Lat. Am. J. Aquat. Res., 43(5): 936-943, 2015
DOI: 10.3856/vol43-issue5-fulltext-13

Research Article

First study on infestation of *Excorallana berbicensis* (Isopoda: Corallanidae) on six fishes in a reservoir in Brazilian Amazon during dry and rainy seasons

Huann Carllo Gentil-Vasconcelos[1] & Marcos Tavares-Dias[1,2]
[1]Postgraduate Program on Tropical Biodiversity (PPGBIO)
Federal University of Amapá Macapá, AP, Brazil
[2]Aquatic Organism Health Laboratory, Embrapa Amapá, Rodovia Juscelino Kubitschek N°2600, 68903-419, Macapá, AP, Brazil
Corresponding Author: Marcos Tavares Dias (marcos.tavares@embrapa.br)

ABSTRACT. We analyzed the infestation levels of *Excorallana berbicensis* on *Acestrorhynchus falcirostris*, *Ageneiosus ucayalensis*, *Geophagus proximus*, *Hemiodus unimaculatus*, *Psectrogaster falcata* and *Serrasalmus gibbus* in a reservoir in the Araguari River basin, northern Brazil, during the dry and rainy seasons. For *P. falcata*, the infestation levels due to *E. berbicensis* were greater during the rainy season. For all the species studied, the peak parasite prevalence was in the month of highest rainfall levels and there were two peaks of parasite abundance: one in the month with highest rainfall level and the other in the month of transition from the rainy season to the dry season. In these hosts, around 70% of the *E. berbicensis* specimens were collected during the rainy season. The body conditions of the hosts also did not suffer any seasonal influence. Despite the differences in seasonal rainfall levels, there was no fluctuation in transparency, turbidity, pH, electric conductivity, temperature and dissolved oxygen levels in the water, due to the stability of these parameters during the seasonal cycle investigated in this artificial Amazon ecosystem. This was the first report on the seasonality of infestation by *E. berbicensis* associated with fish.

Keywords: *Excorallana berbicensis*, isopod, ectoparasites, wild fish, seasonality, Amazon River.

Primer estudio de la infestación de *Excorallana berbicensis* (Isopoda: Corallanidae) en seis peces en un embalse del Amazonas brasileño durante las estaciones seca y lluviosa

RESUMEN. Se analizó los efectos de las estaciones seca y lluviosa sobre los niveles de infestación de *Excorallana berbicensis* en *Acestrorhynchus falcirostris*, *Ageneiosus ucayalensis*, *Geophagus proximus*, *Hemiodus unimaculatus*, *Psectrogaster falcata* y *Serrasalmus gibbus* en un embalse en la cuenca del Río Araguari, norte de Brasil. Para *P. falcata*, la prevalencia y abundancia de *E. berbicensis* fue mayor en la estación lluviosa. Para todas las especies estudiadas, la prevalencia máxima del parásito fue en el mes más lluvioso, donde hubo máximos de abundancia de parásitos: una en el mes con mayores precipitaciones y la otra en el mes de transición de la estación lluviosa a seca. En estos hospederos, se obtuvo alrededor del 70% de muestras de *E. berbicensis* durante la estación lluviosa. Las condiciones del cuerpo de los hospederos tampoco sufrieron influencia estacional. A pesar de las diferencias en los niveles estacionales de precipitaciones, no hubo fluctuaciones en transparencia, turbidez, pH, conductividad eléctrica, temperatura y oxígeno disuelto en el agua, debido a la estabilidad de estos parámetros durante el ciclo estacional analizado en este ecosistema artificial Amazónico. Este es el primer registro sobre la estacionalidad de la infestación de *E. berbicensis* asociado a peces.

Palabras clave: *Excorallana berbicensis*, isópodos, ectoparásitos, peces salvajes, estacionalidad, Amazónia.

Corresponding editor: Mauricio Laterça

INTRODUCTION

Excorallana Stebbing, 1904 (Corallanidae) are isopods consisting of 24 species (Schotte, 2014) occurring predominantly in marine environments of tropical and subtropical latitudes (Guzmán *et al*., 1988; Delaney 1989). They are associated especially with substrates (Delaney, 1984; Hendrickx & Espinosa-Pérez, 1998; Morgado & Tanaka, 2001). Corallanids of this genus have also been occasionally described associated to zooplankton (Guzmán *et al*., 1988), also collected from the intertidal zone (Kensley *et al*., 1995) and to marine fish species from different environments (Williams Jr. & Bunkley-Williams, 1994; Semmens *et al*., 2006; Álvarez-León, 2009). Some species of *Excorallana* occur especially in environments of great depth (Delaney, 1989), but only *Excorallana berbicensis* Boone, 1918, *E. tricornis occidentalis* Richardson, 1905, *E. quadricornis* Hansen, 1890 and *E. longicornis* Lemos de Castro, 1960 have been collected from mangroves (Delaney, 1984). Corallanids are voracious carnivore isopods that act as predators and also as scavengers (Brusca & Wehrtmann, 2009). *E. tricornis occidentalis* is a facultative parasite for many marine fish and, when in massive infestations, it causes serious damage to fishing of *Epinephelus striatus* Bloch, 1792 (Semmens *et al*., 2006). However, information on *Excorallana* spp. on freshwater fish is scarce (Van Name, 1925; Monod, 1969; Thatcher, 1995). *Excorallana* spp. has mostly been studied regarding their taxonomy (Van Name, 1925; Monod, 1969; Delaney, 1984, 1989; Kensley *et al*., 1995; Thatcher, 1995; Hendrickx & Espinosa-Pérez, 1998), but a few studies on their epidemiology in fish have been conducted (Semmens *et al*., 2006).

Excorallana berbicensis was described parasitizing *Lycengraulis grossideus* Spix & Agassiz, 1829 in rivers from French Guiana (Van Name, 1925); a species of shark in freshwater from Guyana (Monod, 1969); and *Ageneiosus inermis* Linnaeus, 1766 from Amazon River basin, in Brazil (Thatcher, 1995). However, in addition to the small number of studies on *E. berbicensis* in association with fish, there are no reports regarding seasonal variation in infestation levels of these isopods in host fish population.

In the Amazon region, seasonality influenced by precipitation is characterized by two cycles, the rainy and dry season (Souza & Cunha, 2010; Cunha *et al*., 2013). These seasonal dynamics greatly influence in ichthyofauna community structures (Galacatos *et al*., 2004) and can also influence infracommunities of parasites in fish populations. For different fish species from Amazon, low levels of infestation by argulids species have been reported in the dry season (Malta, 1982; Malta & Varella, 1983). In contrast, parasitism by *Dolops nana* (Neves *et al*., 2013), *Miracetyma* sp. (Vital *et al*., 2011) and *Ergasilus turucuyus* Malta & Varella, 1996 (Vasconcelos & Tavares-Dias, 2014) have not been found to be influenced by the dry season or rainy season. However, Bauer & Karimov (1990) argued that, in regions between the tropics, the relatively constant climate does not favor seasonal fluctuations of parasitism. In temperate climatic regions, temperature has been considered to be the most important factor influencing the seasonality of parasite infracommunities. Consequently, it can directly or indirectly influence ectoparasites crustacean infestations (Jones, 1974; Guzmán *et al*., 1988; Kadlec *et al*., 2003; Pech *et al*., 2010; Alsarakibi *et al*., 2014). In the Reservoir of the Coaracy Nunes hydroelectric power plant in Araguari River basin, in the eastern Amazon region (Northern Brazil), *Ageneiosus ucayalensis* Castelnau, 1855; *Hemiodus unimaculatus* Bloch, 1794; *Serrasalmus gibbus* Castelnau, 1855; *Geophagus proximus* Castelnau, 1855, *Acestrorhynchus falcirostris* Cuvier, 1819 and *Psectrogaster falcata* Eigenmann and Eigenmann, 1889 are the most abundant fish species (Sá-Oliveira *et al*., 2013, 2015). These six fish species presents different life habits, once *H. unimaculatus* has omnivorous diet, mainly consuming algae, detritus and other aquatic invertebrates, and *P. falcata* is detritivorous, feeding on detritus and microorganisms associated with the substrate. *Geophagus proximus* is omnivorous, mainly feeding of plant material, mollusks, insects and other aquatic invertebrates, and *A. ucayalensis* is carnivorous, consuming fish, insects and other aquatic invertebrates. *Acestrorhynchus falcirostris* and *S. gibbus* are piscivorous fish (Santos *et al*., 2004). However, the parasites fauna on fish of this reservoir is few known (Vasconcelos & Tavares-Dias, 2014). Thus, the aim of study was to investigate the prevalence and abundance of *E. berbicensis* in these six species of fish from this Amazonian reservoir during rainy and dry seasons.

MATERIALS AND METHODS

Study area

The water Reservoir of the Coaracy Nunes Hydroelectric Power Plant (Fig. 1) is located in the municipality of Ferreira Gomes, Amapá State, in the eastern Amazon region (northern Brazil). Its area is 23.5 km^2, capacity 138 Hm^3 and average depth 15 m. This reservoir began its operations in 1974 and is connected to the Araguari River basin, which originates south of the Lombada and Tumucumaque mountain ranges and flows to the Atlantic Ocean (Bárbara *et al*., 2010; Sá-Oliveira *et al*., 2013). This reservoir is a tran-

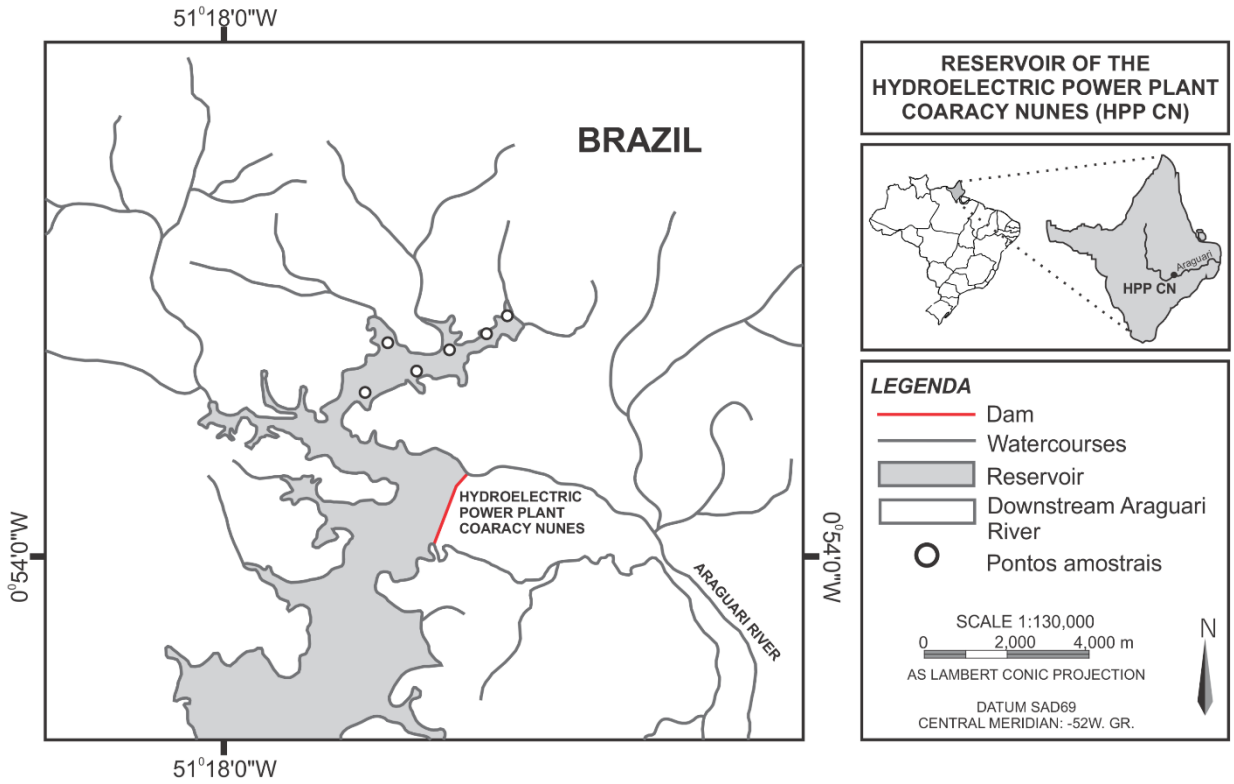

Figure 1. Fish collection locality, in a reservoir from Araguari River basin, in the eastern Amazon region (Brazil).

sition area between lotic and lentic environments and has marginal areas with only a few aquatic macrophytes, especially *Eichhornia crassipes* and *Eleocharis* sp., and great quantities of decomposing arboreal vegetation, due to non-deforestation of the area that was destined for the reservoir.

Fish and collection procedures

For study of parasites, specimens of *Acestrorhynchus falcirostris* (Acestrorhynchidae), *Ageneiosus ucayalensis* (Auchenipteridae), *Geophagus proximus* (Cichlidae), *Hemiodus unimaculatus* (Hemiodontidae), *Serrasalmus gibbus* (Serrasalmidae) and *Psectrogaster falcata* (Curimatidae) were collected in the Coaracy Nunes Reservoir (Fig. 1), a long-established ecosystem, about 40 years (Sá-Oliveira *et al*., 2015). A total of 296 fish specimens were caught during the dry season (October 2012 to February 2013) and rainy season (April to August 2013) at six sampling points, located at a distance of 889 ± 498 m (range: 544-1777 m) from each other (Fig. 1), for analysis on the seasonal level of *E. berbicensis* infestation. A total of 65 *P. falcata*, 63 *A. ucayalensis*, 62 *A. falcirostris*, 56 *H. unimaculatus*, 36 *S. gibbus* and 14 *G. proximus* were examined. The fish were caught using simple gill nets (20, 30, 40, 50 and 60 mm mesh), grouped into lengths of 100 m. These nets were installed near the reservoir margins and were left in the water for 12 h, with inspection every two hours. This study was developed in accordance with the principles adopted by the Brazilian College of Animal Experimentation (COBEA).

Collection procedures and analysis of parasites

After the fish had been removed from the nets, the mouth, integument and fins of each fish were immediately examined for the presence of crustacean parasites. The gills were collected and fixed in 5% formalin, and then were examined with the aid of a stereomicroscope to collect and count the parasites. The crustacean species were conserved in 70% glycerinated alcohol and were prepared for identification, following the recommendations of Eiras *et al*. (2006).

The ecological descriptors used followed the recommendations of Bush *et al*. (1997). Differences in the prevalence of *E. berbicensis* between the rainy and dry seasons, as well as between months were evaluated using the chi-square test (χ^2) with the Yates correction. Differences in the abundance of *E. berbicensis* between rainy and dry seasons were evaluated using the Mann-Whitney (*U*) test, and between months using Kruskal-Wallis test (H). The Shapiro-Wilk test was used to determine whether the parasite abundance presented

normal distribution. Each fish was measured for body weight (g) and length (cm), which were used to determine the relative condition factor of the hosts/Kn (Le-Cren, 1951). The Kn of the overall hosts was compared with the Kn of the hosts during dry and rainy seasons, using the Kruskal-Wallis test (Zar, 2010).

Water temperature, electric conductivity and dissolved oxygen in water were obtained by means of the YSI 85 multiparameter measuring device, and pH by means of the YSI 60 pHmeter. Turbidity was determined using the obtained by means of the Plus II microprocessing turbidimeter. Transparency was measured using Secchi's disc. Rainfall levels were obtained through the National Environmental Data System (SINDA-INPE), from the Coaracy Nunes dam hydrometeorological station.

RESULTS

The body parameters and number of the examined fish by seasons are showed in Table 1. The physical and chemical parameters, with the exception of rainfall levels, were similar during the dry and rainy seasons (Table 2).

Excorallana berbicensis infestations occurred on the mouth, gills and integument of the hosts, except for *S. gibbus*, which only had infestation on its integument. Differences in the prevalence and abundance of this corallanid only occurred in *P. falcata*, which were greater during the rainy season (Table 3). In *G. proximus*, infestations occurred only during the rainy season, but the number of hosts examined was low.

In *A. ucayalensis*, *A. falcirostris*, *H. unimaculatus*, *S. gibbus*, *G. proximus* and *P. falcata*, there was seasonal fluctuation of *E. berbicensis*, with highest prevalence in April and highest abundance in April and August (Fig. 2). Considering all the hosts examined, 262 specimens of *E. berbicensis* were collected during the dry season and 600 during the rainy season.

The Kn of the hosts parasitized by *E. berbicensis* did not differ between the grouped hosts (overall), or between the rainy season and dry season (Table 4). In addition, for *A. falcirostris* (t = -0.014; P = 0.989), *A. ucayalensis* (t = -0.058; P = 0.954), *H. unimaculatus* (t = 0.006; P = 0.995), *P. falcata* (t = -0.005; P = 0.996) and *S. gibbus* (t = -0.155; P = 0.877), the grouped Kn also did not differ from the standard (Kn = 1), thus indicating that the hosts presented good body condition.

DISCUSSION

In *P. falcata*, the levels of infestation by *E. berbicensis* were greater during the rainy season. Similar seasonal patterns were reported for abundance of infestations by *Dolops discoidalis* Bouvier, 1899, *D. bidentata* Bouvier, 1899 (Malta, 1982), *D. striata* Bouvier, 1899 and *D. carvalhoi* Lemos de Castro, 1949 (Malta & Varella, 1983), in different fish of the Amazon region. Pech *et al*. (2010) also reported that seasonal fluctuation in rainfall levels influenced the levels of infestation by *Argulus* sp. and *Ergasilus* sp. in *Cichlasoma urophthalmus* Günther, 1862 from Yucatan Peninsula (Mexico). In the Amazon region, the environmental conditions during the rainy season are favorable for reproduction of some ectoparasite species, thus providing opportunities for encountering infectious forms with their hosts and contributing towards completing their life cycle (Vital *et al*., 2011). However, in piranha *Pygocentrus nattereri* Kner, 1858, *Serrasalmus spilopleura* Kner, 1858 and *S. marginatus* Valenciennes, 1837 from Pantanal of Mato Grosso (Brazil), infestation by *D. carvalhoi, Argulus elongatus* Heller, 1857 and *Argulus juparanaensis* Lemos de Castro, 1950 was greater during the dry season (Carvalho *et al*., 2003).

Seasonal dynamics influence the environmental quality of different natural ecosystems such as the Araguari River basin, which has pH and dissolved oxygen levels that are lower during the dry season in the Amazon basin (Bárbara *et al*., 2010). During the period of the present study, the water level in the reservoir of the Coaracy Nunes hydroelectric power plant was relatively constant during the entire year, as also were the water temperature, electric conductivity, dissolved oxygen, pH, turbidity and transparency, which were similar during the rainy and dry seasons. Thus, these factors did not influence the levels of infestation by *E. berbicensis* in *A. falcirostris*, *A. ucayalensis*, *H. unimaculatus*, *G. proximus* and *S. gibbus*. However, Alsarakibi *et al.* (2014) reported that the occurrence of *A. japonicus* Thiele, 1900 was strongly influenced by pH, temperature, biochemical oxygen demand, ammonia and dissolved oxygen levels in the water. In river reservoirs, such as the one of the present study, the reduction in water speed contributed towards decreasing the turbidity, which consequently could increase the population of parasite crustaceans, in comparison with the river itself (Morley, 2007). Carvalho *et al.* (2003) suggested that the behavior of *S. marginatus* favored greater levels of infestation by ectoparasite crustaceans in environments with higher turbidity. Water turbidity also negatively affects ectoparasite crustaceans, because particulate material in suspension can cause damage to filtration and to delicate feeding organs in planktonic stages (Morley, 2007). Therefore, crustacean ectoparasites seem to have strong interaction with the environment and host fish population, because these factors are directly invol-

Table 1. Body parameters of six fish of a reservoir from Araguari River basin, in the eastern Amazon region (Brazil).

Season			Dry	Rainy
Fish species	Length (cm)	Weight (g)	N	N
Acestrorhynchus falcirostris	18.2 ± 3.2	62.4 ± 36.0	44	18
Ageneiosus ucayalensis	16.3 ± 2.8	39.7 ± 18.3	48	15
Geophagus proximus	14.4 ± 4.2	84.9 ± 77.5	4	10
Hemiodus unimaculatus	14.8 ± 2.3	51.5 ± 19.9	42	14
Serrasalmus gibbus	10.9 ± 2.5	26.9 ± 36.6	12	24
Psectrogaster falcata	18.2 ± 3.9	138.4 ± 96.7	35	30

Table 2. Physical and chemical parameters of the water in a reservoir from Araguari River basin, in the eastern Amazon region (Brazil). Different values in the same column indicate differences according to the Mann-Whitney test (*U*) at the 5% probability level. Precipitation: rainfall. NTU: nephelometric turbidity units.

	Precipitation (mm)	Transparency (m)	Turbidity (NTU)	pH	Conductivity ($\mu S/cm^{-1}$)	Temperature (ºC)	Dissolved oxygen ($mg\ L^{-1}$)
Dry season	87.6 ± 52.4b	1.3 ± 0.3a	6.7 ± 1.9a	6.2 ± 0.5a	21.6 ± 2.8a	28.9 ± 1.6a	5.2 ± 1.5a
Rainy season	317.5 ± 194.1a	1.1 ± 0.1a	4.9 ± 2.1a	6.5 ± 0.2a	19.5 ± 0.9a	26.5 ± 0.5a	5.2 ± 0.5a

ved in their different life cycles and may cause different responses to seasonal fluctuations in water levels.

The dry season was from September to February and the rainy season was from March to August. However, the lowest rainfall rates occurred from September to November and the highest rates occurred from March to May, while the months of June through to August and December through to February were transitional periods between the two seasonality seasons. Although the levels of infestation by *E. berbicensis* were influenced by seasonality only in *P. falcata*, it was found when considering all hosts together that the prevalence of this ectoparasite presented a peak in the month of April, while the abundance showed two peaks, one in April and the other in August. These results possibly indicate that there are two reproductive cycles for *E. berbicensis*: one occurring in the rainiest month (April) and the other at the beginning of the transition period (August). Furthermore, the prevalence and abundance peaks of *E. berbicensis* also coincided with the reproduction period of these fish in the Araguari River basin region (Favero *et al*., 2010). Massive infestation of *E. tricornis occidentalis* was reported in *E. striatus* soon after their spawning (Semmens *et al*., 2006).

In the region from Costa Rica, Guzmán *et al.* (1988) observed that *E. tricornis occidentalis* has a migration cycle over the course of the day, because were found mostly in the water column during the night and it migrates to the benthos during the day, particularly to coral habitats or rocky substrates, in areas under strong thermocline influence. Moreover, this marine coralla-nid presented an influence weaker during the dry season (December to February). The high densities of these corallanid parasites also suggested that there was a seasonal effect relating to the beginning of the dry season. These authors concluded then that the nocturnal migration of these ectoparasites might be a form of behavior aimed at saving resources and might be related to predation of this isopod by fish and planktonic invertebrates. Despite of the life history of *E. berbicensis* is still little known, almost 70% of the specimens of this parasite on fish we collected during the rainy season. Although the migration of *E. berbicensis* to the water surface was not evaluated here, it was also found that there was greater presence of these parasites during nighttime. However, this migratory pattern still needs to be investigated.

The condition factor is a quantitative parameter of fish wellbeing that is used in studies on the parasite-host relationship (Lizama *et al*., 2006; Guidelli *et al*., 2011; Vasconcelos & Tavares-Dias, 2014). It was not influenced by the rainy and dry seasons among the fish investigated here, due to low abundance of parasites. Similar results were reported for *A. falcirostris* and *H. unimaculatus* from eastern Amazon parasitized by *E. turucuyus* (Vasconcelos & Tavares-Dias, 2014). However, high infestation of *E. tricornis occidentalis* reduced the body condition of *E. striatus* in Costa Rica (Semmens *et al*., 2006), due to the high cost of parasitism to the hosts. Corallanid species have been considered to be temporary parasites that change hosts to feed (Bunkley-Williams & Williams Jr., 1998).

Table 3. Seasonal variation of infestation by *Excorallana berbicensis* in fish species in a reservoir from Araguari River basin, in the eastern Amazon region (Brazil). P: prevalence, MA: mean abundance, χ^2: chi-square test for prevalence, *U*: Mann-Whitney test for mean abundance, *P*: probability.

	Dry season		Rainy season					
Hosts fish	P (%)	MA	P (%)	MA	χ^2	*P*	*U*	*P*
Acestrorhynchus falcirostris	15.9	0.9 ± 3.0	38.9	5.1 ± 17.3	3.859	0.103	299.0	0.133
Ageneiosus ucayalensis	33.3	1.7 ± 3.6	40.0	2.9 ± 17.4	0.224	0.871	342.0	0.771
Hemiodus unimaculatus	35.7	1.3 ± 3.6	7.1	0.5 ± 19.1	4.200	0.087	215.0	0.135
Psectrogaster falcata	25.7	2.2 ± 4.3	53.3	6.8 ± 17.4	5.206	0.043	373.0	0.045
Serrasalmus gibbus	33.3	0.3 ± 4.3	12.5	0.1 ± 18.4	2.217	0.297	114.0	0.314
Geophagus proximus	0	0	40.0	8.5 ± 11.8	2.240	0.134	12.0	0.129

Table 4. Relative condition factor (Kn) for fish species in a reservoir from Araguari River basin, in the eastern Amazon region (Brazil). Values in the same line with different letters indicate differences according to the Kruskal-Wallis test (H). *P*: probability.

Hosts fish	Overall	Dry season	Rainy season	H	*P*
Acestrorhynchus falcirostris	1.00 ± 0.06[a]	1.00 ± 0.03[a]	1.00 ± 0.09[a]	0.272	0.873
Ageneiosus ucayalensis	1.00 ± 0.07[a]	1.00 ± 0.06[a]	1.00 ± 0.07[a]	0.159	0.923
Hemiodus unimaculatus	0.99 ± 0.04[a]	1.00 ± 0.03[a]	1.00 ± 0.03[a]	0.008	0.996
Psectrogaster falcata	1.00 ± 0.06[a]	1.00 ± 0.04[a]	1.00 ± 0.05[a]	0.091	0.955
Serrasalmus gibbus	1.00 ± 0.14[a]	1.00 ± 0.11[a]	1.00 ± 0.08[a]	0.134	0.935

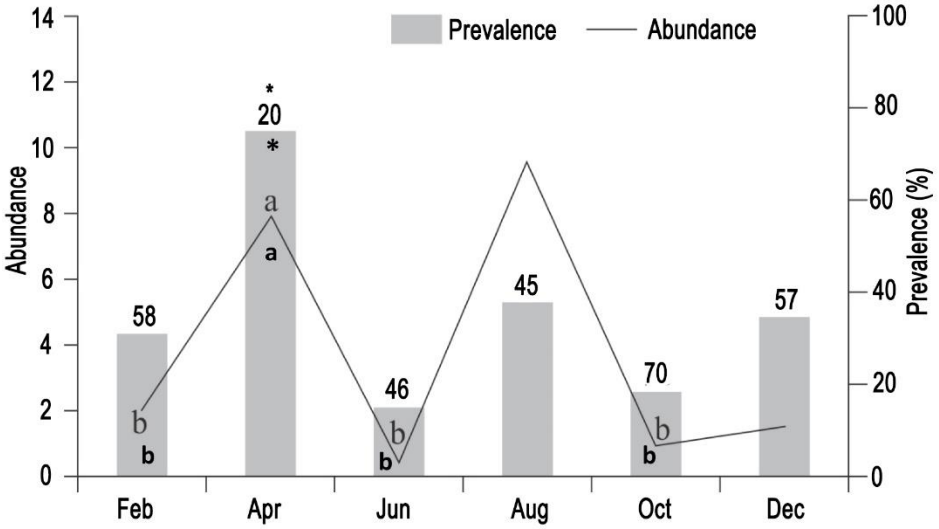

Figure 2. Seasonal fluctuation of infestation by *Excorallana berbicensis* in fish species in a reservoir from Araguari River basin, in the eastern Amazon region (Brazil). Values above each column indicate the total number of hosts examined. Different letters in each line indicate differences according to the Dunn test ($P < 0.05$). *****Indicate differences between prevalence according to the χ^2 test ($P < 0.05$).

Therefore, the lack of studies on the biology of isopods of the genus *Excorallana* makes exact interpretation of their relationship with their hosts difficult.

In summary, since the physical and chemical characteristics of the artificial ecosystem investigated were relatively homogeneous, except for rainfall levels, this latter can be a factor causing the levels of infestation of *E. berbicensis* in *P. falcata*. Moreover, as *P. falcata*, *A. falcirostris*, *A. ucayalensis*, *H. unimaculatus*, *G. proximus* and *S. gibbus* presented seasonal variation of infestation by *E. berbicensis* on a temporal scale, and biological factors relating to these hosts and parasites seemed to be influencing these infestations.

Since homogeneous conditions among environmental parameters in the Amazon region are uncommon, additional studies using more than one seasonal cycle must be conducted to better comprehend the biology and ecology of this Corallanidae in fresh water. Investigation of whether the levels of infestation of *E. berbicensis* in fish in this long-established reservoir in the eastern Amazon are higher than the infestation in fish in the Araguari River is also needed, because water stability can restrict occurrences of these ectoparasites in different aquatic systems, *i.e.*, infestations are possibly lower in fish in an environment of running water, like the Araguari River.

ACKNOWLEDGEMENTS

The authors are grateful to the National Council for Technological Research and Development (CNPq), for the research scholarship granted to Tavares-Dias, M.; to ICMBio, for the authorization for fish specimen collection (License: 35636-1); and to Eletronorte-AP, for logistic support.

REFERENCES

Alsarakibi, M., H. Wadeh & G. Li. 2014. Influence of environmental factors on *Argulus japonicus* occurrence of Guangdong Province, China. Parasitol. Res., 113: 4073-4083.

Álvarez-León, R. 2009. Asociaciones y patologías en los crustáceos dulceacuícolas, estuarinos y marinos de Colombia: aguas libres y controladas. Rev. Acad. Colomb. Cienc. Exact., Fís. Nat., 33: 129-144.

Bárbara, V.F., A.C. Cunha, A.S.L Rodrigues & E.Q. Siqueira. 2010. Monitoramento sazonal da qualidade da água do rio Araguari/AP. Rev. Biociênc., 16: 57-72.

Bauer, O.N. & S.B. Karimov. 1990. Patterns of parasitic infections of fishes in a water body with constant temperature. J. Fish Biol., 36: 1-8.

Brusca, R.C. & I.S. Wehrtmann. 2009. Isopods. In. I.S. Wehrtmann & J. Cortés (eds.). Marine biodiversity of Costa Rica, Central America. Springer Science, New York, pp. 257-264.

Bunkley-Williams, L. & H. Williams Jr. 1998. Isopods associated with fishes: a synopsis and corrections. J. Parasitol., 84: 893-896.

Bush, A.O., K.D. Lafferty, J.M. Lotz & A.W. Shostak. 1997. Parasitology meets ecology on its own terms: Margolis revisited. J. Parasitol., 83: 575-583.

Carvalho, L.N., K. Del-Claro & R.M. Takemoto. 2003. Host-parasite interaction between branchiurans (Crustacea: Argulidae) and piranhas (Osteichthyes: Serrasalminae) in the Pant anal wetland of Brazil. Environ. Biol. Fish., 67: 289-296.

Cunha, A.C., H.F.A Cunha & L.A.R. Pinheiro. 2013. Modelagem e simulação do escoamento e dispersão sazonais de agentes passivos no Rio Araguari -AP: Cenários para a AHE Ferreira Gomes-I-Amapá/Brasil. Rev. Brasil. Rec. Hídricos, 18: 67-85.

Delaney, P.M. 1984. Isopods of the genus *Excorallana* Stebbing, 1904 from the Gulf of California, Mexico (Crustacea, Isopoda, Corallanidae). Bull. Mar. Sci., 34: 1-20.

Delaney, P.M. 1989. Phylogeny and biogeography of the marine isopod family Corallanidae (Crustacea, Isopoda, Flabellifera). Contrib. Sci. Nat. Hist. Mus. Los Angeles County, 409: 1-75.

Eiras, J.C., R.M. Takemoto & G.C. Pavanelli. 2006. Métodos de estudo e técnicas laboratoriais em parasitologia de peixes. Eduem, Maringá, 199 pp.

Favero, J.M., P.S. Pompeu & A.C. Prado-Valladares. 2010. Biologia reprodutiva de *Heros efasciatus* Heckel, 1840 (Pisces, Cichlidae) na reserva de desenvolvimento sustentável Amanã-AM, visando seu manejo sustentável. Acta Amazon., 40: 373-380.

Galacatos, K., R. Barriga-Salazar & D.J. Stewart. 2004. Seasonal and habitat influences on fish communities within the lower Yasuni River basin of the Ecuadorian Amazon. Environ. Biol. Fish., 71: 33-51.

Guidelli, G., W.L.G. Tavechio, R.M. Takemoto & G.C. Pavanelli. 2011. Relative condition factor and parasitism in anostomid fishes from the floodplain of the Upper Paraná River, Brazil. Vet. Parasitol., 177: 145-151.

Guzmán, H.M., V.L. Obando, R.C Brusca & P.M. Delane. 1988. Aspects of the population biology of the marine isopod *Excorallana tricornis occidentalis* Richardson, 1905 (Crustacea: Isopoda: Corallanidae) at Cano Island, Pacific Costa Rica. Bull. Mar. Sci., 43: 77-87.

Hendrickx, M.E. & M.D.C. Espinosa-Pérez. 1998. A new species of *Excorallana* Stebbing (Crustacea: Isopoda: Corallanidae) from the Pacific coast of Mexico, and additional records for *E. bruscai* Delaney. Proc. Biol. Soc. Wash., 111: 303-313.

Jones, M.B. 1974. Breeding biology and seasonal population changes of *Jaera nordmanninordica* Lemercier (Isopoda, Asellota). J. Mar. Biol. Assoc. U.K., 54: 727-736

Kadlec, D., A. Šimková, J. Jarkovský & M. Gelnar. 2003. Parasite communities of freshwater fish under flood conditions. Parasitol. Res., 89: 272-283.

Kensley, B., G. Nelson & M. WSchotte. 1995. Marine isopod biodiversity of the Indian River Lagoon, Florida. Bull. Mar. Sci., 57: 136-142.

Le-Cren, E.D. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). J. Anim. Ecol., 20: 201-219.

Lizama, M.L.A., R.M. Takemoto & G.C. Pavanelli. 2006. Parasitism influence on the hepato, splenosomatic and weight/length relation and relative condition factor of *Prochilodus lineatus* (Valenciennes, 1836) (Prochilodontidae) of the upper Paraná River Floodplain, Brazil. Rev. Brasil. Parasitol. Vet., 15: 116-122.

Malta, J.C.O. 1982. Os Argulídeos (Crustacea, Branchiura) da Amazônia Brasileira. 2. Aspectos da ecologia de *Dolops geayi* Bouvier, 1897 e *Argulus juparanaensis* Castro, 1950. Acta Amazon., 12: 701-705.

Malta, J.C.O. & A.M.B. Varella. 1983. Os Argulídeos (Crustacea: Branchiura) da Amazônia Brasileira. 3. Aspectos da ecologia de *Dolops striata* Bouvier, 1899 e *Dolops carvalhoi* Castro, 1949. Acta Amazon., 13: 299-306.

Monod, T. 1969. Sur trois crustacés isopodes marins de la région Guyane-Amazone. Cah. Orstom, Sér. Océanogr., 7: 47-68.

Morgado, E.H. & M.O. Tanaka. 2001. The macrofauna associated with the bryozoan *Schizoporella errata* (Walters) in southeastern Brazil. Sci. Mar., 65: 173-181.

Morley, N.J. 2007. Anthropogenic effects of reservoir construction on the parasite fauna of aquatic wildlife. EcoHealth, 4: 374-383.

Neves, L.R., F.B. Pereira, M. Tavares-Dias & J.L. Luque. 2013. Seasonal influence on the parasite fauna of a wild population of *Astronotus ocellatus* (Perciformes: Cichlidae) from the Brazilian Amazon. J. Parasitol., 99: 718-721.

Pech, D., M.L.Aguirre-Macedo, J.W. Lewis & V.M. Vidal-Martínez. 2010. Rainfall induces time-lagged changes in the proportion of tropical aquatic hosts infected with metazoan parasites. Inter. J. Parasitol., 40: 937-944.

Sá-Oliveira, J.C., R. Angelini & V.J. Isaac-Nahum. 2015. Population parameters of the fish fauna in a long-established Amazonian reservoir (Amapá, Brazil). J. Appl. Ichthyol., 31: 290-295.

Sá-Oliveira, J.C., H.C.G. Vasconcelos, S.W.M. Pereira, V.J. Isaac-Nahum & A.P Teles-Junior. 2013. Caracterização da pesca no Reservatório e áreas adjacentes da UHE Coaracy Nunes, Ferreira Gomes, Amapá-Brasil. Biota Amazônia, 3: 83-96.

Received: 22 June 2015; Accepted: 21 September 2015

Santos, G.M., B. Mérona, A.A. Juras & M. Jégu. 2004. Peixes do baixo Rio Tocantins: 20 anos depois da Usina Hidrelétrica Tucuruí. Eletronorte, Brasília, 215 pp.

Semmens, B.X., K.E. Luke, Bush P.G., C.M.R. McCoy & B.C. Johnson. 2006. Isopod infestation of post spawning Nassau grouper around Little Cayman Island. J. Fish Biol., 69: 933-937.

Schotte, M. 2014. *Excorallana* Stebbing, 1904. In: M. Schotte, C.B. Boyko, N.L. Bruce, G.C.B. Poore, S. Taiti & G.D.F. Wilson, (eds.). World marine, freshwater and terrestrial isopod crustaceans database. Accessed through: world Register of Marine Species at [http://www.marinespecies.org/aphia.php?p=taxedtails&id=248749]. Reviewed: 28 February 2015.

Souza, E.B. & A.C. Cunha. 2010. Climatologia de precipitação no Amapá e mecanismos climáticos de grande escala. In: A.C. Cunha, E.B. Souza & H.F.A. Cunha (eds.). Tempo, clima e recursos hídricos - resultados do projeto REMETAP no Estado do Amapá. IEPA, Macapá, 216 pp.

Thatcher, V.E. 1995. Comparative pleopod morphology of eleven species of parasitic isopods from Brazilian fish. Amazoniana, 8: 305-314.

Van Name, W.G. 1925. The isopods of the Kartabo Bartica District, British Guiana. Zoologica, 6: 461-503.

Vasconcelos, H.C.G & M. Tavares-Dias. 2014. Influência da sazonalidade na infestação de *Ergasilus turucuyus* (Copepoda: Ergasilidae) em *Acestrorhynchus falcirostris* e *Hemiodus unimaculatus* (Osteichthyes: Characiformes) do Reservatório Coaracy Nunes, Estado do Amapá, Brasil. Biota Amazônia, 4: 106-110.

Vital, J.F., Varella A.M.B., D.B. Porto & J.C.O. Malta. 2011. Sazonalidade da fauna de metazoários de *Pygocentrus nattereri* (Kner, 1858) no lago Piranha (Amazonas, Brasil) e a avaliação de seu potencial como indicadora da saúde do ambiente. Biota Neotropica, 11: 199-204.

Williams, Jr., E.H. & L. Bunkley-Williams. 1994. New hosts and locality records for copepod and isopod parasites of Colombian marine fishes. J. Aquat. Anim. Health, 6: 362-364.

Zar, J.H. 2010. Biostatistical analysis, Prentice Hall, New Jersey, 944 pp.