Seasonal variation of epiphytic hydroids (Cnidaria: Hydrozoa) associated to a subtropical Sargassum cymosum (Phaeophyta: Fucales) bed
ABSTRACT. Hydroids are broadly reported in epiphytic associations from different localities showing marked seasonal cycles. Studies have shown that the factors behind these seasonal differences in hydroid richness and abundance may vary significantly according to the area of study. Seasonal differences in epiphytic hydroid cover and richness were evaluated in a Sargassum cymosum C. Agardh bed from Lázaro beach, at Ubatuba, Brazil. Significant seasonal differences were found in total hydroid cover, but not in species richness. Hydroid cover increased from March (early fall) to February (summer). Most of this pattern was caused by two of the most abundant species: Aglaophenia latericaudata Allman, 1877 and Orthopyxis sargassicola (Nutting, 1915). Hydroid richness seems to be related to S. cymosum size but not directly to its biomass. The seasonal differences in hydroid richness and algal cover are shown to be similar to other works in the study region and in the Mediterranean. Seasonal recruitment of hydroid species larvae may be responsible for their seasonal differences in algal cover, although other factors such as grazing activity of gammarid amphipods on S. cymosum must be taken into account.

KEY WORDS. Epibionts; hydroid cover; hydrozoans.
In this sense, this study aims to evaluate the possible influence of season and algal characteristics on epiphytic hydroid cover and richness in a subtropical Sargassum cymosum C. Agardh bed.

**MATERIAL AND METHODS**

The sampling was carried out at Lázaro beach, located at Fortaleza inlet (23°30'S, 45°08'W), in the municipality of Ubatuba, northeastern coast of the state of São Paulo, Brazil. This area presents large and continuous macroalgal beds that extend from the infralittoral fringe to approximately 4 m deep, and is moderately sheltered from wave action (JACOBUCCI & LEITE 2002). Sargassum cymosum is dominant in the area but other species of algae such as Dictyopteris delicatula Lamouroux may be found in lower abundances (SZECHY & PAULA 1997).

NEGRIEROS-FRANSOZO et al. (1991) registered higher values of maximum rainfall during March and lower levels during August for the Fortaleza inlet, with mean annual values of water temperature, dissolved oxygen and salinity of 23.5°C, 5.46 mg/L and 34.4‰, respectively. In this same region, mean values of S. cymosum biomass and length were shown to be higher during spring and lower during summer and autumn by PAULA & OLIVEIRA-FILHO (1980). These authors observed the presence of young and mature plants during the entire year, showing their primary and secondary axis in various stages of development, from initial differentiation to fertile or in senescence.

To evaluate seasonal variation in richness and abundance of epiphytic hydroids associated with S. cymosum, sampling was carried out in March, July and December 2007, and February 2008. In each sampling date, 20 algal fronds of S. cymosum were randomly collected by snorkeling, excepting July when 13 fronds were collected, due to logistical problems. The fronds were scraped off with a spatula and wrapped in cloth bags. The hydroids on S. cymosum were anesthetized immersing the fronds in a 7.5% MgCl₂·6H₂O solution for approximately two minutes, as described by OLIVEIRA-ET AL. (2006).

To measure hydroid cover, each frond was placed between two 30 x 30 cm glass plates, marked with square subdivisions of 10 x 10 mm (Fig. 1). When necessary the fronds were cut into fragments before being placed between the glass plates to avoid any overlap of the thallus. The measure of hydroid cover was done counting the subdivisions in which the algal fronds were present, and those in which hydroids were present (considering both sides of the plates). The number of subdivisions occupied by the fronds was used as a measure of the size of the fronds. Hydroid cover was calculated as the ratio between the number of subdivisions occupied by hydroids and the number of subdivisions occupied by the fronds. In this way, a proportion value was obtained, and then transformed into the percentage values of hydroid cover, for each frond and sampling period. After measuring hydroid cover, the fronds were dried pressing them between paper towels at room temperature for 48 h and then weighted to obtain their dry biomass.

**RESULTS**

Hydroid species were identified with the help of specific literature (CALDER 1991b, CORNELLUS 1995a, b, MEGOTTO 1996). Hydroid species frequency of occurrence, that is, the percentage of fronds in which each hydroid species was present, was calculated as the ratio between the number of fronds occupied by each hydroid species and the total number of fronds collected in each sampling period.

The data were compared among sampling periods through one way ANOVA followed by post hoc Tukey test, for significant differences. To infer possible relations of hydroid cover and richness with algae frond size and biomass we tested the association of these variables using Pearson correlation test. When necessary, the data were arcsine and log(x+1) transformed to meet the assumptions of the tests (ZHAR 1996).

In the dry biomass comparison among sampling periods, the relation of the samples from July and February with the other months was not clear. The same happened with the samples of species cover from July. That may happen when the multiple comparison test was not able to determine from which population these samples came from (ZHAR 1996), even though the analysis of variance stated that they were different. In this sense, the comparisons of these variables were done only among those months which did not present any conflicts when the results of the multiple comparison test were interpreted.
Seasonal variation of epiphytic hydroids associated to *Sargassum cymosum*

Figures 2-17. Species of hydroids found during analysis: (2) *Aglaophenia latecarinata*; (3) *Clytia gracilis*; (4) *Coryne pusilla*; (5) *Dentitheca bidentata*; (6) *Orthopyxis sargassicola*; (7) *Eudendriidae sp1*; (8) *Cladocoryne floccosa*; (9) *Monotheca margaretta*; (10) *Obelia dichotoma*; (11) *Halopteris diaphana*; (12) *Dynamena disticha*; (13) *Plumularia strictocarpa*; (14) *Sertularia marginata*; (15) *Halecium tenellum*; (16) *Sertularia turbinata*; (17) *Haleciidae sp. 1*. Scales: (2) 1 mm, (3, 6, 7, 11, 12) 200 µm, (4) 300 µm, (5, 8, 9, 13) 400 µm, (10, 14, 16) 700 µm, (15) 100 µm, (17) 250 µm.
cymosum fronds varied among sampling periods ($F_i = 14.14, p < 0.05$), with higher cover values on the fronds collected in February (Fig. 18).

Hydroid richness was not different among sampling periods ($F_i = 1.95, p > 0.05$), with a mean value of three to four species per sampling period (Fig. 19). The highest number of hydroid species occurring on the same frond was seven, and few fronds (approximately 5%) presented only one species. The size of the fronds, as well, was not different among sampling periods ($F_i = 2.01, p > 0.05$, Fig. 20), but was positively correlated with hydroids species richness ($r = 0.29, p < 0.05$, Fig. 21). The dry biomass of the *S. cymosum* fronds was different among sampling periods ($F_i = 2.96, p < 0.05$, Fig. 22) with higher values in December, but no correlation was detected among the fronds dry biomass and hydroids species richness ($r = 0.19, p > 0.05$, Fig. 23).

Considering all the species found, five were present in all sampling periods while the others varied in their occurrences (Tab. 1, Figs 24-27). *Aglaophenia latecarinata* Allman, 1877 presented the highest value of frond cover, with maximum of 71.4% of cover in one frond collected in February. Since many species occurred sporadically and presented low frond cover, we evaluated the seasonal difference of hydroid species cover only for the four species which occurred in at least 50% of the fronds collected in each month. Among these species, *A. latecarinata* and *Orthopyxis sargassicola* (Nutting, 1915) presented a higher percentage of cover in December and February (first species), and February (second species). *Dynamena disticha* (Bosc, 1802) and *Sertularia turbinata* (Lamouroux, 1816) had similar frond cover among sampling periods (Tab. II).

### Table I. Frequency of occurrence (%) of hydroid species in Lázaro beach, Ubatuba. Taxonomic list in accordance with Migotto et al. (2002).

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<tbody>
<tr>
<td>Number of Fronds</td>
<td>20</td>
<td>13</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Anthoathecata</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Cladocorynidae</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cladocoryne floccosa Rotch, 1871</td>
<td>CF</td>
<td>–</td>
<td>7.7</td>
<td>10.0</td>
</tr>
<tr>
<td>Eudendriidae</td>
<td></td>
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<td></td>
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<tr>
<td>Eudendriidae sp. 1</td>
<td>ED</td>
<td>30.0</td>
<td>7.7</td>
<td>30.8</td>
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<tr>
<td>Corynidae</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Coryne pusilla Gaertner, 1774</td>
<td>CP</td>
<td>–</td>
<td>7.7</td>
<td>–</td>
</tr>
<tr>
<td>Leptotheccata</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Aglaopheniidae</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aglaophenia latecarinata Allman, 1877</td>
<td>AL</td>
<td>85.0</td>
<td>92.3</td>
<td>90.0</td>
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<tr>
<td>Haleciidae</td>
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<tr>
<td>Haleciidae sp. 1</td>
<td>HA</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Halecium tenellum Hincks, 1861</td>
<td>HT</td>
<td>–</td>
<td>15.4</td>
<td>–</td>
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<tr>
<td>Halopterididae</td>
<td></td>
<td></td>
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<tr>
<td>Halopteris diaphana (Heller, 1868)</td>
<td>HD</td>
<td>25.0</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Plumulariidae</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Dentitheca bidentata (Jäderholm, 1920)</td>
<td>DB</td>
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<td>–</td>
</tr>
<tr>
<td>Monotheca margaretta Nutting, 1900</td>
<td>MM</td>
<td>15.0</td>
<td>46.2</td>
<td>20.0</td>
</tr>
<tr>
<td>Plumularia strictocarpa Pictet, 1893</td>
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<td>20.0</td>
<td>7.7</td>
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</tr>
<tr>
<td>Sertulariidae</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dynamena disticha (Bosc, 1802)</td>
<td>DD</td>
<td>85.0</td>
<td>84.6</td>
<td>70.0</td>
</tr>
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<td>Sertularia marginata (Kirchenpauer, 1864)</td>
<td>SM</td>
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<td>–</td>
<td>5.0</td>
</tr>
<tr>
<td>Sertularia turbinata (Lamouroux, 1816)</td>
<td>ST</td>
<td>80.0</td>
<td>84.6</td>
<td>65.0</td>
</tr>
<tr>
<td>Campanulariidae</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Clytia gracilis (M. Sars, 1851)</td>
<td>CG</td>
<td>10.0</td>
<td>15.4</td>
<td>–</td>
</tr>
<tr>
<td>Obelia dichotoma (Linnaeus, 1758)</td>
<td>OD</td>
<td>–</td>
<td>15.4</td>
<td>–</td>
</tr>
<tr>
<td>Orthopyxis sargassicola (Nutting, 1915)</td>
<td>OS</td>
<td>50.0</td>
<td>53.8</td>
<td>50.0</td>
</tr>
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Figures 18-19. Hydroid algal cover and richness (mean values/frond ± standard error) in Lázaro beach, Ubatuba. Cover was calculated as the ratio between the number of 1 cm² subdivisions occupied by hydroids and the number of subdivisions occupied by the fronds (see text for details). Same letters indicate absence of significant differences.

Figures 20-21. *Sargassum cymosum* frond size (number of 1 cm² subdivisions occupied by the algae, see text for details) in Lázaro beach, Ubatuba, with its correspondent hydroid species richness. Same letters indicate absence of significant differences.

Table II. Mean values of hydroid cover (± standard error), ANOVA and Tukey test results of the most frequent and abundant hydroid species at Lázaro beach (M: March, J: July, D: December, F: February). Cover was calculated as the ratio between the number of 1 cm² subdivisions occupied by hydroids and the number of subdivisions occupied by the fronds (see text for details). Underlined letters indicate absence of significant differences.

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<tbody>
<tr>
<td><em>Aglaophenia latecarinata</em></td>
<td>0.040 ± 0.010</td>
<td>0.11 ± 0.03</td>
<td>0.180 ± 0.030</td>
<td>0.25 ± 0.06</td>
<td>F = 7.82*</td>
<td>M DF**</td>
</tr>
<tr>
<td><em>Dynamena disticha</em></td>
<td>0.060 ± 0.020</td>
<td>0.06 ± 0.03</td>
<td>0.080 ± 0.030</td>
<td>0.06 ± 0.03</td>
<td>F = 0.11</td>
<td>MDF</td>
</tr>
<tr>
<td><em>Orthopyxis sargassicola</em></td>
<td>0.002 ± 0.001</td>
<td>0.02 ± 0.01</td>
<td>0.003 ± 0.001</td>
<td>0.11 ± 0.05</td>
<td>F = 3.94*</td>
<td>MDF*</td>
</tr>
<tr>
<td><em>Sertularia turbinata</em></td>
<td>0.020 ± 0.010</td>
<td>0.02 ± 0.01</td>
<td>0.030 ± 0.010</td>
<td>0.03 ± 0.01</td>
<td>F = 0.14</td>
<td>MDF</td>
</tr>
</tbody>
</table>

*p < 0.05. **The relation between July and the other months is not clear by the multiple comparison test.
Figures 22-23. *Sargassum cymosum* dry biomass (mean values ± standard error) in Lázaro beach, Ubatuba, with its correspondent hydroid species richness. Same letters indicate absence of significant differences. The relation between July and February with the other months is not clear by the multiple comparison test.

Figures 24-27. Percentages of hydroid species algal cover (mean values/frond ± standard error) in the sampling periods in which they occurred. Cover was calculated as the ratio between the number of 1 cm² subdivisions occupied by hydroids and the number of subdivisions occupied by the fronds (see text for details). Species codes are in accordance with table I.
DISCUSSION

Hydroid cover in Lázaro beach showed lower levels during early autumn, winter and early summer (March, July and December, respectively) followed by an increase during late summer (February). Hydroid richness however, was constant, without seasonal variations. Epiphytic hydroid richness and abundance were also shown to be higher during summer at the Mediterranean region (Llobet et al. 1991, Fraschetti et al. 2002), although Fauci & Boero (2000) reported an increase in hydroid richness and abundance during the cold season at this same region. Watson (1992) found differences in hydroid colonization level between two different sites, at southern and southwestern Australia, the first presenting maximum hydroid colonization during summer and the last during early winter. Also in Australia, Borowitzka et al. (1990) found a higher number of epiphytic organisms during summer. At the Atlantic coast of United States, Calder (1990) found marked seasonal activity cycles of hydroid species, and the greatest number of species occurring during late spring.

The number of hydroid species (16) occurring on S. cymosum in Lázaro beach may be considered relatively high when compared to other studies of epiphytic hydroids on Sargassum. Nishihiira (1965) found 14 species on S. hemiphyllum (Turner) C. Agardh and 10 species on S. tortile C. Agardh from Japan, Calder (1995) found 10 species on S. fluitans Boergesen and eight species on S. natans (Linnaeus) Gallion from Bermuda, and Haddad & Chiaverini (2000) found seven species on S. stenophyllum Martius from Guaratuba, Brazil. Differences in hydroid richness among localities may be caused by the different algal substrate in which they occur. Studies have shown that hydroid species composition may even differ among algal species that occur at the same locality (e.g. Watson 1992, Fauci & Boero 2000), and that is probably caused by variations in the life cycle of the host. It can influence the hydroid ability of colonization of different host parts and provide more or less available space for attachment during different periods of the year (Borowitzka et al. 1990, Llobet et al. 1991, García-Rubies 1992).

The maximum species richness recorded for a single frond was similar to that recorded by Calder (1995) on S. fluitans from Bermuda, although he did not find less than two species of hydroids occurring on the same frond. In the present study, approximately 5% of the fronds of S. cymosum presented only one hydroid species. Haddad & Chiaverini (2000) found the majority of the S. stenophyllum samples colonized by one species of hydroid, while O.M.P. Oliveira (pers. comm.) noticed a high frequency of S. cymosum fronds from the São Sebastião channel without any hydroid species. These authors believe that the occurrence of few or no species per algal frond seems to be a result of its size, considering that smaller fronds may offer less available space for attachment. This may be evidenced when the size of the fronds of Sargassum is compared. S. cymosum from Ubatuba present a maximum length of about 30 cm (Paula & Oliveira-Filho 1980) and S. stenophyllum from Guaratuba 35 cm (Haddad & Chiaverini 2000), while S. fluitans and S. natans from Bermuda present a maximum length of about 100 and 50 cm, respectively (Little et al. 1989). The positive correlation between algal frond size and hydroid richness found in the present study reinforces the importance of available space for attachment to hydroid richness. This factor may explain the absence of differences in the number of species colonizing S. cymosum among sampling periods since no differences on the size of the fronds were detected among periods.

The structural complexity of the algae may also influence hydroid colonization and species richness, since more complex algae offers a higher number of microhabitats for attachment (Fraschetti et al. 2006, Ronowicz et al. 2008). Studies have shown that algal biomass may be a measure of its complexity, since higher values of biomass may be related to increased living space, food availability and protection from predators, favoring epiphytic species richness and abundance (Heck & Westone 1977, Stoner 1980, Leite & Turra 2003). Despite this, in this study S. cymosum biomass was not related to hydroid species richness. The dry biomass of S. cymosum fronds of Lázaro beach increased in December, but it was not followed by an increase in hydroid richness, which may evidence that the increase in the biomass of fronds did not reflect important differences in the availability of space for attachment.

Concerning the hydroid species, the occurrence of some dominant species which are always more frequent and abundant than the others seems to be common (e.g. Kato et al. 1961, Boero & Fresi 1986, Rocca et al. 1991). Haddad & Chiaverini (2000) found that three species of hydroids, Obelia geniculata (Linnaeus, 1758), O. sargassicola and Sertularia distans (Lamouroux, 1816) were responsible for the higher levels of S. stenophylum cover, while the other four species together did not achieve 1% of algal cover. In our study A. latecarinata, O. sargassicola, D. disticha and S. turbinata were usually dominant in algal cover, being present in almost all fronds collected in all sampling periods.

Dominant hydroid species may influence the spatial distribution of other species of hydroids growing on the same alga by means of interspecific competition, inducing a decrease in their colony size and abundance (Kato et al. 1962a, b, 1969). It was not possible, however, to observe the existence of interspecific competition among the dominant and non-dominant species in this study, since no analysis was done on the spatial distribution of the hydroid species on the algal fronds. Despite this, many studies have shown that hydroid larvae may settle at specific places on the algal thallus, as a response to different environmental conditions and continual growth of the algal substrate (Hughes et al. 1991, Fraschetti et al. 2006), especially when perennial algae species are considered, such as S. cymosum (Paula & Oliveira-Filho 1980). The morphology of the alga, chemical substances produced by it and the period of larval recruitment may also influence the intensity of larval settlement, and consequently, hydroid species abundance (Nishihiira 1967, 1968a, b, c).
In general, epiphytic hydroid studies report the prevalence of species with fixed gonophores (e.g. Boero 1987, Fraschetti et al. 2006), and the same was observed in our study. Considering all the species found, only Clytia gracilis (M. Sars, 1851) and Obelia dichotoma (Linnaeus, 1758) produce free medusa, while all the others reproduce by fixed gonophores (Calder 1991b, 1997, Cornelius 1999a, Migotto 1996). An exception may be the case of Denditheca bidentata (Jäderholm, 1920), O. sargassica and Sertularia marginata (Kirchenpauer, 1864), which produce short-lived medusoids (Calder 1991b, Migotto 1998, Migotto & Marques 1999). The absence of a long-lived medusa stage in the majority of epiphytic hydroid species enables them to persist on a favorable algal substrate, ensuring a suitable substrate for subsequent generations (Fraschetti et al. 2002, Ronowicz et al. 2008).

In favorable conditions, these species larvae may settle at the vicinity of their conspecific colonies, and substantially increase their abundance on the alga. Considering the dominant hydroid species, little information exists on their life cycle and reproduction periods. L.P. Andrade (pers. comm.) verified that A. latecarinata from São Sebastião, Brazil, have its peak of reproduction during the summer months, the same period of this species highest cover values recorded in the present study. In what concerns O. sargassica, no information on its reproduction periods is available for the study area.

Other species of the fauna associated to Sargassum may also directly or indirectly affect hydroid cover. Studies have shown that macroalgal larvae and juveniles may be affected by meiofauna, in terms of predation, competition for food or space, by increasing their mortality rates and decreasing successful settling (e.g. Dahms et al. 2004). Other members of the macrofauna may also affect epiphytic species abundance indirectly, by grazing on macrophytes (Stoner et al. 1995). Herbivore grazing pressure greatly affects the macrophyte community structure, reducing parts of the plants frequently occupied by epiphytic hydroids (Garcia-Rubies 1987, Elger et al. 2009).

Gammarid amphipods are important meso-herbivores on macroalgal communities, grazing on Sargassum and associated epiphytes (Jacobucci & Leite 2008). Jacobucci & Leite (2002) observed that the abundance of gammarid amphipods associated with S. cymosum from Lázaro beach was higher during winter (minimum hydroid cover) and lower during summer, which coincides with the period of maximum hydroid algal cover recorded in this study. Their grazing activity on S. cymosum during the period of their maximum abundance (winter) may have contributed to the lower levels of hydroid algal cover recorded in this season.

In what concerns the environmental factors, it is known that in tropical areas species have their peak of abundance during the periods of maximum rainfall, mostly because of the large availability of food, characteristic of this period (e.g. Camillo et al. 2008). Energetic constraints caused by the seasonal variation of food availability may be responsible for declines on hydroid growth rates and regression of polyps (Gili & Hughes 1995), being also considered one of the factors behind the occurrence of summer dormancy of some hydroid species on the Mediterranean (Coma & Riba 2003). Since no abiotic factors were examined during the sampling of this study, it is difficult to associate the variations on hydroid cover with the changes on nutrient availability with season. It is known, however, that the sediments from Lázaro beach present the highest organic matter content when compared to other sites located at the Fortaleza inlet, in Ubatuba (Negeiros-Fransozo et al. 1991). Studies have shown that this higher organic matter content is responsible for the higher abundance of some benthic organisms in this area (Fransozo et al. 1992, Mantelatto et al. 1995). This may evidence the importance of nutrient availability for benthic species in Lázaro beach, and it may also be true for epiphytic hydroids. It may be considered another important factor affecting hydroids algal cover, especially in tropical epiphytic communities.

Hydroid algal cover changed significantly with time, and this change may be influenced by a variety of biotic and abiotic factors that might be different considering the study area. Therefore, the seasonal effect must be taken into account in any study involving epiphytic hydroid species, since it can determine the composition and abundance of species in a specific time and place.

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LITERATURE CITED


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