VOLUME 11, NÚMERO 1, NOVEMBRO 2011 ISSN 1519-1982

# *BIOLOGIA GERAL E EXPERIMENTAL*

MANAUS - AM

# BIOLOGIA GERAL E EXPERIMENTAL




***Biologia Geral e Experimental*** é indexada nas Bases de Dados: Latindex, Biosis Previews, Biological Abstracts e Zoological Record.

Edição eletrônica: ISSN 1980-9689.
www.biologiageralexperimental.bio.br

Endereço: ***Biologia Geral e Experimental***, Instituto Nacional de Pesquisas da Amazônia, Coordenação de Pesquisas em Biologia Aquática, Av. André Araújo.2936, Petrópolis, Manaus, AM, CEP 69060-001.

## SUMÁRIO

Biol. Geral Exper., vol. 11, num. 1 28.xi.2011

Biologia Geral e Experimental

Biol. Geral Exper., 11(1):4-14 28.xi.2011

# ANFÍBIOS DO LAVRADO DE RORAIMA

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RESUMO

São apresentadas chaves de identificação e comentários sobre os hábitats, reprodução e dieta de 16 espécies de anuros do lavrado de Roraima, região do Tepequém.

**Palavras-chave:** anuros, hábitat, reprodução, dieta, lavrado, Roraima.

ABSTRACT

It is presented identification keys and comments on habitats, reproduction and diet of 16 species of anurans from the lavrado of Roraima, region of Tepequém.

**Key words:** anurans, habitat, reproduction, diet, lavrado, Roraima.

## INTRODUÇÃO

A região de Roraima (Figura 1), situada ao norte do domínio morfoclimático amazônico, é constituída por áreas fechadas ao norte, oeste e sul, e áreas abertas a leste, o lavrado da formação Boa Vista (Vanzolini & Carvalho, 1987; Ab'Saber, 1997). As áreas abertas do lavrado abrigam uma interessante herpetofauna, com espécies associadas aos domos, a algumas áreas estritas no contato da mata e lavrado, e regiões serranas (Heyer, 1994; Carvalho, 2002). Nas áreas do lavrado também ocorrem diversas espécies de anfíbios e répteis de ampla distribuição em mais de um domínio morfoclimático além do amazônico, e espécies restritas a algumas regiões da Amazônia (Rebêlo, *et. al*., 1997; Carvalho, 2009; Nascimento, 1998; Heyer, 1995).

Neste contexto de áreas abertas de Roraima, com serras baixas, domos e inselbergs, lagos e veredas de buritis, ocorre uma formação serrana, com rochas expostas, mata em boa parte das encostas, e fisionomia do lavrado no topo, que é relativamente plano, recortado por igarapés e pequenas manchas de mata. É a região do Tepequém (03º45'N, 61º42'W) onde fizemos um levantamento dos anfíbios, aqui relatado,com a finalidade de contribuir para o conhecimento sobre a biologia e distribuição regional de anuros nos ambientes do lavrado. Neste relato comentamos também sobre os hábitats, dietas, reprodução e chaves de identificação das espécies registradas.

## RESULTADOS

Foram coletadas 16 espécies e 4 morfotipos (133 exemplares) de anuros durante maio-julho de 2007 (Tabela 1), nas áreas abertas, igarapés e bordas de mata (Figuras 2-5). A maior riqueza de espécies (12)

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foi na bordas de mata; a menor r foi nas áreas abertas (3), devido a vários fatores ecológicos, por exemplo, clima, disponibilidade de abrigo e de recursos (Vanzolini, 1986). As espécies de mata chegam até a borda com as áreas abertas, o que também contribuiu para maior riqueza observada na borda.

A reprodução ocorre durante os meses de chuva (maio-agosto). O bufonídeo *R. marina* (Figura 6) pode ser avistado o ano todo nas áreas abertas, mas a reprodução é restrita ao período das chuvas, durante o qual os indivíduos vocalizam mais intensamente nos dias de maior precipitação, em torno de poças temporárias. *Rhinella granulosa* (Figura 7) também forma grupos nas poças temporárias de áreas abertas, onde os indivíduos vocalizam mais intensamente nos dias de maior precipitação. Os poucos exemplares de *Rhinella proboscidea* (Figura 8) foram avistados no chão da mata, no folhiço.

Com relação à dieta, formigas e grilos fazem parte da alimentação das *Rhinella*. No estomago de 1 indivíduo de *Rhinella marina* foi encontrado Hymenoptera (50) e Orthoptera (1). Em *Rhinella granulosa*, também em 1 indivíduo, foi encontrado Hymenoptera (5) . Não temos informações sobre a dieta de *R. probscidea*.

*Cochranella oyampiensis* foi encontrada no ambiente que gosta de viver, áreas úmidas, com água correndo entre pedras. Os indivíduos formam grupos e vocalizam voltados para o igarapé, aproximadamente a 1 metro de altura, nas folhas e galhos de arbustos e arvoretas. As desovas são colocadas na parte inferior das folhas, nas arvoretas sobre o igarapé. Não temos informações sobre a dieta desta espécie.

*Dendrobates leucomelas* (Figuras 9-11) pode ser encontrado na beira de igarapés, no chão ou debaixo de pedras. É frequente encontrar esta espécie

Tabela 1. Anuros do Tepequém, Roraima.

| | Coletados | Hábitat |
|---|---|---|
| **Bufonidae** | | |
| *Rhinella granulosa* | 1 | Chão, áreas antropizadas |
| *Rhinella marina* | 2 | Chão, áreas antropizadas |
| *Rhinella cf. proboscídea* | 1 | Chão, folhiço, mata |
| **Centrolenidae** | | |
| *Cochranella oyampiensis* | 1 | Arbustos, igarapé, mata |
| **Dendrobatidae** | | |
| *Dendrobates leucomelas* | 15 | Sob pedras, folhiço e troncos de árvores, igarapé, borda da mata |
| **Hylidae** | | |
| *Dendropsophus microcephalus* | 17 | Arbustos próximos a água, borda da mata |
| *Dendropsophus minutus* | 17 | Arbustos próximos a água, borda da mata |
| *Dendropsophus* sp. | 3 | Arbustos próximos a água, borda da mata |
| *Hypsiboas boans* | 3 | Árvores, mata e borda da mata |
| *Hypsiboas crepitans* | 24 | Poças temporárias, borda da mata |
| *Hypsiboas multifasciatus* | 2 | Arbustos próximos a água, borda da mata |
| *Phyllomedusa hypochondrialis* | 13 | Arbustos próximos a água, borda da mata |
| *Scinax boesemani* | 6 | Arbustos próximos a água, borda da mata |
| *Scinax fuscomarginatus* | 2 | Arbustos próximos a água, borda da mata |
| *Scinax ruber* | 4 | Arbustos próximos a água, borda da mata |
| **Leiuperidae** | | |
| *Physalaemus cuvieri* | 4 | Poças temporárias, borda da mata, áreas antropizadas |
| *Physalaemus cf.olfersii* | 3 | Poças temporária, bordea da mata, áreas antropizadas |
| **Leptodactylidae** | | |
| *Leptodactylus fuscus* | 4 | Chão, áreas antropizadas |
| **Ranidae** | | |
| *Lithobates palmipes* | 9 | Chão ou dentro da água, igarapé, mata |
| **Strabomantidae** | | |
| *Pristimantis* sp. | 2 | Arbustos e arvoretas, mata |

nos troncos de árvores (Figura 10 ), aproximadamente a 2-3 metros de altura. O gênero é conhecido por apresentar cuidado parental, machos e fêmeas adultos podem carregar os girinos nas costas, de um lugar para outro (Duellman & Trueb, 1994:43).

A dieta de *leucomelas* consta basicamente de formigas. Foram analisados 8 indivíduos, todos continham pequenas formigas pretas (1-2mm), aparentemente da mesma espécie, cerca de 40 por indivíduo (amplitude 4-122 formigas por indivíduo). Os demais itens alimentares encontrados nos estômagos de *Dendrobates* foram Coleoptera (3), Araneae (2), Acarina (3), Isoptera (1).

Os hilídeos *Dendropsophus microcephalus* (Figura 12), *D. minutus* (Figuras 13-15), *Hypsiboas multifasciatus* (Figura 16) e os *Scinax* (Figura 17 - *S. boesemani*) foram as espécies mais avistadas durante o estudo, encontradas sobre pequenos arbustos, na vegetação herbácea de bordas de mata e nas matinhas de igarapés próximas das áreas abertas. Desovam nas poças temporárias e apresentam reprodução contínua durante todo o período chuvoso. Estas pererecas vocalizam o ano todo, mais intensamente durante as chuvas. *Dendropsophus* e *Hypsiboas* começam a vocalizar assim que escurece, os *Scinax* quando já está noite. Permanecem vocalizando por aproximadamente 5-6 horas, após este período a atividade é reduzida até cessar durante a madrugada.

Na dieta de *D. microcephalus* ocorreram Coleoptera (1) e Orthoptera (1) em 2 indivíduos analisados; *D. minutus* inclui Heteroptera (1), Orthoptera (2), Hymenoptera (2) e Blattodea (2), com base em 6 indivíduos analisados. Em 2 indivíduos de *Hypsiboas multifasciatus* foram encontrados Araneae (1), Orthoptera (2) e Hymenoptera (2). Dentre os *Scinax*,1 indivíduo de *boesemani* continha Hymenoptera (1), e 1 indivíduo de *ruber* continha Acarina (1) e Hymenoptera (1).

Os demais hilídeos foram de ocorrência mais discreta, apresentando também reprodução contínua durante o período das chuvas. *Phyllomedusa hypocondrialis* (Figuras 18) gosta mais dos ambientes de borda da mata ou mais para dentro um pouco; os indivíduos vocalizam com breves estalidos, agrupados nos galhos das árvores mais baixas, exibindo comportamento reprodutivo típico do gênero, desovas dentro de folhas enroladas (Figura 19). *Hypsiboas boans* (Figura 20) vocaliza no alto das árvores, perto dos igarapés, o ano todo; mais intensamente durante as chuvas. A desova de *boans* é típica, ninhos no chão, em forma de panela, próximas aos igarapés (Figura 21). *Hypsiboas crepitans* (Figuras 22-24) é mais frequente nas áreas abertas e nas bordas da mata, podendo ser encontrada nos arbustos próximos às poças temporárias, onde desova. Nas épocas de estiagem *crepitans* se expõe menos.

Com relação à dieta dos hilídeos, 5 indivíduos de *P. hypochondrialis* continham Hymenoptera (2), Coleoptera (1), Araneae (1), Orthoptera (1) e Heteroptera (1). Em 2 indivíduos de *H. boans* foram encontrados Diptera (1), Heteroptera (1) e Coleoptera (1). Em14 indivíduos de *H. crepitans* foram encontrados Acarina (1), Hymenoptera (6), Orthoptera (4), Araneae (6), Odonata (1) e Blattodea (2). Os itens mais frequentes na dieta de *H. crepitans* foram aranhas, formigas e grilos.

Os dois *Physalaemus* (Figura 25 - *P.cuvieri*) são comuns na área durante as chuvas mais intensas, os picos reprodutivos ocorrem durante os dias mais chuvosos. As duas espécies de *Physalaemus* preferem as poças de água temporárias nas áreas abertas e nas bordas da mata, mas não são encontrados juntos nas mesmas poças. Na dieta de *P. cuvieri* em 2 indivíduos analisados ocorreram Coleoptera (1), Hymenoptera (7). Em 2 indivíduos de *P. olfersii* foram encontrados Coleoptera (2), Hymenoptera (2) e Heteroptera (1).

O único leptodactilídeo encontrado nas áreas abertas do topo da Serra do Tepequém foi *Leptodactylus fuscus* (Figura 26), nas poças temporárias das áreas abertas. A desova de *fuscus* é típica, dentro dos ninhos construídos pelos machos (Martins, 1988). Esta é uma espécie também de reprodução contínua durante a época das chuvas; durante a estiagem é muito discreto. Certamente ocorrerão outros leptodactilídeos no Tepequém, nas áreas de mata das encostas e nos igarapés. Nos estômagos de 3 indivíduos de *L. fuscus* analisados ocorreram Coleoptera (1), Hymenoptera (2), Blattodea (1) e Orthopterra (1).

*Lithobates palmipes* (Figura 27) ocorre associado aos igarapés e nada sabemos sobre a reprodução desta rã. É comum encontrar os indivíduos de *palmipes* na beira dos igarapés, dentro da água ou nas margens. Em 3 indivíduos de *L. palmipes* analisados, ocorreram Araneae (5), Odonata (2), Coleoptera (4), Hymenoptera (1), Diptera (1), Heteroptera (2), Orthoptera (4), Gastropoda (1).

Os exemplares de *Pristimantis* estavam na beirada de uma poça temporária, perto de igarapé, em ambiente de mata. O gênero é conhecido por ter todo o desenvolvimento do girino dentro do ovo; a desova, com ovos grandes, é depositada no solo (Lynn & Lutz, 1946; Duellman, 1994:35). Nada sabemos sobre a dieta de *Pristimantis.*

Dentre as 8 ordens de insetos, 2 aracnídeos e 1 molusco (classe Gastropoda) que compuseram a dieta dos anfíbios analisados, Hymenoptera foi o item mais importante em todas as espécies de anfíbios (16), ocorrendo em praticamente todos os indivíduos (133). *Dendrobates leucomelas* (8) foi responsável por cerca de 70% da ocorrência das formigas encontradas na dieta dos anfíbios analisados. *Hypsiboas crepitans* (14) foi a espécie na qual ocorreu mais aranhas, responsável por cerca de 80% de Araneae na dieta dos anfíbios analisados. *Lithobates palmipes* (8) foi a espécie na qual ocorreu a maioria dos itens alimentares presentes nas demais espécies, ausência apenas de ácaros e cupins, e foi também a única espécie na qual ocorreu gastropodes na dieta.

**Agradecimentos:** Pelo apoio e identificação dos materiais somos gratos à bióloga Carolina Castro-Mello, do Museu de Zoologia da USP; aos pesquisadores Silvio Silva e Jaime Gama Neto, do Museu Integrado de Roraima, e ao biólogo do ICMbio Sylvio Romério Briglia Ferreira.

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Aceito em 28.v.2011

## Chave para identificação de anuros do Tepequém, Roraima

### Famílias

1. Glândula paratóide presente....................Bufonidae
1'. Não....................2

2. Focinho bicudo....................3
2'. Não....................6

3. Dobras dorsais presentes....................Leptodactylidae
3'. Não....................4

4. Membrana interdigital presente nos pés....................Ranidae
4'. Não....................5

5. Ponta dos dedos modificadas....................Strabomantidae
5'. Não....................Leiuperidae

6. Manchas negras sobre fundo amarelo....................Dendrobatidae
6'. Não....................7

7. Ventre transparente....................Centrolenidade
7'. Não....................Hylidae

### Espécies gênero *Rhinella* (Bufonidae)

1. Glândula paratóide bem desenvolvida....................*marina*
1'. Não....................2

2. Focinho pontudo....................*proboscidea*
2'. Focinho truncado....................*granulosa*

### Gêneros Hylidae

1. Pupila verticalmente elíptica....................*Phyllomedusa*
1'. Não....................2

2. Focinho truncado ou triangular....................3
2'. Focinho comprido, arredondado....................*Scinax*

3. Focinho triangular, listas transversais dorsais ou lista dorsal desde a ponta do focinho ou corpo uniformemente colorido......................................................................................................................*Hypsiboas*
3'. Focinho truncado, mancha escura triangular na cabeça e parte anterior do dorso, ou manchas longitudinais dorsais, ou linha clara no focinho......................................................................*Dendropsophus*

Espécies gênero *Scynax* (Hylidae)

1.Lista dorsal do focinho até o meio do corpo, canto rostral e porção dorso-lateral castanho ............*fuscomarginatus*
1'. Não.......................................................................................................................................2

2. Dorso amarelado ou castanho com pequenas manchas castanhas.............................................*rubra*
2'. Dorso castanho com manchas amarelas.........................................................................*boesemani*

Espécies gênero *Hypsiboas* (Hylidae)

1. Prépolex presente.............................................................................................................*boans*
1'. Não.......................................................................................................................................2

2. Dorso castanho com tarjas escuras transversais...............................................................*multifasciatus*
2'. Dorso esverdeado ou amarelado.........................................................................................*crepitans*

Espécies gênero *Dendropsophus* (Hylidae)

1. Dorso castanho com manchas triangulares mais escuras na cabeça e dorso em forma de ampulheta, às vezes interrompida ou formando duas faixas dorsais incompletas..................................................*minutus*
1'. Linha clara sobre os olhos e focinho...........................................................................*microcephalus*

Espécies gênero *Physalaemus* (Leiuperidae)

1. Tubérculos tarsais presentes ..............................................................................................*cuvieri*
1'. Ausentes............................................................................................................................*olfersii*


Figura 1. O lavrado de Roraima (1), entre a Guiana e a Venezuela; e áreas abertas do Pará (2).

Figura 2. Serra do Tepequém.

Figura 3. Igarapé.

Figura 4. Igarapé com pedras.

Figura 5. Borda da mata.

Figura 6. *Rhinella marina.* (jovem).

Figura 7. *Rhinella granulosa*

Figura 8. *Rhinella.proboscidea.*

Figura 9. *Dendrobates leucomelas.*

Figura 10. *Dendrobates leucomelas.*

Figura 11. *Dendrobates leucomelas.*

Figura 12. *Dendropsophus microcephalus.*

Figura 13. *Dendropsophus minutus.*

Figura 14. *Dendropsophus minutus.*

.Figura 15. *Dendropsophus minutus.*

Figura 16. *Hypsiboas multifasciatus*

Figura 17. *Scinax boesemani.*

Figura 18. *Phyllomedusas hypchondrialis.*

Figura 19. *Phyllomedusas hypcondrialis,* desova.

Figura 20. *Hypsiboas boans.*

Figura 21. *Hypsiboas boans, girinos.*

Figur 22. *Hypsiboas crepitans.*

Figura 23. *Hypsiboas crepitans.*

Figura 24. *Hypsiboas crepitans*.

Figura 25. *Physalaemus cuvieri*.

Figura 26. *Leptodactylus fuscus*

Figura 27. *Lithobates palmipes*.

# Biologia Geral e Experimental

Biol. Geral Exper., 11(1):15-22 28.xi.2011

## AIRBORNE FUNGI IN THE CITY OF ARACAJU, SERGIPE, BRAZIL

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ABSTRACT

In the present study airborne fungi are reported from the city of Aracaju, Sergipe. Sabouraud agar plates were exposed in 36 boroughs, incubated and cultured. Twenty-six genera were identified. *Aspergillus, Botryodiplodia* and *Curvularia,* were the most common, whereas 14 genera were recorded in only one of the four main zones of the city. The incidence of airborne fungi in Aracaju was relatively low, probably due to the local climate and minor industrial pollution.

**Key words:** airborne fungi, urban environment, Aracaju, Sergipe.

RESUMO

No presente estudo são registrados fungos anemófilos na cidade de Aracaju, Sergipe. Placas de Petri com ágar-Sabouraud foram expostas em 36 bairros da cidade, e incubadas até o crescimento das colônias. Foram identificados vinte e seis gêneros. *Aspergillus, Botryodiplodia* e *Curvularia* foram os mais frequentes, enquanto 14 gêneros foram registrados numa das quatro zonas principais da cidade. A incidência de fungos anemófilos em Aracaju foi considerada baixa, possivelmente devido ao clima local e pouca poluição industrial.

**Palavras-chave:** fungos anemófilos, áreas urbanas, Aracaju, Sergipe.

## INTRODUCTION

An important component of environmental pollution, airborne fungi are highly mobile, and are able to disperse rapidly through the atmosphere, depending on climatic conditions. Air temperature and humidity, and the direction and velocity of winds have a direct influence on the production and dissemination of spores, which are a major cause of respiratory diseases in humans (Homrich, 1961).

There is a very strong link between airborne fungi and respiratory allergies, which has prompted epidemiological studies of air quality throughout the World, in an attempt to determine the exact nature of the relationship between the types and quantities of spores in the air, and the prevalence of allergies in a given location (Menezes *et al*., 2004). Despite these efforts, relatively few studies are available for Brazilian

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cities, which limits the analysis of the influence of fungal allergens on local rates of disorders such as asthma and allergic rhinitis (Mezzari *et al*., 2002).

Lima (1941) found that the spores of relatively common airborne fungi, such as *Alternaria*, *Aspergillus*, *Helmintosporium*, *Mucor* and *Penicillium*, constitute an important group of allergens of the respiratory system in many countries. Obviously, reliable knowledge of the abundance and diversity of the local airborne fungal flora is fundamental to the evaluation of allergy patterns and the development of healthcare strategies within a given area (Mendes, 1989; Menezes *et al*., 2006).

With these considerations in mind, the present study analyzed the incidence of airborne fungi in the northeastern Brazilian city of Aracaju, capital of the state of Sergipe. An ample variety of genera were recorded, many of which are prominent allergens, although overall frequencies were relatively low in comparison with many other Brazilian cities, possibly because Aracaju is less heavily industrialized and polluted, and has relatively good climatic conditions for the dispersal of spores.

## METHODS

**Study Area:** The city of Aracaju (Figure 1), capital of the state of Sergipe, is located at the mouth of the River Sergipe (10º54' S, 37º02' W). The municipality has a total area of 174 km², and approximately 520,000 inhabitants (IBGE, 2008). The city has a megathermic climate, with a moderate hydrological deficit during the summer months (September to February). Annual precipitation is around 1600 mm, and mean temperature 26ºC (IBGE, 2000). Climatic parameters for the study period (Table1) were consistent with the season. Once part of the coastal Atlantic Forest, the study area now consists of a typical urban landscape, with abundant mangrove swamps along riverbanks.

**Collection and identification of samples:** For the collection of a representative sample of the city, in addition to possible local variation, samples were collected in each of the city's 36 neighborhoods, which were arranged for analysis in four geographic zones (Figure 1). All samples were collected at open-air public locations, such as bus terminals and parks.

Two Sabouraud agar plates were exposed simultaneously at each location, 50 cm above the ground, for 15 minutes at mid-morning, between November 2002 and February 2003. Samples were collected on clear or, at most, partially cloudy days. Once exposed, plates were sealed and taken to the Immunology Laboratory of the Federal University of Sergipe, where they were incubated at room temperature (29ºC ± 2ºC) with a 12-hour photoperiod for 4 or 5 days. The resulting fungi were transferred to culture medium for growth, and identified under the microscope according to the available literature (Barnett & Hunter, 1960; Lacaz, 1973; Mendes, 1989).

## RESULTS AND DISCUSSION

A total of 26 genera of airborne fungi were identified (Table 2), although almost a quarter of the plates also contained colonies which could not be identified reliably because of the lack of reproductive structures. As in other Brazilian cities (Homrich, 1961; Lima *et al.*, 1963; Buck & Gambale, 1985; Oliveira *et al*., 1993), the table is characterized by relatively high frequencies of a few, more common genera, referred to as "universal dominants" by Morrow *et al.* (1964).

The genus *Aspergillus* was by far the most common genus, appearing in more than half the plates, in comparison with less than 40% in any other genus. *Aspergillus* is an opportunistic taxon which causes pulmonary aspergillosis, a disease of the respiratory tract. Other common genera include *Botryodiplodia* and *Curvularia,* which are known (Lacaz *et al.*, 1984) to cause pheohyphomycosis, a general term which applies to systemic or subcutaneous mycoses observed in humans or animals, characterized by darkened, septated mycelia. *Curvularia* may also invade a host's tissue, resulting in a morbid state similar to those observed in some forms of aspergillosis

(Jawetz *et al.*, 1991). The fourth most common genus – *Monotospora* – does not appear to be important as a pathogen.

The main results of this study are very similar to those obtained in Presidente Prudente, state of São Paulo (Buck & Gambale, 1985), where *Aspergillus* was also recorded in more than half of samples (55.8%). At this site, both *Aspergillus* and *Penicillium* were most common in the wet season. However, the former is present throughout the year (Carvalho & Rios, 1982), causing chronic, continuous and perennial asthma. A predominance of *Aspergillus* was also recorded in other Brazilian cities, such as Natal, Rio Grande do Norte (65.0%: Oliveira *et al.*, 1993), and Fortaleza, Ceará (44.7%: Menezes *et al*., 2006), both of which have climates very similar to that of Aracaju.

One major difference in comparison with Presidente Prudente is the relative scarcity of *Cladosporium* in the present study (one record), whereas the genus was recorded frequently (74.3%) in the former city. Lima *et al.* (1963) recorded a clear seasonal pattern in the occurrence of this fungus in Rio de Janeiro, and its relatively reduced frequency in the present study is likely due to the period of collection, given that dry season conditions – low humidity and precipitation – are generally inhibitive to the growth of fungi (Gambale *et al.*, 1983).

An overview of the results (Table 3) points to marked differences among city zones in the diversity of airborne fungi. While the absolute values were similar, the Central zone appeared to have a much more diverse community of airborne fungi, with 14 genera identified from 12 samples (1.2 per sample), in comparison with only 0.6-0.8 in the other zones. In addition to this recorded diversity, half of the plates contained unidentified colonies, in comparison with 4-33% in the remaining zones, which suggests that the actual variety of genera in this zone may even have been underestimated relative to the other zones. A similarly high rate of exclusive genera was also recorded in comparison with other zones, especially the North. By contrast, the Western zone was distinct in terms of the elevated number of genera collected per sample, in other words, its relative abundance of fungi.

Perhaps surprisingly, some of the exclusive genera were among the most frequently-recorded in their respective zones (Table 4). In the Northern zone, for example, *Gliocladium* was identified in almost a third of samples, and was the fourth most frequently recorded of the twelve genera recorded in this zone. Similarly, both *Staphylotrichum* and *Trichosporonoides* were recorded in a quarter of the samples collected in the Central zone, a proportion second only to *Monotospora*. Most other exclusive genera were recorded only once or twice, however, which suggests that their appearance in the sample of one or other zone may have been determined primarily by random factors, rather than a markedly localized distribution.

One major environmental difference among zones may be their proximity to bodies of water and mangrove swamps, given that the North, South and Central zones are all located along the edges of either rivers, the coastline or both (Figure 1), in contrast with the Western zone, which is located further inland. It remains unclear, however, whether, or to what extent this difference may have affected the results. One possibility is that this zone is less exposed to the prevailing winds, which blow almost invariably from the Atlantic Ocean, to the east. This may explain the greater abundance of colonies in this zone, which are less likely to disperse on the wind. These same winds might also be expected to carry fungi primarily from the Central zone to the West, although the data (Table 3) do not indicate any greater similarity between these two zones in comparison with the others.

The relatively high frequencies of colonies recorded in the Western zone, especially of the more common, allergenic genera such as *Aspergillus*, *Botryodiplodia* and *Curvularia* suggest that the local population may be more vulnerable to respiratory allergies or mycoses. In this context, a complementary analysis of allergy and infection rates in the populations of the different zones could provide useful insights into the etiology of these medical problems, although this is beyond the scope of the present study.

Overall, the results of the present study indicate that Aracaju is most similar to Natal (05º46' S, 35º12'W), which is not only the geographically nearest city for which reliable data are available (Table 5), but also comparable to Aracaju in terms of size, coastal location and industrialization. Further west, along the northern coast of Brazil, Fortaleza (03º43'S, 38º32'W) is also relatively similar, but differentiated by generally much lower frequencies. By contrast, the incidence of airborne fungi appears to be much higher in the more industrialized cities of the Brazilian Southeast, such as Presidente Prudente (22º07'S, 51º23'W) and São Paulo (23º32'S, 46º38'W), where relatively high values were recorded for a much wider range of genera (Table 5).

Supporting this hypothesis, Schoenlein-Crusius *et al*. (2001) recorded a significant increase in the incidence of airborne fungi in the nearby city of Cubatão (São Paulo) during periods of increased atmospheric pollution. While the incidence of fungi recorded in this study was relatively high, the results are not directly comparable with those presented here, because the fungi were identified to species.

Much further south, in the city of Porto Alegre (30º01'S, 51º13'W), airborne fungi appear to be relatively rare, in terms of both diversity and abundance. As this city is at least as large as the others mentioned here (Table 5), it seems possible that its much cooler subtropical-temperate climate may be an important factor.

Overall, the factors determining observed contrasts among cities are difficult to interpret for a number of reasons, in particular methodological differences, which include the sampling effort, period and taxon identification. Given the potential importance of understanding the incidence of airborne fungi, especially allergenic forms, there is a clear need, not only for studies of a much larger number of Brazilian cities, but also the standardization of data collection procedures, with regard to sample size, period, and data analysis.

**Acknowledgements:** We are grateful to Dr. Iracema Helena Schoenlein-Crusius, of the Mycology and Lichenology Section of the Instituto de Botânica de São Paulo for the provision of references and technical assistance. The research of SFF is supported by CNPq (Process no. 307506/2003-7).

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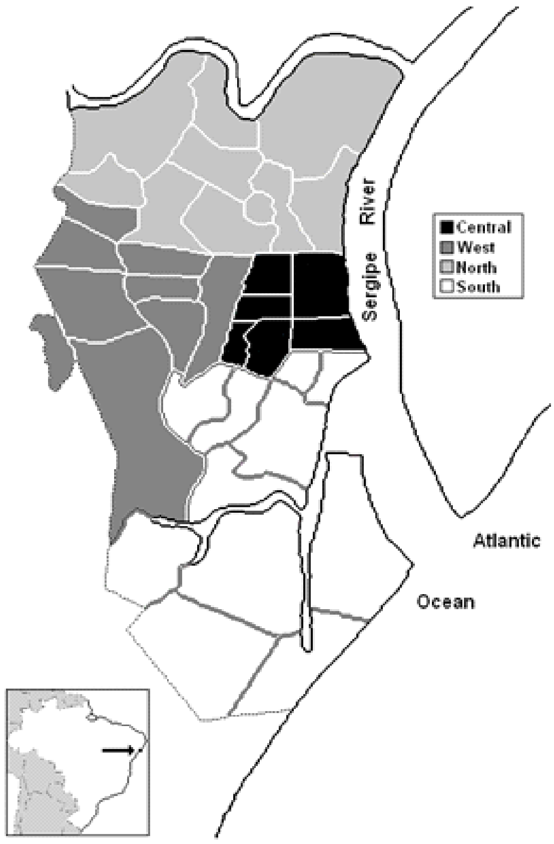


**Figure 1.** City of Aracaju: division of the 36 boroughs into the four zones analyzed in the present study.

**Table 1.** Climatic parameters for the study period, November 2002 to February 2003 (source: INFRAERO, Sergipe).

| Month | Relative humidity (%) | Temperature (ºC) | Total precipitation (mm) |
|---|---|---|---|
| November | 57-100 | 24.0-31.4 | 40.7 |
| December | 62-93 | 24.0-31.6 | 7.6 |
| January | 61-91 | 24.8-31.4 | 13.1 |
| February | 62-96 | 23.2-31.2 | 99.7 |

**Table 2.** Absolute and relative frequencies of airborne fungi in Aracaju, Sergipe, 2003.

| Genus | Number of colonies | % of plates (N = 72) |
|---|---|---|
| *Aspergillus* | 37 | 51.3 |
| *Botryodiplodia* | 27 | 37.5 |
| *Curvularia* | 24 | 33.3 |
| *Monotospora* | 20 | 27.7 |
| *Geotrichum* | 15 | 20.8 |
| *Penicillium* | 14 | 19.4 |
| *Fusarium* | 13 | 18.0 |
| *Helminthosporium* | 12 | 16.0 |
| *Candida* | 8 | 11.1 |
| *Oidiodendron* | 7 | 8.3 |
| *Gliocladium* | 6 | 8.3 |
| *Neurospora* | 4 | 5.5 |
| *Pullularia* | 4 | 5.5 |
| *Staphylotrichum* | 3 | 4.1 |
| *Trichosporonoides* | 3 | 4.1 |
| *Trichocladium* | 3 | 4.1 |
| *Alternaria* | 2 | 2.7 |
| *Microsporum* | 2 | 2.7 |
| *Mycotypha* | 2 | 2.7 |
| *Nigrospora* | 2 | 2.7 |
| *Trichoderma* | 2 | 2.7 |
| *Colletotrichum* | 2 | 2.7 |
| *Acremonium* | 1 | 1.3 |
| *Cephalosporium* | 1 | 1.3 |
| *Cladosporium* | 1 | 1.3 |
| *Papularia* | 1 | 1.3 |
| Unidentified | 17 | 23.6 |

**Table 3.** Comparação entre as zonas de Aracaju e as porcentagens de fungos que ocorreram em cada zona. Aracaju – SE, 2003.

| Zone | Samples | Genera identified | Exclusive genera (found only in this zone) | Mean number of genera per sample |
|---|---|---|---|---|
| North | 20 | 12 | 2 | 3.0 |
| South | 22 | 15 | 5 | 2.8 |
| West | 18 | 15 | 4 | 4.2 |
| Central | 12 | 14 | 4 | 2.8 |

**Table 4.** Absolute and relative frequencies of colonies of the different airborne fungus genera by zone of Aracaju.

| | Number (%) of colonies in zone: | | | |
|---|---|---|---|---|
| Genus | North | South | West | Central |
| *Aspergillus* | 16 (80.0) | 9 (50.0) | 9 (50.0) | 3 (25.0) |
| *Botryodiplodia* | 3 (15.0) | 23 (59.0) | 10 (55.5) | 1 (8.3) |
| *Curvularia* | 7 (35.0) | 7 (31.8) | 9 (50.0) | 1 (8.3) |
| *Monotospora* | 2 (10.0) | 3 (13.6) | 8 (44.4) | 7 (58.3) |
| *Geotrichum* | 4 (20.0) | 6 (27.2) | 4 (22.2) | 1 (8.3) |
| *Penicillium* | 4 (20.0) | 1 (4.5) | 8 (44.4) | 1 (8.3) |
| *Fusarium* | 7 (35.0) | 2 (9.0) | 2 (11.1) | 2 (16.6) |
| *Helminthosporium* | 2 (10.0) | 5 (22.7) | 5 (27.7) | - |
| *Cândida* | 3 (15.0) | - | 3 (16.6) | 2 (16.6) |
| *Oidiodendron* | - | 7 (31.8) | - | - |
| *Gliocladium* | 6 (30.0) | - | - | - |
| *Neurospora* | - | 1 (4.5) | 2 (11.1) | 1 (8.3) |
| *Pullularia* | - | - | 3 (16.6) | 1 (8.3) |
| *Staphylotrichum* | - | - | - | 3 (25.0) |
| *Trichosporonoides* | - | - | - | 3 (25.0) |
| *Trichocladium* | - | - | 3 (16.6) | - |
| *Alternaria* | 2 (10.0) | - | - | - |
| *Microsporum* | - | 2 (9.0) | - | - |
| *Mycotypha* | - | 2 (9.0) | - | - |
| *Nigrospora* | - | 2 (9.0) | - | - |
| *Trichoderma* | - | - | 2 (11.1) | - |
| *Colletotrichum* | 1 (5.0) | 1 (4.5) | - | - |
| *Acremonium* | - | 1 (4.5) | - | - |
| *Cephalosporium* | - | - | 1 (5.5) | - |
| *Cladosporium* | - | - | - | 1 (8.3) |
| *Papularia* | - | - | - | 1 (8.3) |
| Unidentified | 4 (20.0) | 1 (4.5) | 6 (33.3) | 6 (50.0) |
| **Number of plates** | **20** | **22** | **18** | **12** |

**Table 5.** Most common airborne fungi (>10% of plates) recorded in the present study and five other Brazilian cities.

| Genus | % of plates in[1]: Aracaju | Fortaleza | Natal | Porto Alegre | São Paulo | Presidente Prudente |
|---|---|---|---|---|---|---|
| *Aspergillus* | 51.3 | 44.7 | 65.0 | 15.0 | 23.3 | 55.8 |
| *Botryodiplodia* | 37.5 | - | - | - | - | - |
| *Curvularia* | 33.3 | 9.8 | 15.8 | 0.9 | 7.7 | 10.2 |
| *Monotospora* | 27.7 | - | - | - | - | 1.3 |
| *Geotrichum* | 20.8 | 0.2 | 0.8 | - | 0.9 | 0.6 |
| *Penicillium* | 19.4 | 13.3 | 50.0 | 15.0 | 41.7 | 17.9 |
| *Fusarium* | 18.0 | 3.5 | 20.8 | 0.1 | 14.0 | 26.9 |
| *Helminthosporium* | 16.0 | - | - | 2.5 | 9.3 | 2.7 |
| *Candida* | 11.1 | - | - | - | 14.7 | 20.5 |
| *Cladosporium* | 1.3 | 6.8 | 17.5 | 17.8 | 64.8 | 74.3 |
| *Rhizopus* | - | 3.1 | 14.1 | - | 1.9 | 26.9 |
| *Rhodotorula* | - | 0.9 | 10.8 | - | 48.9 | 22.4 |
| *Epicoccum* | - | 0.4 | - | - | 51.7 | 16.0 |
| *Monascus* | - | - | - | - | - | 44.2 |
| *Aureobasidium* | - | - | - | - | 19.6 | 37.2 |
| *Neurospora* | 5.5 | 1.4 | 7.5 | - | 4.4 | 35.9 |
| *Trichoderma* | 2.7 | 0.1 | 3.3 | - | 11.2 | 24.4 |
| *Mucor* | - | 0.4 | 1.6 | - | 1.4 | 17.3 |
| *Alternaria* | 2.7 | 2.4 | 0.8 | 1.1 | 17.0 | 16.0 |
| *Phoma* | - | 0.1 | 0.8 | - | 17.7 | 13.5 |
| *Trichotecium* | - | - | - | - | 1.9 | 10.2 |
| *Cryptococcus* | - | - | - | - | 0.2 | 10.2 |
| *Cephalosporium* | 1.3 | - | 0.8 | - | 11.0 | 0.6 |

[1]Source: Aracaju (present study), Fortaleza (Menezes *et al.*, 2006), Natal (Oliveira *et al.*, 1993); Porto Alegre (Homrich, M.H. 1961), São Paulo (Gambale *et al.*, 1983), Presidente Prudente (Buck & Gambale, 1985).

Biologia Geral e Experimental

Biol. Geral Exper., 11(1):23-28 28.xi.2011

# *PERULERNAEA GAMITANAE* (CRUSTACEA: LERNAEIDAE) PARASITIZING *COLOSSOMA MACROPOMUM* (OSTEICHTHYES: SERRASALMINAE) RAISED IN CAPTIVITY IN THE BRAZILIAN AMAZON

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## ABSTRACT

It was studied the parasitism of *Perulernaea gamitanae* in *Colossoma macropomum* raised in earthen ponds in the city of Benjamin Constant, State of Amazonas, northern Brazil. It was examined 40 fish – weight 1.258 ± 0.33 kg, size 40.64± 3.23 cm – and found 225 individuals of *P. gamitanae* parasitizing *C. macropomum* on the tongue (117), nasal cavities (3), gills and internal opercle surface (105). Prevalence was 100%, intensity was 3-14, and the average intensity and abundance were both 6.15 ± 2.14.

**Key words**: fish parasites, Cyclopoida, Copepoda, Solimões River, fish farming, Amazônia.

## RESUMO

Foi estudado o parasitismo de *Perulernaea gamitanae* em *Colossoma macropomum* criados em viveiros escavados no município de Benjamin Constant, Estado do Amazonas. Foram examinados 40 peixes – peso 1.258 ± 0,33 kg, tamanho 40.64 ± 3.23 cm – e encontrados 225 indivíduos de *P. gamitanae* parasitando *C. macropomum* na língua (117), fossas nasais (3), brânquias e a superfície interna do opérculo (105). A prevalência foi 100%, a intensidade foi 3-14, a intensidade média e a abundância foram ambas 6.15 ± 2.14.

**Palavras-chave:** parasitas de peixes, Cyclopoida, Copepoda, rio Solimões, criação de peixes, Amazônia.

## INTRODUCTION

The rise of an intensive and semi-intensive rearing of fish in the Brazilian Amazonian region motivated the increase of studies for control and treatment of many fish diseases (Morais, 2009). Among the health problems that affect fish reared in captivity, parasitism is a very worrying one, because factors related to fish management may break the host-symbionts balance, resulting in epizooties difficult to control (Malta *et al.*, 2001).

Many organisms parasitize freshwater fish, like crustaceans, isopods and copepods (Malta & Varella, 2000; Benetton & Malta, 1999). Among the copepods, the lernaeid *Perulernaea gamitanae* Thatcher & Paredes, 1985, has a great parasitological importance, because it is one of the Amazonian species that parasitize the tambaqui *C. macropomum*, and may even kill this fish when they are reared in captivity

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(Thatcher & Williams, 1998).

As the tambaqui is one of the most economically important fish species throughout the Amazonian region, we conducted the present study in order to contribute to the knowledge of fish parasitism.

## MATERIAL AND METHODS

***Fish acquisition and first transportation*:** The tambaqui fingerlings were obtained through induced spawning in the fish culture station of the Hydroelectric of Balbina (01º52'S, 59º28'W), Amazonas State, northern Brazil. In October 2004 it was obtained fingerlings with 30 days life, size 1-2 cm, and kept in sealed plastic bags, with one part of water and three parts of oxygen. From the hydroelectric the fingerlings were transported to Manaus (03º08'S, 60º01'W), nearly 200 km from Balbina.

***Second transportation*:** After the fingerlings acquisition and the transportation to Manaus, the fish were transported from Manaus to the city of Tabatinga (05º47'S, 65º24'W), Brazilian Amazonia in the upper course of the Negro River, where they were stocked in earthen tanks during one month.

***Third transportation*:** The fingerlings grew up to 5cm in the first place where they were stocked and then they were transported to the fish culture station at the city of Benjamin Constant (04º 24'S, 70º 02' W), also in the Brazilian Amazonia.

***Fourth transportation*:** On May 2005 the fish weighed 30g and were redistributed to two fish farmers in the city of Benjamin Constant: the Sete Irmãos and the Aldrim farmers. However, only in the former the fish had parasites, reported here.

***The intermediate and permanent earthen ponds*:** The Sete Irmãos fish farm received 4,700 *C. macropomum* juveniles, placed in one of the eight earthen ponds with 0.7 ha in size, at a density of 5.2 fish per square meter. After 30 days, the fish weighed 150g and were transferred to a second pond with 0.8 ha in size, at a density of 5 fish per square meter. The fish were fed with extruded food containing 35% of net protein (NP).

***Field epizooty observations*:** In May 2006 the tambaqui fish were 1 year and 6 months old, when the epizooty was first recorded. At this time a sample of 40 fish was removed with gill nets and each individual was examined looking for parasites.

***Laboratory parasite observations and other procedures*:** The fish were weighed (g), measured (standard, furcal and total length - cm) and numbered before death through brain puncture. Body surface, fin bases, nasal cavities, oral and gill cavities, tongue and anus were searched for ectoparasites. The parasites found were removed with tweezers and knife, fixed and preserved in 70% alcohol.

***Sample and inferences*:** 40 fish – weigh 1.258 ± 0,33 kg, size 40.64 ± 3.23 cm – were examined. The parasite indexes were calculated according to Bush *et al*. (1997). The number of fish from the parasitological sample was calculated according to the *American Fisheries Society* table, modified by Kabata (1985), with a 95% degree of confidence and prevalence estimated at 10%.

## RESULTS

We recorded 225 *P. gamitanae* individuals parasitizing the first gill arch (19), the third (2) and the gill rakers (9). Other organs were also parasitized, such as the nasal cavities (3), the inner gill surface (75) and the tongue (117).

The gills showed hyperplasia and anemia. The internal portion of the opercle and the nasal cavities had hemorrhagic processes near the fixation spots. Intense hemorrhage occurred when the parasites were removed from the fish's tissues.

It was also observed strong inflammatory reaction, with red and darkened lesions, all over the parasitized portions of the fish, especially in the tong, where drillings could be clearly observed, but with no parasites.

The parasite indices of *P. gamitanae* on the 40 *C. macropomum* individuals were: prevalence 100%, mean intensity (range 3-14) and mean abundance were both 6.15 ± 2.14 parasites on the host. No other parasite species was observed on the fish; therefore mean intensity and mean abundance could only be the same in this case (Margolis *et al*., 1982).

Other ponds of the farm had the pirarucu *Arapaima gigas* (Shinz, 1822) and the matrinxã *Brycon amazonicus* (Spix & Agassiz, 1829) collected in nature, however, only *C. macropomum* was parasitized by *P. gamitanae*.

## DISCUSSION

Some factors addressed in this study are relevant for brief discussions, such as the importance of the fish and parasitism on the species, some taxonomic characteristics of the parasite, specificity of the parasite to the host, parasitized organs with tissue inflammation, and indices of parasitism on the studied fish.

### *The fish in this study context*

Because of the economic importance of the tambaqui *C. macropomum* we conducted the present study related to parasitism. This fish is widely distributed in the main South American northern rivers, where individuals may reach 1 meter long and 30 kg (Araujo-Lima & Goulding, 1998). The body proportions of this fish and its good meet led him to be one of the first species in the Amazon region with sufficient knowledge to enable plans for natural stocks management and rearing. However, one problem related to this is that the tambaqui is seriously attacked by parasites when reared in captivity.

### *Parasitism in* **Colossoma macropomum (Cuvier, 1818)**

Among the organisms that parasitize freshwater fish, the crustaceans, isopods and copepods are the most frequent. *Colossoma macropomum*, for example, is parasitized by six crustacean species – five from the class Branchiura: *Dolops carvalhoi* Lemos de Castro, 1949 (Malta & Varella, 1983); *D. geayi* (Bouvier, 1892); *Argulus multicolor* Stekhoven, 1937 (Malta, 1983); *A. chicomendesi* Malta & Varella, 2000 (Malta & Varella, 2000) and one unidentified form of the genus *Argulus* (Malta, 1884).

Also, *C. macropomum* is parasitized by one Isopoda species, *Braga patagonica* Schiödte & Meinert, 1884, and three Copepoda species, namely *Gamidactylus jaraquensis* Thatcher & Boeger, 1984 (Fischer *et al.* 2003), one unidentified species from genus *Miracetyma* (Malta, 1993) and *Perulernaea gamitanae* (Fischer *et al*, 2003; Benetton & Malta, 1999).

### *Taxonomic characteristics of* **Perulernaea gamitanae**

This copepod species is endemic to the Neotropical region and seems to be specific to *C. macropomum*. The species is characterized by round head anchors in the post-metamorphic females, thin neck, posterior region of body fusiform and few post-equatorial pores, uropods, four pairs of well separated legs and multiseriate egg sacks (Thatcher & Paredes, 1985; Benetton & Malta, 1999).

The naupliar stages are free-living and the time of development from nauplius I to VI is around 5 days. In the copepodite stage I it is necessary a host to continue the life cycle. The free-living stage I copepodite survived seven days with no ecdysis.

### *Parasite specificity*

The first record of *P. gamitanae* parasitizing *C. macropomum* in captivity was reported by Benetton & Malta (1999). They collected adults reared in earthen ponds in the Aquiculture Station of the Instituto Nacional de Pesquisas da Amazônia, in Manaus.

The literature reports no *P. gamitanae* infestation in a sample of 435 fish of four orders and 44 species from the rivers Guaporé, Mamoré, Pacaás-Novos, Jamari, Jiparaná and Urupá, in the State of Rondônia, southeast Brazilian Amazon (Malta, 1993a;

1993b; 1993c; 1993d; 1993e; 1994a; 1994b; Malta & Varella, 1996; Varella & Malta, 1995; 2001).

However, in a sample of 1,355 fish of five orders and 80 species from Lake Janauacá, Solimões River, in the Central Amazon Basin, Malta (1984) and Malta & Varella (1983) reported that *P. gamitanae* was found specifically parasitizing *C. macropomum,* while no other fish species was observed parasitized by this copepod in their studies.

### *Organs affected by the infestation of* **P. gamitanae** *and tissue inflammation*

Although the fish conditions of this present study, such as the induced spawning, captivity, and size (36.0 cm – 44.5 cm), an expressive number of *P. gamitanae* was observed parasitizing *P. macropomum* – 225 parasites in 40 examined fish. The most parasitized portion of the body was the oral cavity, with 117 parasites in the tongue and 3 in the nasal cavities.

In other studies cited in the current literature, Fischer *et al.* (2003) reported 51 *P. gamitanae* specimens parasitizing the oral cavity of five tambaqui fish and the nasal cavities in 69 collected tambaqui in the Amazon Basin. In the oral cavity they anchored to the dentary bone, tongue, esophagus wall, inner and outer surfaces of the opercle.

We observed that the tissue inflammation caused by *P. gamitanae* was red and darkened. The gills presented a process of hyperplasia and anemia. We found evident hemorrhagic processes close to the fixation spots in the internal region of the opercle and nasal cavities. When *P. gamitanae* individuals were removed from tambaqui tissues, intense hemorrhages occurred.

The strong inflammatory reaction, with red and darkened lesions in the portions of the fish found parasitized, were caused by the fixation spots of *P. gamitanae*. The severe inflammatory process observed in the tongue was caused by the penetration of the parasite's head, which was inserted nearly three centimeters inside the muscle. The deep perforations observed on the tongue were probably caused by previous lernaeids parasites and their respective fixation spots.

### *Indices of parasitism in* **C. macropomum**

The prevalence we observed in this study was 100%, intensity ranged from 3 to 14 parasites per fish; mean intensity and abundance were both 6.15 ± 2.14, considered very high, probably due to the fact that fish reared in captivity are concentrated in small areas. Also, *P. gamitanae* has a direct life cycle and no natural predators, which optimize the life cycle of the parasite.

Eight out of 36 *C. macropomum* fish from the Upper Solimões River, examined by Fischer *et al.* (2003), were parasitized by *P. gamitanae,* less then we report here. They found and discussed that: i) prevalence was 22.2%, mean intensity 2.5, intensity varied between 1 and 6, and abundance was 0.5 lernaeid per tambaqui, ii) 15 out 33 fish in another sample reported by Fisher and his colleagues from the Lower Amazon River were parasitized by *P. gamitanae*, iii) in this case, prevalence was 45.4%, average intensity 1.5, intensity 1 to 3, and abundance was 0.7 lernaeid per tambaqui.

Bastos *et al.* (1996) reported a sample of 30 *C. macropomum* from a fish farm in Bom Jesus de Itabapoana, Rio de Janeiro State. In 20 fish they found no parasites; in 10 juveniles 4-20 months old, 7 were parasitized by no more than 3 lernaeids. The parasite species reported by Bastos and his colleagues was the copepod *Lernaea cyprinacea* Linnaeus, 1758, an exotic species introduced to Brazil in 1988, belonging to the same Lernaeidae family of *P. gamitanae*. The authors reported that *L. cyprinacea* was found in fins and in its respective insertion bases in the body; the parasite indexes were very low, prevalence 20%, and intensity of 1 to 3 parasites per fish.

Benetton & Malta (1999) reported that *P. gamitanae* collected in tambaqui at Inpa's Aquiculture Station in Manaus, was found parasitizing the oral, gill and nasal cavities of the fish; prevalence was 95%. These results are so close to those found in this present study and we conclude corroborating with other studies (e.g. Malta, 1983; Malta & Varella, 1983) that establish *P. gamitanae* as a specific parasite to *P. macropomum*.

**Acnowledgements:** For financial and logistical support we thank the Fundação de Amparo à Pesquisa do Estado do Amazonas, Instituto Nacional de Pesquisas da Amazônia, Instituto de Desenvolvimento Agropecuário e Florestal Sustentável do Estado do Amazonas. We also acknowledge the students of the Fish Farming Technical Course in the city of Benjamin Constant, Amazon State, for helping in the collection of fish and parasites.

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Aceito em 17.ii.2011