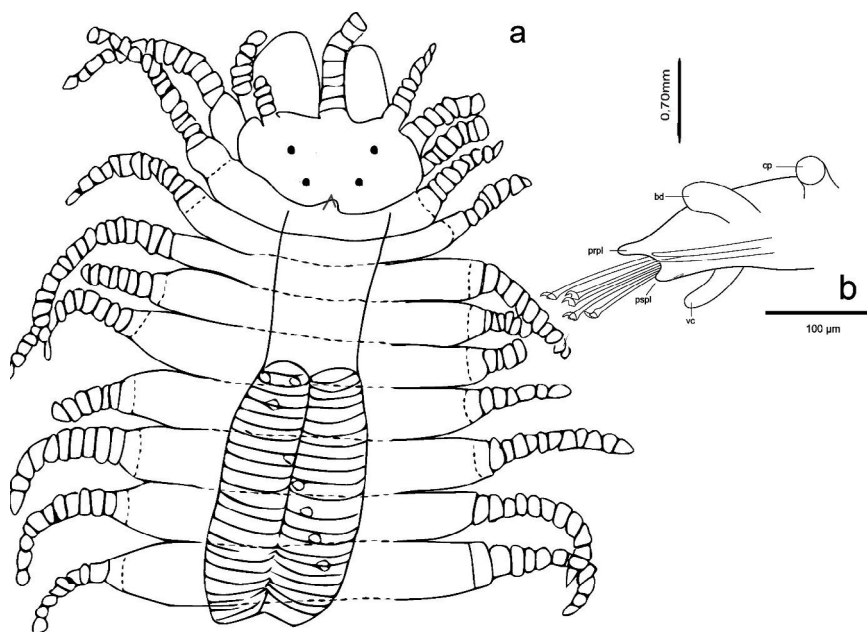


**Figure 2.** *Branchiosyllis lanai* sp. nov. A, entire animal, dorsal view. B, anterior body, dorsal view. C, posterior body with stolon in formation, dorsal view.

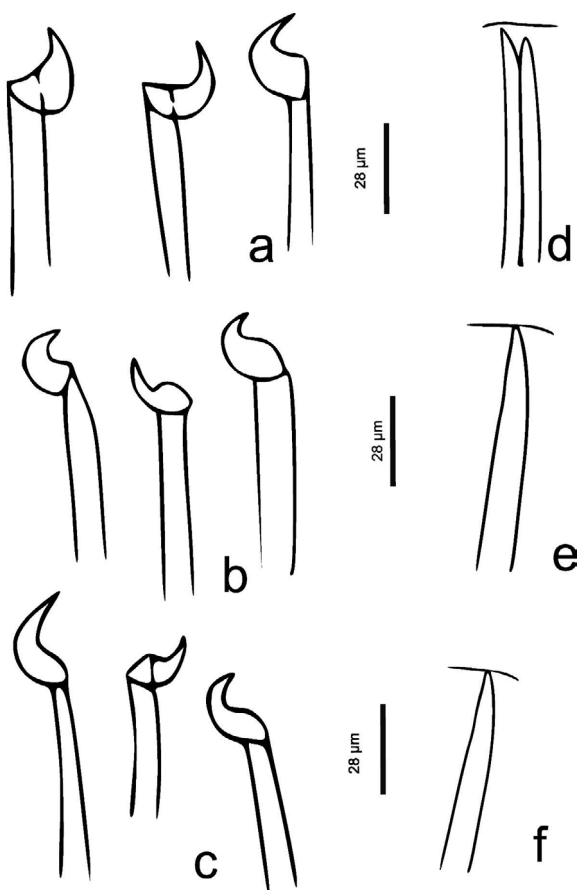




**Figure 3.** *Branchiosyllis lanai* sp. nov., SEM. A, anterior body, dorsal view; B, midbody, dorsal view. C, anterior to midbody parapodia, dorso-lateral view. D, parapodium, anterior body, ventral view. E, detail, multilobed branchiae, midbody. b, branchiae; dc, dorsal cirri; p, parapodium; pa, palp; pspl, pre-chaetal parapodial lobe; vc, ventral cirrus. Scale bars: A-B = 200  $\mu$ m; C = 50  $\mu$ m; D = 50  $\mu$ m; E = 20  $\mu$ m.



**Figure 4.** *Branchiosyllis lanai* sp. nov. A, anterior body, dorsal view. B detail of parapodium, anterior view. bd, branchiae; cp, cirrophore; prpl, pre-chaetal parapodial lobe; pspl, post-chaetal parapodial lobe; vc, ventral cirrus.



**Figure 5.** *Branchiosyllis lanai* sp. nov. A-C, unguiae, anterior, mid- and posterior body, respectively. D-F, aciculae, anterior, mid-, and posterior body, respectively.

**Type series.** Atlantic Ocean, Brazil, state of Pernambuco, Cabo de Santo Agostinho, Paiva Beach (08°17'89"S, 34°57'30"W), associated with *Cinachyrella apion* Uliczka, 1919, from intertidal reefs. MOUFPE-POL0001 (holotype); MOUFPE-POL0002 (paratype 1); MOUFPE-POL0003 (paratype 2); MOUFPE-POL0004 (paratype 3); MZUSP 5444 (paratype 4); MZUSP 5445 (paratype 5), coll. & det. A. Lira, february/2020.

**Diagnosis:** Body enlarged in anterior region; cirrophores with collar; branchiae varying from dome-shaped to multilobed.

**Description.** Medium-sized syllids, largest specimen analyzed was 5.0 mm long, 0.7 mm wide, with 75 chaetigers. Body anteriorly enlarged (Figures 2a-c; 3a-b); live specimens yellow (Figure 2a-c), without clear pigmentation pattern. Palps triangular; prostomium rectangular, about as long as palps or slightly larger (Figures 3a), with two pairs of eyes in trapezoidal arrangement (Figure 2a-b), anterior eyespots absent. Median antenna inserted slightly away from anterior border, anteriorly to anterior pair of eyes, elongated, reaching beyond tip of palps, with approximately 13 articles; lateral antennae inserted on anterior border, slightly shorter than median antenna, each with 9–13 articles (Figures 3a; Table 1). Peristomium dorsally inconspicuous, covered by a fold of chaetiger 1; dorsal peristomial cirri longer than antennae, each with 15–30 articles; ventral peristomial cirri shorter, about as long as lateral antennae, each with 10–11 articles (Figures 2a-b; 3a; 4a; Table 1). Dorsal cirri of chaetiger 1 similar in length to dorsal peristomial cirri, with 13–20 articles; dorsal cirri on anterior and midbody parapodia with no clear pattern of alternation in length, longer cirri with up to 25 articles, shorter cirri with up to 11 articles (Figures 2a; 3b-c; Table 1); ventral cirri approximately same length as parapodial lobes or slightly longer, conical to digitiform, progressively more tapered distally (Figures 3d; 4b). Antennae without cirrophores; cirrophores present in peristomial cirri and dorsal cirri along body, with collar-shaped fold (Figures 3d-e; 4a); articles flatter in the proximal region, rectangular toward the distal region, the latter longer and more conical (Figures 3a-c; 4a).

Branchiae varying along body—absent from chaetiger 1; dome-shaped or multilobed (2-3) on chaetiger 2; multilobed (3-4) on anterior and midbody chaetigers; with 4 lobes on posterior body (Figures 3c, e; 4b). Parapodia on chaetiger 1 with only one pre-chaetal lobe; from second chaetiger onwards, parapodia trilobed, with pre- and post-chaetal, and ventral lobes (Figures 3c-d, 4b). Falcigers absent. Anterior parapodia each with 3–6 unguulae (Table 1), blades unidentate, bent at 90° from shafts; last parapodia, usually in formation (Figure 2c), each with 3–5 unguulae (Figures 3c-d; 4b; 5a-c). Anterior parapodia each with 2 aciculae, one subdistally oblique and one straight, distally tapered; from midbody onwards, parapodia with only one straight, smooth acicula each (Figures 4b; 5d-f; Table 1). Pygidium semicircular, with two articulated anal cirri slightly shorter than posterior body dorsal cirri (Figure 2a, c). Pharynx extending for 4–6 segments, opening surrounded by 10 papillae (Table 1); large, conical, pointed tooth close to opening; proventricle occupying 5–7 segments, with around 24 rows of muscle cells (Figure 4a; Table 1).

**Remarks.** *Branchiosyllis lanai* sp. nov. resembles *B. australis* Hartmann-Schröder, 1981, *B. belchiori*, *B. gonzaguinhai*, *B. oculata*, and *B. tamandarensis* (Table 2), by the presence of branchiae and compound chaetae as unguulae only, without falcigers.

However, *B. australis*, from Western Australia and the Philippines, presents only dome-shaped branchiae, similar to *B. oculata*, which occurs in the North Atlantic, Gulf of Mexico, Caribbean Sea, and Brazil. Besides *B. oculata*, from the abovementioned group of species, *B. belchiori*, *B. gonzaguinhai*, and *B. tamandarensis* also occur on the Brazilian coast, specifically in the states of Paraíba, Pernambuco, and Bahia, in northeastern Brazil (and are known, up to date, only from their original descriptions). However, *B. belchiori* has oval to pyriform branchiae, a unique coloration pattern, and relatively thin dorsal cirri with articles alternating in length, while *B. gonzaguinhai* has exclusively multilobate branchiae with up to five lobes, and dorsal cirri that vary in length more than in *B. lanai* sp. nov., especially on the anterior body.

**Table 1.** Morphological variation of selected characters among the type series of *Branchiosyllis lanai* sp. nov.

<i>B. lanai</i> sp.nov.						
	MOUFPE- -POL0001	MOUFPE- POL0002	MOUFPE- POL0003	MOUFPE- POL0004	MZUSP5444	MZUSP5445
Collection data	February 2020	Janeiro 2020	February 2020	February 2020	February 2020	February 2020
Type series	Holotype	Paratype 2	Paratype 2	Paratype 3	Paratype 4	Paratype 5
Number of chaetigers / Total length x width at proventricle (mm)	46+8 (stolon)/0.39	56+5 (stolon)/0.41	68/0.39	50+11 (stolon)/0.41	75/0.42	52/0.40
Length of pharynx (chaetigers)	6	6	4	5	6	4
Length of proventricle (chaetigers) / number of muscle cell rows	7/24	6/24	6/23	7/-	7/24	5/24
Number of articles						
Median antenna	13	-	-	10	12	10
Lateral antennae	13;13	-	-;13	-;9	10;10	-;12
Dorsal peristomial cirri	20;19	-	-; 30	19; -	15;21	20;10(broken)
Ventral peristomial cirri	10; 10	-	-;11	11; -	-	-; 10
Dorsal cirri 1	20;17	-	19;22	20; -	13;20	12;8
Dorsal cirri 2	14;0	-	18; 20	15; -	20;28	14;15
Dorsal cirri 3	24; 20	-	-;26	27; -	-;35	18;15
Dorsal cirri 4	24; 20	0;3	18;21	17; -	-	12;16
Dorsal cirri 5	23;16	0;24	17;17	16; -	-	14;12
Long cirri, midbody	11;20;0;23;16;-	28;0;0;0;0;0	14;17;17;17;-;-	-;-	25;22;23;25;24;0	12;11;11;11;10;10
Short cirri, midbody	19;15;17;15;14;16	-	13;17;15;14;16;15	16;19;22;22;18;14	22;20;30;28;28;27	9;5;7;10;8;10
Anal cirri	-	-	11	12	8	10
Number of unguiae per parapodium						
Anterior body	4-5	4	4-5	4	4-5	4-5
Midbody	4-5	4	4-5	4-5	4-5	4-5
Posterior body	3	4	4	3	4	4
Number of aciculae per parapodium	2/1/1	2/1/1	2/1/1	2/1/1	2/1/1	2/1/1



**Table 2.** Morphological comparison between species of *Branchiosyllis* occurring in Brazilian waters.

	<i>B. belchiori</i>	<i>B. diazi</i>	<i>B. exilis</i>	<i>B. gonzaguinhai</i>	<i>B. oculata</i>	<i>B. tamandarensis</i>	<i>B. lanai</i> sp. nov.
Original description	Nascimento, Fukuda & (Paiva, 2019)	Rioja, 1958	Gravier, 1900	Nascimento, Fukuda & Paiva, 2019	Ehlers, 1887	Paresque, Fukuda Nogueira 2016	This paper
Reference	Nascimento et al 2019	Alvares et al 2012	San Martín et al 2008a	Nascimento et al 2019	San Martín et al 2008a	Paresque et al 2016	This paper
Body	Subcylindrical	Flattened	Cylindrical	Flattened	Flattened	Flattened	Flattened
Eye spots	-	-	Absent	-	-	Absent	Absent
Branchiae	Present	Present	Absent	Present	Present	Present	Present
Falcigers	Absent	Present	Present	Absent	Absent	Absent	Absent
Ungulae	All parapodia	Posterior parapodia	Posterior parapodia	All parapodia	All parapodia	All parapodia	All parapodia
Pharynx length (segments)	3-5	7–8	5–6	5	6	5	4-6
Proventricle length (segments)	3	7–8	7–8	4	8	3.5–5	5-7
Number of muscle cell rows in proventricle	24–27	-	27–30	24	22	25–30	23/24
Habitat	Associated with the sponge <i>Haliclona caerulea</i>	Intertidal, among algae and in sand	Shallow waters, algae, gorgonians and coral rubble	Sponges	Intertidal, sand, algae, coral Rubble, sponge	Associated sponges	associated <i>Cinachyrella apion</i>
Distribution	Brazil (Todos os Santos Bay, Fernando de Noronha Island)	Gulf of México (Verdeland, Veracruz), and Brazil (Recife)	Circumtropical, warmer areas of the Mediterranean Sea, Australia (North and central Western Australia, South Australia, New South Wales, Northern Territory)	Brazil (Fernando de Noronha Island and Rocas Atoll)	Gulf of México and Caribbean Sea (Florida, Cuba, México, Venezuela)	Brazil (Paraíba and Pernambuco)	Brazil (Pernambuco)

The most similar species to *B. lanai* sp. nov. is *B. tamandarensis* which, in addition to the traits mentioned above, has exclusively multilobate branchiae with up to six lobes on midbody parapodia. In comparison with *B. tamandarensis*, however, parapodia from chaetiger 1 of *B. lanai* sp. nov. has no branchie, presenting, instead, dome-shaped branchiae on the parapodia of chaetiger

2, with multilobed branchiae (3 or 4 lobes) from chaetiger 3 onwards (Figure 3c, e).

Although *B. tamandarensis* and *B. lanai* sp. nov. have multilobed branchiae, these branchiae are different in shape. The branchiae of *B. tamandarensis* are more flattened than those of *B. lanai* sp. nov., and in the new species, their configuration varies along the anterior part of the body, with parapodia

of chaetiger 1 abbranchiate, and those of chaetiger 2 presenting dome-shaped branchiae, branchiae becoming slightly larger and with up to 4 lobes on midbody (Figure 3c, e), while midbody branchiae in *B. tamandarensis* may present up to 6 lobes (Table 2). In addition, while *B. tamandarensis* has ciliary tufts in different parts of the body (e.g., parapodial lobes and close to bases of cirri), no such ciliation was observed in specimens of *B. lanai* sp. nov.; moreover, dorsal cirri of *B. lanai* sp. nov. are somewhat stouter and slightly shorter throughout than those found in *B. tamandarensis*. Finally, there is a structure on the distal region of the cirrophore (Figure 3c) of *B. lanai* sp. nov. that has not been mentioned in any other *Branchiosyllis* species, and a dorsal protuberance was observed on the cirrophores of *B. lanai* sp. nov., which conveys the impression that this structure is relatively thicker in the new species than it is in other *Branchiosyllis* (e.g. *B. tamandarensis*; Paresque et al., 2016, Fig.10c).

**Etymology.** The species epithet is a posthumous tribute to Professor Paulo da Cunha Lana, lecturer and researcher at the Center for Marine Studies of the Federal University of Paraná, who continues to be an inspiration to all the authors of this study for his lifetime of contributions to the marine sciences and, in particular, to the study of the polychaetes. He will always be held dear in our memories.

**Habitat.** Specimens were found in association with sponges of the genus *Cynachirella* on the beach rocks in the intertidal zone of Paiva Beach. It was not possible to confirm a species-specific association.

**Reproduction.** Presence of acephalous reproductive stolon (Figure 2c).

## UPDATED KEY TO THE SPECIES OF GENUS BRANCHIOSYLLIS KNOWN TO OCCUR IN BRAZILIAN WATERS

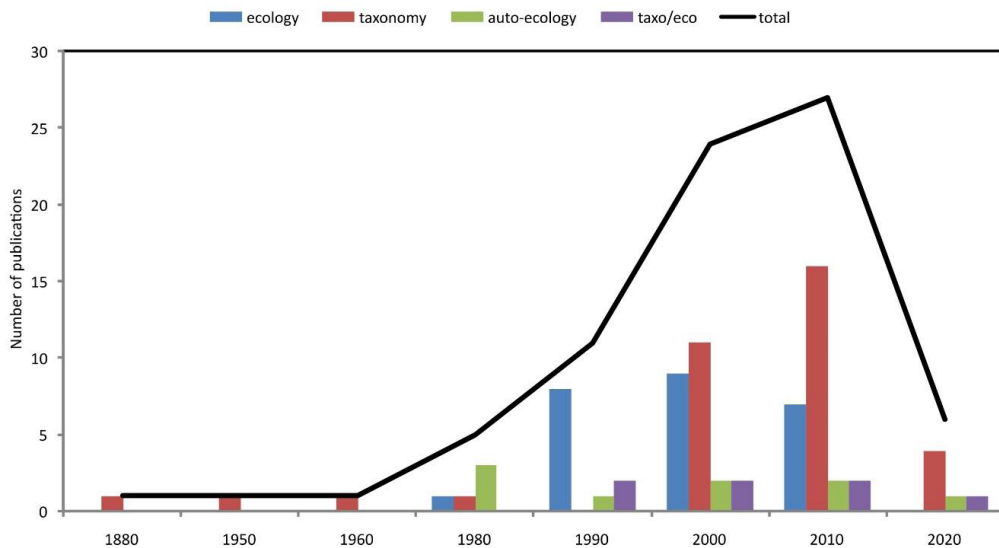
- 1a – Branchiae absent.....*B. exilis*
- 1b – Branchiae present..... 2
- 2a – Compound chaetae as unguulae and bidentate and unidentate falcigers.....*B. diazi* Rioja, 1958
- 2b – Compound chaetae as unguulae only ..... 3
- 3a – Unilobed branchiae only.....4
- 3b – Multilobed branchiae .....5
- 4a – Branchiae dome-shaped or flattened. Proventricle extending for 8 segments, with ~22 muscle-cell rows.....*B. oculata*

- 4b – Branchiae ovate to pyriform. Proventricle extending for 3 segments, with 24 – 27 muscle-cell rows..... *B. belchiori*
- 5a – Chaetiger 1 abbranchiate; branchiae on chaetiger 2 unilobed; branchiae multilobed from chaetiger 3 onwards, with up to 4 lobes. Cirrophore with collar..... *lanai* sp. nov.
- 5b – Multilobed branchiae on all setigers, with up to 6 lobes. Cirrophore without collar.....6
- 6a – Body subcylindrical, ciliary tufts present on parapodia. Branchiae with up to six lobes..... *B. tamandarensis*
- 6b – Body flattened, ciliary tufts absent on parapodia. Branchiae with up to five lobes.....*B. gonzaguinhai*.

## LITERATURE REVIEW

A total of 76 papers were considered. The first studies focusing on syllid-sponge associations were published in 1850, when Grube described polychaetes from the tropical coast of Australia. The number of published studies increased progressively over the subsequent decades, peaking from 1990 to 2000. Up until 1960, all the studies focused on the taxonomy of the syllids, whereas from the 1980s onward, additional subjects were considered (Figure 6). Most of the 76 papers analyzed here focused on taxonomy (46.09%), followed by ecology (32.89%), autoecology (11.84%), and taxonomy and ecology (9.21%) (Figure 6). Most of the studies were conducted in tropical countries, primarily in the Greater Caribbean region (Table S3 Supplementary Material).

In addition to the articles resulting from the PRISMA survey, other articles were used as references for this work, as well as for the development of a table with the associations of syllids-sponges already recorded (Table S3), reinforcing the intensity of the relationship between the two taxa. A total of 106 syllid-sponge associations were identified, which included 61 syllid species inhabiting 57 different sponge taxa (identified to at least genus, without considering the common name or description of the color). These associations included mutualism, commensalism, and parasitism. Most of the interactions were recorded in the tropics. Haplosyllis Langerhans, 1879 was the syllid genus involved in most associations (Table S3), with 18 species involved in 48 associations, followed by Branchiosyllis (15 species in 21 associations), Exogone Örsted, 1845 (six species in 11 records), and Syllis Savigny in Lamarck, 1818 (five species in six records).



**Figure 6.** Temporal evolution of the number of scientific publications about syllids inhabiting sponge. tax/eco: taxonomy and ecology.

## DISCUSSION

In general, polychaetes are a group of organisms with high ecological and physiological diversity, being able to live in diverse marine environments, and associated with other organisms, such as algae, mollusks, crustaceans, and sponges (Fauchald, 1977; Serrano and Preciado, 2007; Quirós-Rodríguez et al., 2023; Craveiro et al., 2024). As one of the most diverse polychaete groups, members of the family Syllidae are great examples of these successful adaptations (Serrano et al., 2006; Martins et al., 2013; Martin and Britayev, 2018).

The first studies about Syllidae inhabiting sponges were published in the 1880s, with the number of studies increasing progressively over the subsequent decades, and peaking in 1990–2000. While the initial studies focused on species descriptions, the focus shifted to other topics from the 1980s onward. Similar trends for an increase over time in both the number of studies and the topics considered have been observed in several other groups of marine plants and animals (Fauchald and Rouse, 1997; Montanara et al., 2022). This is primarily a consequence of the advances in ecological research that occurred during the second half of the 20<sup>th</sup> century, when the purely descriptive approach of early studies, which focused on the description of new species, shifted toward a more ecological perspective,

analyzing parameters such as feeding behavior and population dynamics (Pawlik, 1983; Martin et al., 2003; Turon et al., 2019), in addition to the characteristics (e.g. symbiosis and coevolution) of the biological interactions with the sponges (Martin and Britayev, 1998; Neves and Omena, 2003; Goren et al., 2021).

Most papers on syllid-sponge associations have been conducted in the tropics, in particular in the Caribbean region. This may reflect the greater species richness (Saeedi et al., 2022; Kolenbach et al., 2023), and more intense biological interactions at low latitudes (Longo et al., 2019), as well as the attractiveness of tropical coral reefs for tourism, which make these areas economically important, attracting more scientific interest and funds for research (Rull, 2014; Carlino and Saiz, 2019). In fact, the latitudinal diversity gradient is one of the most prominent patterns of biodiversity found on the planet (Zhang et al., 2022), and the species richness of virtually all marine groups is highest in equatorial regions, from which it declines progressively toward the poles (Hillebrand, 2004; Edgar et al., 2017). Following this trend, sponges are more diverse in tropical waters (Ruzicka and Gleason, 2008) and in particular in the Caribbean, where the taxonomy of this group is best known (Zea et al., 2014). While questioned by some authors (Schemske et al., 2009; Rabosky, 2021),

as pointed out by Wulff (2006), symbioses involving sponges appear to be more ubiquitous and diverse in tropical waters, which is consistent with the findings of this study. Another factor that may drive the scientific interest in tropical syllid-sponge associations is the relative abundance of coral reefs in the tropical zone, and their economic importance for tourism activities, such as fishing and diving (Rivera et al., 2020).

Although few studies have presented detailed data on the ecology of the syllids that inhabit sponges (which is probably due to the difficulty in developing more objective and efficient studies on the subject), some information is available on their reproductive patterns, feeding habits, and their role in colonization. *Haplosyllis*, Lattig, and Martin (2011) observed that these syllids maintain their stolons within the sponge during reproduction, avoiding dispersion of the juveniles and thus optimizing colonization. Martin et al. (2009) observed similar behavior in *Haplosyllides floridana* Augener, 1922 associated with the sponge *Xestospongia muta* (Schmidt, 1870). Most syllids are considered to be omnivores, and Giangrande et al. (2000) found spicules of the host sponge in the feces of *Syllis gracilis* Grube, 1840, *S. prolifera* Krohn, 1852, and *S. khronii* Ehlers, 1864, although their study also found species of detritivorous and herbivorous syllids. In addition, Giangrande et al. (2000) established the relationship of the guilds (based on the pharynx armature) with the type of feeding presented by different species of *Syllis*, which prompted Martin and Britayev (2018) to conclude that *Haplosyllis* species may also prey on their host sponges. *Ramisyllis multicaudata* Glasby, Schroeder, and Aguado, 2012 is also known to suck sponge cells to feed (Martin and Britayev, 2018), while some *Haplosyllis* species are territorial and were observed defending their hosts from spongivorous nudibranchs of the genus *Hypseloferis* W. Stimpson, 1855 (Martin et al. 2009; Lattig and Martin, 2011).

In total, seven syllid genera (*Branchiosyllis*, *Exogone*, *Haplosyllis*, *Odontosyllis* Claparède, 1863, *Parexogone* Mesnil and Caullery, 1918, *Salvatoria* McIntosh, 1885, and *Syllis*) were recorded inhabiting *Cinachyrella* sponges from Paiva Beach, with dominance of *Branchiosyllis*. These polychaetes

were found either on the sponges surface or in the inner channels of the sponges. Nearly half (51.55%) of the *Branchiosyllis* specimens from Paiva Beach were found in the oscula of the sponges, and the other 48.45% in the channels. Most of the specimens were female, and some had stolons, which indicates that they were reproducing, as observed in other syllids associated with sponges (Lattig and Martin, 2011; Martin and Britayev, 2018). All individuals were yellowish, the same color as the host sponge. Pawlik (1983) observed that *Branchiosyllis oculata* was of the same color of the host sponge, which may indicate a certain level of mimicry. As recorded in *Haplosyllis* by Turon et al. (2019), specimens of different species of the same genus, in this case *Branchiosyllis tamandarensis* and *Branchiosyllis lanai* sp. nov., were found inhabiting the same individuals of *Cinachyrella apion* (Uliczka, 1929) at Paiva beach.

## CONCLUSIONS

While scarce detailed data is available on the interspecific interactions between syllid polychaetes and sponges, there was a significant advance in this area of research toward the end of the 20<sup>th</sup> century, via both an increase in the number of studies and a major shift in the scope of the research, beyond the taxonomic description of syllid species. These advances represent an important step forward in the scientific understanding of the organization of benthic communities and their ecological and evolutionary relationships. The quest to understand how these communities function, in particular those associated with sponges, can also lead to the discovery of new species, as observed in the case of this study, which described *Branchiosyllis lanai* sp. nov., a syllid polychaete found in association with sponges in the South Atlantic Ocean.

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N.C.: Formal Analysis & Writing.

K.P.: Formal Analysis & Writing.

M.V.F.: Formal Analysis; Writing & Revised.

J.S.R.F.: Funding Acquisition; Project Administration; Conceptualization; Methodology; Writing & Revised.

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