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Cover photo of this issue: *Chilomycterus antillarum* Jordan & Rutter, 1897 (Teleostei, Tetraodontidae) *in situ* at the Barra Grande beach, state of Piauí, Brazil. Underwater picture taken on March 2007 by Ana Cecília Giacometti Mai.

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Composição da ictiofauna durante o período de alagamento em uma mata paludosa da planície costeira do Rio Grande do Sul, Brasil

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Abstract. Ichthyofaunal assemblage of a swamp forest located in the Rio Grande do Sul coastal plain, Brazil. The few remaining swamp forests fragments that occur in the coastal region of southern Brazil are poorly revised and studies on their ichthyofaunal composition are rare. In the present article we describe the fish assemblage of a swamp forest fragment in the Rio Grande county, Rio Grande do Sul state, southern Brazil. Thirty eight samples where collected with a small fish-trap (locally known as 'covo') in the flooded period between October-November 2005 and August-November 2006. A total of 18 species were sampled, representing four orders (Characiformes, Siluriformes, Cyprinodontiformes, Synbranchiformes) and seven families (Characidae, Heptapteridae, Callichthyidae, Rivulidae, Anablepidae, Poeciliidae, Synbranchidae). The family Characidae presented the larges number of species while the Cyprinodontiforms were the most abundant (86% of the total number of fish collected). Among the Cyprinodontiforms the numerical dominance of the killifishes *Austrolebias minuano* and *Austrolebias wolterstorfii* was of particular importance, specially because both are threatened species, and represented the second and third more abundant species in this fish assemblage, evidencing the relevance of the swamp forest preservation for the conservation of the remaining annual fish populations of southern Brazil and Rio Grande do Sul state.

Key words: swamp forest, fishes, survey, flooded period, Rivulidae.

Resumo. Os poucos fragmentos existentes de matas paludosas da região costeira do extremo sul do Brasil são pouco estudados sendo raras as informações sobre a composição da ictiofauna. O presente trabalho descreve a assembléia de peixes em um fragmento de mata paludosa no município de Rio Grande, Rio Grande do Sul, Brasil. Trinta e oito coletas com amostrador tipo covo foram realizadas no período alagado da mata paludosa, entre os meses de outubro e novembro 2005 e entre agosto e novembro de 2006. Um total de 18 espécies de peixes foi amostrado, com representantes de quatro ordens (Characiformes, Siluriformes, Cyprinodontiformes, Synbranchiformes) e sete famílias (Characidae, Heptapteridae, Callichthyidae, Rivulidae, Anablepidae, Poeciliidae, Synbranchidae). A família Characidae foi a que apresentou o maior número de espécies (9) e os Cyprinodontiformes corresponderam, em número, a 86% do material coletado. Dentre os Cyprinodontiformes destacam-se os peixes anuais *Austrolebias minuano* e *Austrolebias wolterstorfii*, espécies ameaçadas de extinção, que corresponderam, respectivamente, a segunda e terceira espécies mais abundantes nessa assembléia, o que evidencia a importância da preservação das matas palustres para a manutenção das populações remanescentes de peixes anuais no Rio Grande do Sul.

Palavras-chave: mata palustre, peixes, inventário, alagamento, Rivulidae.

Introdução

As matas paludosas, também conhecidas como brejos, matas brejosas, palustres ou higrófilas (Waechter 1990) caracterizam-se por apresentar alagamento permanente ou temporário, sendo as margens pouco definidas e o solo rico em matéria orgânica vegetal (Villwock *et al.* 1980). Nestes ambientes, o acúmulo de matéria orgânica vegetal no sedimento, composta por celulose, lignina e outras substâncias com estrutura química cíclica de difícil degradação, combinado com condições desfavoráveis à decomposição aeróbica, como excesso de água, ausência de oxigênio e reação ácida, facilitam o processo de humidificação (formação do ácido húmico ou colóides húmicos insaturados) (Villwock *et al.* 1980, *sensu* Costa *et al.* 2003).

Na planície costeira do Rio Grande do Sul, as matas paludosas estão presentes em formas insulares, geralmente adjacentes às matas arenosas (*sensu* Dorneles & Waechter 2004). No estado do Rio Grande do Sul menos que 5% da cobertura original do domínio de Mata Atlântica permanecem como remanescentes florestais, principalmente nas regiões norte e central (Conservation International do Brasil *et al.* 2000). Segundo Joly *et al.* (1990) as matas palustres das restingas costeiras do Sudeste e Sul do Brasil estão inseridas no bioma Mata Atlântica e, portanto, estão protegidas pela legislação ambiental (lei n° 4.771), que as classifica como Áreas de Preservação Permanente (APPs).

A ictiofauna de ambientes límnicos da planície costeira do Rio Grande do Sul é relativamente bem conhecida, com diversos trabalhos já publicados (Buckup & Malabarba 1983, Grosser *et al.* 1994, Tagliani 1994, Costa & Cheffe 2001, Bemvenuti & Moresco 2005, Loebmann & Vieira 2005a, b, Burns *et al.* 2006, Garcia *et al.* 2006). Estes estudos, no entanto, estão limitados a áreas abertas e bem iluminadas, sendo que a composição e estrutura das assembléias de peixes em matas palustres da região permanecem praticamente desconhecidas, com apenas registros pontuais de *Austrolebias minuano* Costa & Cheffe, 2001 e *Austrolebias wolterstorffi* (Ahl, 1924) na cidade de Rio Grande (Porciuncula *et al*. 2006).

Este trabalho teve por objetivo verificar a composição e abundância relativa da ictiofauna presente em um fragmento de mata paludosa no município de Rio Grande, região sul da Planície Costeira do Rio Grande de Sul, e identificar sua relação com o período de alagamento da área estudada.

Material e Métodos

O município de Rio Grande (31°47’02’’- 32°39’45’’ S; 52°03’50’’ - 52°41’50’’ W) está localizado na região sul da planície costeira do Rio Grande do Sul, a oeste do estuário da laguna Lagoa dos Patos. Com uma área de 2834 km², apresenta baixas cotas altimétricas, que ficam entre zero e dois metros, exceto as formações dunares. O clima é classificado como mesotérmico superúmido, com médias de temperatura máxima anual de 23,3 °C e mínima de 12,7 ºC. As estações do ano são bem definidas, com boa insolação e evaporação, o que condiciona uma boa homogeneidade pluviométrica, com média anual de precipitação total de 1252 mm (Vieira 1983).

O ambiente estudado é um fragmento de mata paludosa conhecida como “Mata da Estrada Velha” (32º07’S; 52º09’W) localizada no 1º Distrito do município de Rio Grande (Figura 1). A mata possui uma área de 220000 m^2 e um perímetro aproximado de 1760 m, pertencendo ao Distrito Industrial do município. A vegetação é composta principalmente por espécies arbóreas (*Erythrina crista-galli* L., *Syagrus romanzoffiana* (Cham.), *Ficus cestrifolia* Chodat), macrófitas aquáticas das famílias Ranunculaceae (*Ranunculus apiifolius* Pers.), Umbeliiferae (*Hydrocotyle ranunculoides* L. F., *Centella asiática* L.), *Enydra* sp. Lour., Cyperaceae (*Scirpus* sp. L.), Alismataceae (*Sagittaria montevidensis* Cham. & Schltdl.), Compositae (*Senecio bonariensis* Hook. & Arn.), Salviniaceae (*Azolla filiculoides* Lam.), Ricciaceae (*Ricciocarpus natans* L.) e Lemnaceae (*Spirodela intermédia* W. Kock, *Lemna valdiviana* Phil.). Observações pontuais de parâmetros ambientais (19/10/2005) revelaram valores de pH entre 5,8 e 5,60 (medidor de ph digital Hanna® 8314); oxigênio dissolvido entre 3,37 e 3,59 mg.l^{-1} (oxímetro digital Oakton® DO300); condutividade 419 µS.cm^{-1} (condutivímetro digital Hanna® 8733) a uma temperatura de 20 ºC, medidos na sub-superfície (profundidade de 20 cm).

As coletas de peixes foram realizadas em uma secção alagada de aproximadamente 772 m², sob densa cobertura vegetal original, nos meses de outubro e novembro de 2005 e entre agosto e novembro de 2006, período em que as mesmas permaneceram alagadas. Para a coleta dos exemplares foram utilizados três amostradores retangulares do tipo covo (60 x 52 x 37 cm), totalizando 38 amostras. Os covos foram distribuídos aleatoriamente na área de coleta e instalados sobre o substrato, permanecendo em posição fixa durante todo o período de amostragem.

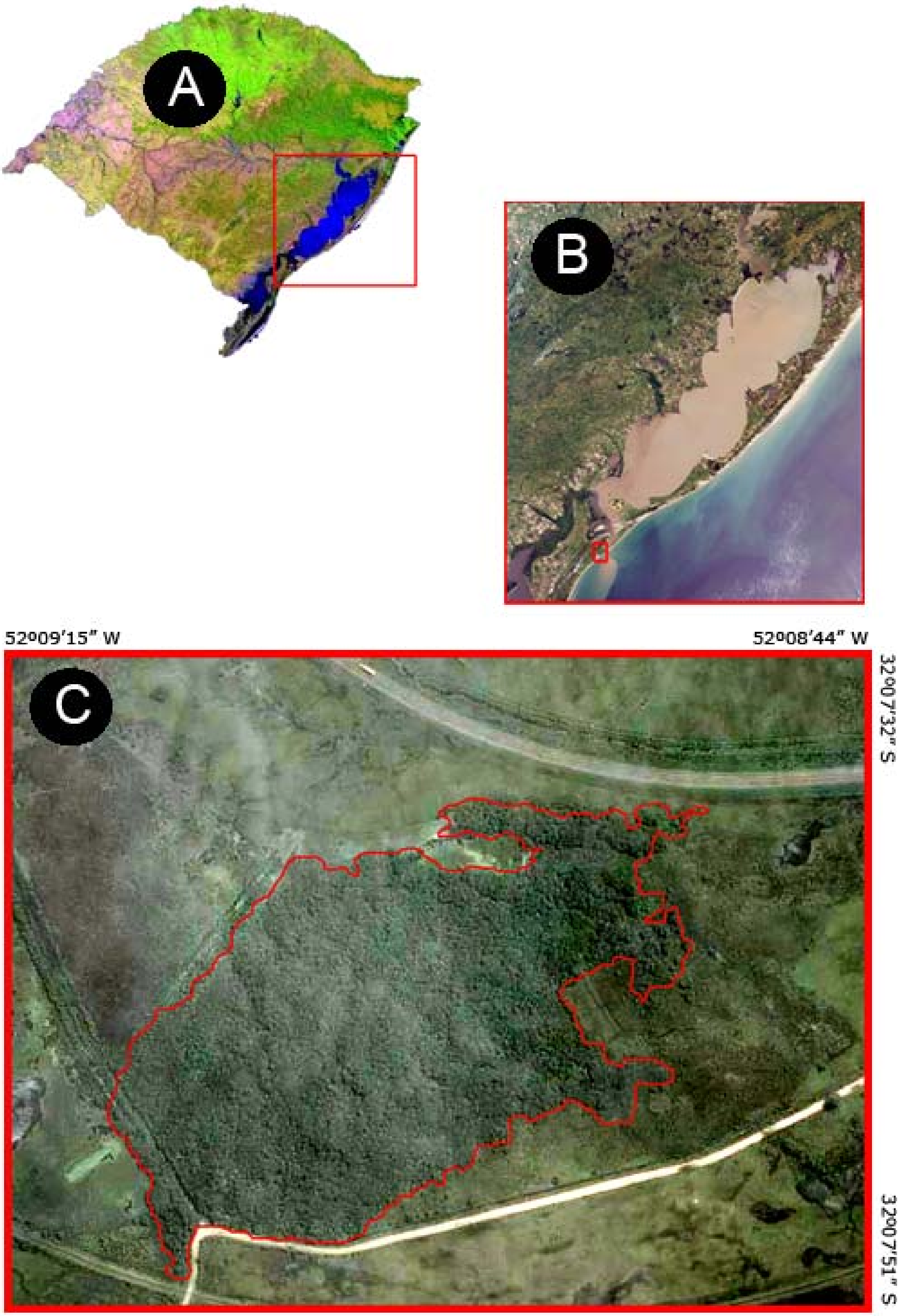

Figura 1. Área de estudo. A – Estado do Rio Grande do Sul; B – Sistemas Lagoa dos Patos; C – Mata Paludosa estudada.

Foram utilizados como isca pão e presunto moído. Os amostradores eram verificados a cada 24 horas após sua instalação. Os exemplares coletados foram fixados em formalina 10% e levados para laboratório, onde foram identificados, contados e medidos. Os exemplares de *Austrolebias* spp. coletados foram colocados em aquários, onde foram contados, identificados e fotografados, sendo posteriormente soltos no local de coleta. Oito exemplares de *Austrolebias* spp. foram fixados em formalina 10%, conservados em álcool 70% e medidos, sendo que para a análise de estrutura dessas espécies foram incluídos os dados biométricos apresentados por Porciuncula *et al.* (2006). Os exemplares coletados e fixados foram depositados na coleção ictiológica da Fundação Universidade Federal do Rio Grande (FURG). A cada coleta foi obtida a profundidade por meio de régua fixa graduada em milímetros.

Resultados

As 38 amostras obtidas durante o período alagado resultaram em um total de 819 exemplares de peixes coletados, distribuídos em quatro ordens, seis famílias e 18 espécies (Tabela I). A ordem Characiformes apresentou a maior riqueza (50% do total de espécies), com nove espécies amostradas, todas representantes da família Characidae. Seis espécies da ordem Cyprinodontiformes foram amostradas, representando 33% do total de espécies. Apenas duas espécies da ordem Siluriformes (*Rhamdia* aff. *quelen* Quoy & Gaimard, 1824 e *Corydoras paleatus* (Jenyns, 1842)) foram amostradas (11% do total de espécies), enquanto que um único exemplar da ordem Synbranchiformes (*Synbranchus marmoratus* Bloch, 1795) foi coletado (5,6% do total de espécies).

A abundância relativa de Cyprinodontiformes correspondeu a 86% dos espécimes coletados (n = 705), sendo que os rivulídeos representaram cerca de 83% desse percentual (n = 587). *Cynopoecilus melanotaenia* Regan, 1912 (Figura 2a) foi a espécie mais abundante, com 306 exemplares (37,4%) amostrados. *Austrolebias minuano* (n = 199) (Figura 2b) e *Austrolebias wolterstorfii* (n = 83) (Figura 2c) corresponderam a segunda e terceira espécies mais abundantes, respectivamente. *Cheirodon interruptus* (Jenyns, 1842) (n = 45) (Figura 2d) e *Hyphessobrycon boulengeri* (Eingenmann, 1907) (n = 21) foram os caracídeos mais abundantes, ao passo que *Cyanocharax alburnus* (Hensel, 1870), *Cheirodon ibicuhiensis* Eingenmann, 1915, *Astyanax eingenmaniorum* (Cope, 1894) e *Astyanax* sp. tiveram apenas um indivíduo amostrado. *Rhamdia* aff. *quelen* foi a espécie de siluriforme mais abundante, com 32 exemplares coletados (Tabela I).

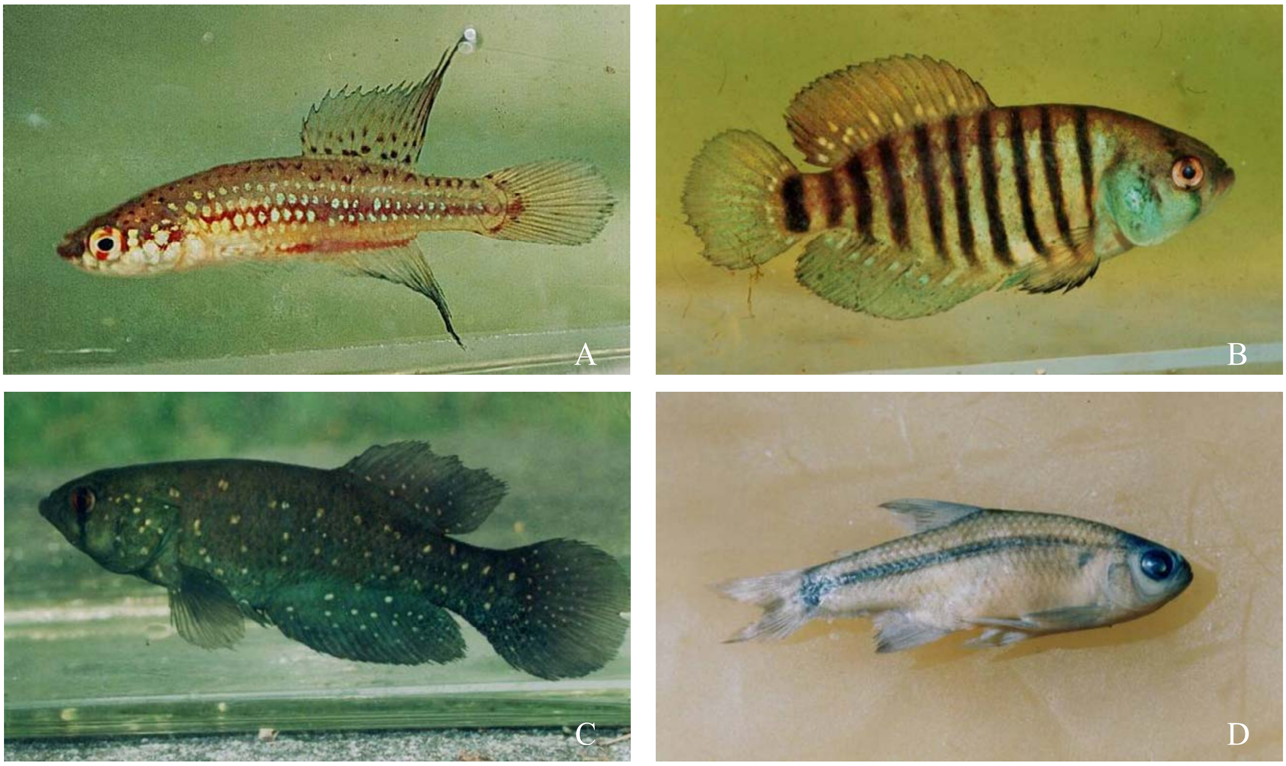

Figura 2. Principais elementos da ictiofauna (A - *Cynopoecilus melanotaenia*; B - *Austrolebias minuano*; C - *Austrolebias wolterstoffi*; D - *Cheirodon interruptus*).

Tabela I. Profundidade média mensal, número de exemplares coletados (N) e contribuição percentual numérica mensal (PN%) das espécies de peixes encontradas em uma secção alagada de mata paludosa do município de Rio Grande, RS, entre outubro de 2005 e novembro de 2006.

Período das coletas (mês/ano)	**out/05**		**nov/05**		**ago/06**		**set/06**		**out/06**		**nov/06**	
Profundidade média em centímetros; (nº. de coletas)	45(5)		45(5)		37(7)		41(11)		41(5)		42(5)	
Táxon	**PN%**	**N**	**PN%**	**N**	**PN%**	**N**	**PN%**	**N**	**PN%**	**N**	**PN%**	**N**
Characiformes												
Characidae												
Astyanax eigenmanniorum (Cope, 1894)			0,8	1								
Astyanax fasciatus (Cuvier, 1819)			2,5	3								
Astyanax sp. Baird & Girard, 1854											0,5	1
Cheirodon ibicuhiensis Eingenmann, 1915											0,5	1
Cheirodon interruptus (Jenyns, 1842)	8,3	9	0,8	1	0,8	1	9,1	10	5,1	9	7,4	14
Cyanocharax alburnus (Hensel, 1870)							0,9	1				
Hyphessobrycon luetkeni Boulenger, 1887	3,7	4										
Hyphessobrycon boulengeri (Eingenmann,1907)			0,8	1	1,7	2	1,8	2	3,9	7	4,8	9
Oligosarcus jenynsii (Günther, 1864)			1,7	2								
Siluriformes												
Heptapteridae												
Rhamdia aff. *quelen* Quoy & Gaimard, 1824	13,8	15	14,3	17								
Callichthyidae												
Corydoras paleatus (Jenyns, 1842)											0,5	1
Cyprinodontiformes												
Rivulidae												
Austrolebias minuano Costa & Cheffe, 2001	11,9	13	7,6	9	44,9	53	36,7	40	29,5	52	16,4	31
Austrolebias wolterstorffi (Ahl, 1924)	4,6	5	4,2	5	21,2	25	19,3	21	10,2	18	5,8	11
Cynopoecilus melanotaenia Regan, 1912	49	53	26,8	32	22,9	27	28,4	31	43,1	76	46,2	87
Anablepidae												
Jenynsia multidentata (Jenyns, 1842)	1,8	2	18,5	22	3,4	4	3,7	4	3,4	6	3,2	6
Poeciliidae												
Cnesterodon decenmaculatus (Jenyns, 1842)									0,6	1		
Phalloceros caudimaculatus (Hensel, 1868)	7,3	8	21,8	26	5,1	6			3,9	7	13,8	26
Synbranchiformes												
Synbranchidae												
Synbranchus marmoratus Bloch, 1795											0,5	1
TOTAL	**100**	**109**	**100**	**119**	**100**	**118**	**100**	**109**	**100**	**176**	**100**	**188**

A estrutura de tamanho da assembléia estudada mostrou-se com um grande predomínio de indivíduos de pequeno porte (< 70 mm), que corresponderam a 98,75% dos exemplares amostrados e medidos. A maior medida registrada foi de um exemplar de *Synbranchus marmoratus* (367 mm) (Tabela II).

Observações regulares realizadas em dois anos consecutivos (2005 e 2006) apontaram um período de alagamento permanente entre os meses de maio a novembro. Durante o segundo período de amostragem (ago.-nov./2006) a composição ictiofaunística apresentou comportamento distinto em função de seu ciclo temporal. Nas coletas realizadas durante as primeiras duas semanas de amostragem (profundidades entre 32 cm e 35 cm; ago./2006) foram observados apenas indivíduos da família Rivulidae (*C. melanotaenia*, *A. minuano*, *A. wolterstorffi*). Durante a terceira semana de amostragem (profundidade = 37 cm; ago./2006) foram observados pontos de comunicações entre secções alagadas da mata e canais e banhados adjacentes, através de estreitos fluxos hídricos com profundidade inferior a 10 cm. Durante esse período, além dos rivulídeos foram coletados adultos de *Phalloceros caudimaculatus* (Hensel, 1868) e *Hyphessobrycon boulengeri*. No final do período de alagamento (profundidade máx. = 45 cm; nov./2006), as 13 espécies registradas nesse ciclo anual foram coletadas. Outras cinco espécies não amostradas nesse ciclo foram registradas no final do período de alagamento do ano de 2005 (profundidade máxima = 45 cm) (Tabela I).

Tabela II. Número de exemplares medidos (N), amplitude de comprimento (CT (mm)) e número de tombo das espécies amostradas. Espécies assinaladas (*) são incluídos os dados biométricos apresentados por Porciuncula *et al*. (2006).

Táxon	**N**	**CT (mm)**	**Nº Tombo**
Astyanax eigenmanniorum (Cope, 1894)	1	30	FURG 05-019
Astyanax fasciatus (Cuvier, 1819)	3	25 - 31	FURG 05-021
Astyanax sp.	1	35	FURG 06-020
Cheirodon ibicuhiensis Eingenmann, 1915	1	29	FURG 06-018
Cheirodon interruptus (Jenyns, 1842)	45	17 - 66	FURG 05-017
Cyanocharax alburnus (Hensel, 1870)	1	31	FURG 06-017
Hyphessobrycon luetkeni Boulenger, 1887	4	17 - 31	FURG 05-016
Hyphessobrycon boulengeri (Eingenmann,1907)	21	33 - 64	FURG 06-013
Oligosarcus jenynsii (Günther, 1864)	2	43 - 46	FURG 05-018
Rhamdia aff. *quelen* Quoy & Gaimard, 1824	32	37 - 56	FURG 05-022
Corydoras paleatus (Jenyns, 1842)	1	26	FURG 06-016
Austrolebias minuano Costa & Cheffe, 2001*	17	23 - 50	FURG 06-014
Austrolebias wolterstorffi (Ahl, 1924)*	9	35 - 105	FURG 06-015
Cynopoecilus melanotaenia Regan, 1912	306	18 - 40	FURG 05-020
Jenynsia multidentata (Jenyns, 1842)	44	29 - 55	FURG 06-019
Cnesterodon decenmaculatus (Jenyns, 1842)	1	25	FURG 06-022
Phalloceros caudimaculatus (Hensel, 1868)	73	18 - 47	FURG 06-021
Synbranchus marmoratus Bloch, 1795	1	367	FURG 06-023

Discussão

A variação na composição da ictiofauna durante o período de alagamento permitiu identificar três diferentes estratégias de colonização, sendo: 1- Peixes anuais de ciclo de vida curto, com forma juvenil e adulta no período alagado e com ovos de resistência no período de seca (Rivulidae: *C. melanotaenia*, *A. minuano*, *A. wolterstorffi*); 2 – espécies visitantes que colonizam a área após a conexão das matas com outros corpos d'água de áreas abertas adjacentes; 3- espécies de ciclo de vida longo (> 1 ano), apresentando o modo de colonização anterior e a capacidade de permanecerem na fase adulta mesmo no período de seca, permanecendo enterradas no sedimento (Synbranchidae: *S. marmoratus*). A permanência de *S. marmoratus* durante o período de seca foi verificada com base no encontro de dois exemplares enterrados no lodo, sob pedras, no período de estiagem posterior às amostragens (jan./2007). Foram identificados como visitantes espécies de pequeno porte (Characidae, Anablepidae, Poeciliidae, Callichthyidae) e juvenis de espécies de grande porte (Heptapteridae: *Rhamdia* aff. *quelen*).

Embora as diferenças entre o esforço e as artes de pesca empregadas não permitam uma comparação direta com os estudos de assembléias de ambientes límnicos da planície costeira do Rio Grande do Sul (Buckup & Malabarba 1983, Lucena *et al.* 1994, Tagliani 1994, Grosser *et al.* 1994, Loebmann & Vieira 2005 a, b, Burns *et al.* 2006, Garcia *et al.* 2006), a composição da ictiofauna estudada apresentou um padrão de dominância peculiar, quando comparados a esses estudos. Ou seja, mesmo que a maior riqueza de espécies seja de caracídeos, corroborando com os estudos supramencionados, a alta abundância de rivulídeos encontrada nesse estudo revela um padrão ainda não registrado para a planície costeira do Estado.

Os rivulídeos quando presentes em inventários realizados em outros ecossistemas límnicos da região (Buckup & Malabarba 1983, Tagliani 1994) não apresentam abundância significativa frente às outras espécies amostradas. *Austrolebias minuano* e *Cynopoecilus melanotaenia* foram amostrados por Tagliani (1994) na várzea do arroio Bolaxa, enquanto que *C. melanotaenia* foi encontrado em banhados temporários do Sistema Hidrológico do Taim (Buckup & Malabarba 1983). Exemplares de *Austrolebias wolterstorffi* foram amostrados em diversos pontos da planície costeira (ver Costa 2006), todavia, dados comparativos sobre a abundância desta espécie nos ambientes de ocorrência não estão disponíveis na literatura para fins comparativos. A grande predominância dos rivulídeos no presente estudo está associada ao marcado ciclo sazonal de alagamento da área.

Uma outra observação importante refere-se ao aparecimento de exemplares adultos de espécies de pequeno porte (*Phalloceros caudimaculatus* e *Hyphessobrycon boulengeri*) a partir da conexão da Mata Paludosa com áreas alagadas abertas, sugerindo um fluxo de espécies de pequeno porte de áreas abertas para áreas fechadas. Uma possível explicação seria a procura de áreas protegidas de predadores visualmente orientados, já que a secção alagada na mata é completamente coberta por macrófitas aquáticas, tornando-a um ambiente com baixa visibilidade.

A ausência de ciclídeos no presente estudo sugere uma limitação de representantes dessa família em habitar matas paludosas, uma vez que exemplares de *Geophagus brasiliensis* (Quoy & Gaimard, 1824), *Crenicichla lepidota* Heckel, 1840 e *Australoheros cf. facetus* (Jenyns, 1842), são freqüentemente capturados, utilizando-se do mesmo amostrador, em lagos próximos situados em áreas abertas (FMQ obs. pess.).

No presente estudo foi observado a dominância numérica dos rivulídeos sobre outras espécies representativas de ambientes palustres da região, sugerindo um padrão ictiológico característico dos fragmentos de matas paludosas das restingas costeiras do Rio Grande do Sul. No entanto, ainda é necessário ampliar esforços de investigação em outras matas palustres da planície costeira para confirmação desse padrão. Além disso, os resultados apresentados são importantes para medidas de conservação e manejo, uma vez que, os peixes anuais representam 39% da ictiofauna considerada ameaçada no Rio Grande do Sul (Reis *et al.* 2003).

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Morphology of Oplophorid and Bresiliid larvae (Crustacea, Decapoda) of Southwestern Atlantic plankton, Brazil

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Abstract. The present study describes the morphology of Oplophoridae and Bresiliidae larvae collected during the cruise of the RV Thalassa in the Southwestern Atlantic Ocean in 1999. The larvae were caught by oblique hauls from the surface to 200 meters using a bongo net. Thirteen stages of five species of Oplophoridae (*Acanthephyra* sp.1 to 4, and *Janicella spinicauda*), and two stages of a single species of Bresiliidae (*Discias* sp.) were identified and described. All these larvae were very abundant in the shelf break, mainly those of *Acanthephyra* sp.1. *Acanthephyra* spp. larvae resembles in morphology those of *Discias* sp., with exception of the modified dactylus of first pereopod in the larvae of *Discias* sp. These similarities suggest convergence between Oplophoridae and Bresiliidae larval forms. In contrast, the larvae of *Janicella spinicauda* share little details with *Acanthephyra* larvae and are easily recognized by the long serrated rostrum on both ventral and dorsal margins.

Key words: larval morphology, *Acanthephyra*, *Janicella*, *Discias*, meroplankton, southwestern Atlantic.

Resumo. Morfologia das larvas de Oplophoridae e Bresiliidae (Crustacea, Decapoda) do plâncton do Atlântico Sudoeste, Brasil. O presente trabalho descreve morfologia das larvas de Oplophoridae e Bresiliidae coletadas durante o cruseiro oceanográfico do NO Thalassa no Atlântico Sudoeste em 1999. As larvas foram coletadas por meio de arrastos oblíquos desde próximo da superfície até 200 metros com uma rede bongo. Foram identificados e descritos 13 estádios larvares de Oplophoridae (*Acanthephyra* sp.1 a sp.4, e *Janicella spinicauda*), e dois estádios de uma única espécie de Bresiliidae (*Discias* sp.). Todas essas larvas foram abundantes no talude continental, especialmente *Acanthephyra* sp.1. As larvas de *Acanthephyra* spp. assemelham-se às larvas de *Discias* sp., exceto pelo dáctilo modificado em *Discias* sp. Essas semelhanças sugerem convergência na morfologia larvar entre Oplophoridae e Bresiliidae. Em contrapartida, as larvas de *Janicella spinicauda* compartilham poucos detalhes com as larvas de *Acanthephyra* e podem ser reconhecidas pelo rostro serrilhado nas margens ventral e dorsal.

Palavras-chave: morfologia larvar, *Acanthephyra*, *Janicella*, *Discias*, meroplâncton, Atlântico Sudoeste.

Introduction

The great majority of the Southwestern Atlantic Ocean (SAO) waters are adjacent to three countries of South America: Brazil, Uruguay and Argentina. The tropical boundaries of the SAO comprise a highly diverse area, with about 110 caridean species (Coelho *et al.* 2006). For such an important area, there are many species for which larval developmental stages remain unknown and some efforts have been made to minimize this lack (Calazans, 1994; Pohle *et al.*, 1999; Fernandes *et al.*, 2006). In the North Atlantic Ocean, where diversity is lower, many researchers are trying to study ecology, physiology and distribution of decapod larvae (Barnich 1996, González-Gordillo *et al.* 2001, Santos & González-Gordillo 2004) but developmental stages of many species are also undescribed. One of the main reasons could be that pointed out by Santos & Gonzalez-Gordillo (2004: 205): “identification of decapod larvae from plankton samples is not easy, principally because there are great morphological changes between developmental phases”. Also contributing for this scenario, most of the larvae of adults decapods reported for the region remain unknown and differences in larval morphology between geographically separated populations increase the difficulty in specific identification (Martin & Goy 2004).

Larvae of Oplophoridae and Bresiliidae are common in Brazilian oceanic waters (Fernandes *et al.* 2006), although full larval descriptions and keys are still rare. Larval descriptions in Caridea include both laboratory-reared and field-collected specimens, some times revealing inconsistency in larval development (Villamar & Brusca 1988, González-Gordillo & Rodríguez 2000, Wehrtmann & Albornoz 2003). Interspecific and intraspecific differences in larval morphology between geographically separated populations are also common and should be considered prior to taxonomical and phylogenetic studies (Clarke & Webber 1991, Pohle 1991).

Works concerning larval morphology based upon laboratory-reared specimens depend on the catch of at least one ovigerous female alive, which could be identified with some degree of certainty after hatch. This is the best way to avoid misidentification, except if there is no consensus about the taxonomic position of the species. In addition, to collect and to keep alive an ovigerous female of deep oceanic species, for example, depends on the previous knowledge of adult distribution, physiological constraints and reproductive cycle. Among the known Caridea, for example, larval descriptions are common mainly in the families Hippolytidae (e.g., Pike & Williamson 1961, Ewald 1969, Shield 1978, Haynes 1985, Wehrtmann & Albornoz 1998, 2003, Thatje & Bacardit 2000, Yang *et al.* 2001), Crangonidae (e.g., Haynes 1985, Villamar & Brusca 1988, Jagadisha *et al.* 2000, González-Gordillo & Rodríguez 2000, Li & Hong 2003), Palaemonidae (e.g., Lebour 1925, Fielder 1970, Williamson 1972, Fincham 1979, Santos *et al.* 2004), Processidae (Jagadisha & Sankolli 1977, Williamson 1980) and Alpheidae (e.g., Knowlton 1973, Bhuti *et al.* 1977). Other families include only few studies on larval morphology, as Lysmatidae (e.g., Calado *et al.* 2004), Campylonotidae (Thatje *et al.* 2001) and Pandalidae (Haynes 1985). Additional literature concerning larval development in caridean larvae can be found in González-Gordillo *et al.* (2001).

In contrast to laboratory-reared larvae, planktonic specimens were used as a fast and easy way to describe larval morphology. Unfortunately, it is hard to ascribe a planktonic larva to any given species, even when there is complete correspondence among adult and larval distribution. In this sense, the field-collected larva represents a good way to study morphology in a more inclusive taxon, as genus or family, but rarely at the species level. Extensive works on larval morphology based upon planktonic specimens were conducted mainly by Gurney (e.g., 1924, 1927, 1936a, 1936b, 1937, 1938, 1939a, 1939b, 1942), Gurney & Lebour (1941), Williamson (e.g., 1957a, 1957b, 1962, 1967a, 1967b, 1982), Bourdillon-Casanova (1960), Barnich (1996), Schwamborn (1997), Báez (1997) and Fernandes *et al.* (2006).

Among the 110 species of Caridea recorded in Brazilian waters, there are about nine of Oplophoridae and two of Bresiliidae (Young 1998, Cardoso & Young 2005, Coelho *et al.* 2006). Informations concerning larval development in these two families are available mainly from plankton-collected specimens. Gurney & Lebour (1941) and Gurney (1942) described some stages of *Acanthephyra*, *Oplophorus*, and *Systellaspis* (Oplophoridae), and *Discias* (Bresiliidae) collected in the plankton of North and South Atlantic. The absence of full larval descriptions for many Oplophoridae and Bresiliidae lead us to concentrate on the morphology of the larvae collected in the SAO. The aim of this study is to describe the larvae of these families from the plankton of South Atlantic Ocean between Rio Real (BA – 12°S) and Cabo de São Tomé (RJ – 22°S).

Materials and Methods

Samples were taken at 114 oceanographic stations in the winter of 1999 during oceanographic cruise of the RV Thalassa along Brazilian Central coast, between Rio Real (12°S) and Cabo de São Tomé (22°S) (Figure 1). This study is a part of the Program called REVIZEE (Assessment of the Sustainable Living Resources Potential of the Exclusive Economic Zone). Oblique hauls were done to the maximum depth of 200 m using a bongo net with 330 and 500 µm mesh size. Only decapod larvae collected with 500 µm mesh were used in this study. After hauls were brought onboard, the samples were immediately preserved in 4% buffered formaldehyde.

In the laboratory, larvae of Oplophoridae and Bresiliidae were sorted from the samples, placed in 70% ethanol, and permanently stored in the collection of the Zoology Department, Federal University of Rio de Janeiro, Brazil (DZUFRJ).

Total length (TL), measured from the rostral tip to the posteriormost edge of the telson excluding setae, and rostral length (RL), measured from the rostral tip to the point of eye-stalk insertion of all the specimens collected, were estimated under a Zeiss Stemi SV6 stereoscope with a micrometer ruler (precision 0.1 mm). Larval stages were estimated according to the degree of development of the larval appendages (Williamson, 1962; Haynes, 1985). Larval appendages were dissected under an Olympus SZX12 stereoscope. Illustrations of the larvae and their appendages were made using a Zeiss Stemi SV6 stereoscope and a Zeiss Axiostar Plus optical microscope, all equipped with drawing tubes.

The terminology used for the differentiation of the larval phases and the larval morphology corresponds to that suggested by Gurney (1942), Williamson (1960, 1968, 1982), Boschi (1981), Haynes (1985), Clark *et al.* (1998) and Thatje *et al.* (2001). The setae were classified according to Garm (2004) and Cardoso & Young (2005).

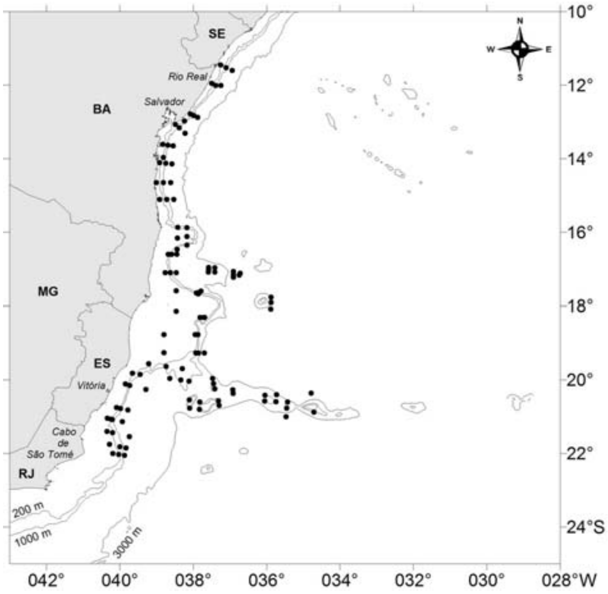

Figure 1. Study site and the 114 sampling stations (black circles).

Systematics

Suborder PLEOCYEMATA Burkenroad, 1963
Infraorder CARIDEA Dana, 1852
Family OPLOPHORIDAE Dana, 1852
Genus *Acanthephyra* A. Milne-Edwards, 1881

Ephyra – Roux 1831: 24. [junior homonym of *Ephyra* Péron & Lesueur, 1810 (Coelenterata), and also junior homonym of *Ephyra* Duponchel, 1829 (Lepidoptera). Type-species: *Alpheus pelagicus* Risso, 1816, by subsequent designation.

Miersia – Kingsley 1880, 1879: 416, pl. 14 [substitute name of *Ephyra* Roux, 1831]. Type-species: *Alpheus pelagicus* Risso, 1816, by subsequent designation.

Acanthephyra A. Milne-Edwards 1881, 11(4): 12. Type-species: *Acanthephyra armata* A. Milne-Edwards, 1881, by original designation.

Bentheocaris – Bate 1888, 24: 723, figs 3-4, pl. 123. Type-species: *Bentheocaris stylorostratis* Bate, 1888, by subsequent designation.

Caricyphus – Bate 1888, 24: 714, fig. 3, pl. 121. Type-species: *Caricyphus cornutus* Bate, 1888, by subsequent designation.

Acanthephyropsis – Riggio 1895, 14: 246. Type-species: *Acanthephyra pulchra* A. Milne-Edwards, 1890 [= *Acanthephyra eximia* Smith, 1884], by monotype.

Hoplocaricyphus – Coutière 1907, 104: 7. Type-species: *Hoplocaricyphus similis* Coutière, 1907 [= *Alpheus pelagicus* Risso, 1816], by monotype.

REMARKS – The family Oplophoridae Dana, 1852 is comprised of 13 species grouped in seven genera: *Acanthephyra* Milne-Edwards, 1881; *Ephyrina* Smith, 1885; *Janicella* Chace, 1986; *Meningodora* Smith, 1882; *Notostomus* A. Milne-Edwards, 1881; *Oplophorus* H.Milne-Edwards, 1837; and *Systellaspis* Bate, 1888 (Ramos-Porto & Coelho 1998, Cardoso & Young 2005). Larvae are known for some species of *Acanthephyra*, *Oplophorus* and *Systellaspis* (Gurney & Lebour 1941). The oplophorid larvae are usually grouped according to the amount of yolk in the eggs and also egg size. *Acanthephyra* and *Notostomus* are known to have small eggs, with little yolk, and many larval stages before metamorphosis. On the other hand, *Oplophorus*, *Systellaspis*, *Ephyrina* and *Hymenodora* have big eggs with high amount of yolk and usually abbreviated or direct development (Gurney & Lebour 1941, Gurney 1942, Williamson 1962, Cardoso & Young 2005)

Acanthephyra sp1.

(Figures 2 – 6)

MATERIAL EXAMINED. – Bahia State, REVIZEE, R.V. Thalassa, st. T5020, 14.65°S, 038.61°W, 0-200 m, 1 *zoea* (DZUFRJ 1073); st. T5065, 17.1°S, 038.62°W, 0-200 m, 3 *zoea* (DZUFRJ 386). Royal-Charlotte seamount, st. T5029, 15.87°S, 038.18°W, 0-200 m, 2 *zoea* (DZUFRJ 1001); st. T5031, 16.35°S, 038.17°W, 0-200 m, 1 *zoea* (DZUFRJ 1012); st. T5060, 16.6°S, 038.45°W, 0-200 m, 1 *zoea* (DZUFRJ 691); st. T5061, 16.6°S, 038.59°W, 0-200 m, 1 *zoea* (DZUFRJ 2050); st. T5062, 16.6°S, 038.68°W, 0-40 m, 1 *zoea* (DZUFRJ 2051). "Arquipélago dos Abrólhos", st. T5052, 18.3°S, 037.68°W, 0-200 m, 1 *zoea* (DZUFRJ 2047); st. T5057, 17.68°S, 037.87°W, 0-65 m, 1 *zoea* (DZUFRJ 2048); st. T5058, 17.65°S, 037.91°W, 0-200 m, 1 *zoea* (DZUFRJ 2049); st. T5063, 17.59°S, 038.46°W, 0-20 m, 1 *zoea* (DZUFRJ 2052). Hotspur seamount, st. T5042, 17.77°S, 035.88°W, 0-200 m, 7 *zoea* (DZUFRJ 1028). – Espírito Santo State, REVIZEE, R.V. Thalassa, st. T5046, 19.27°S, 037.86°W, 0-200 m, 1 *zoea* (DZUFRJ 745); st. T5086, 20.0°S, 038.34°W, 0-200 m, 4 *zoea* (DZUFRJ 1095); st. T5092, 19.56°S, 039.22°W, 0-60 m, 1 *zoea* (DZUFRJ 2053); st. T5094, 19.7°S, 038.3°W, 0-65 m, 1 *zoea* (DZUFRJ 1049); st. T5095, 19.96°S, 037.47°W, 1 *zoea* (DZUFRJ 2054); st. T5096, 20.1°S, 037.45°W, 7 *zoea* (DZUFRJ 817); st. T5097, 20.24°S, 037.42°W, 0-200 m, 1 *zoea* (DZUFRJ 2055); st. T5105, 20.27°S, 036.92°W, 0-200 m, 1 *zoea* (DZUFRJ 2057); st. T5110, 21.0°S, 035.47°W, 0-200 m, 1 *zoea* (DZUFRJ 2059). Vitória seamount, st. T5100, 20.8°S, 037.83°W, 0-60 m, 4 *zoea* (DZUFRJ 803); st. T5101, 20.6°S, 037.82°W, 0-200 m, 1 *zoea* (DZUFRJ 2056). Jaseur seamount, st. T5107, 20.4°S, 035.73°W, 0-200 m, 1 *zoea* (DZUFRJ 2058). Davis seamount, st. T5113, 20.87°S, 034.71°W, 0-200 m, 1 *zoea* (DZUFRJ 1215); st. T5114, 20.36°S, 034.78°W, 0-200 m, 5 *zoea* (DZUFRJ 948).

DIAGNOSIS – Rostrum dorsally compressed, shorter than antennules and serrated on lateral margin from the base to the middle point; third somite humped and with small dorsal spine; postero-lateral spine on fifth somite curved; dorso-lateral spine on sixth somite acute.

DESCRIPTION – *Zoea* IV (Fig. 2), TL=3.6 mm; RL=0.5 mm; body bent on the third somite in about a right angle (Fig. 2A); carapace short with two small dorsal process and serrated on the posterior margin; supraorbital spine absent; pterygostomian spine followed by three small spines; antero-ventral margin with 4 spines (Fig. 2B); rostrum dorsally compressed, about half the length of antennules, and serrated on lateral margin from the base to near the middle point; pleura of first and second abdominal somites serrated; third somite humped and with small dorsal spine; postero-lateral spine on fifth somite curved; dorso-lateral spine on sixth somite acute; antennule (Fig. 2C) with a two-jointed peduncle; ventral margin with a curved spine; exopod shorter than endopod and bearing five aesthetascs; endopod with three apical simple setae; antenna (Fig. 2D) shorter than the antennules; peduncle with an apical spine; exopod scale-like with an outer spine and 15 plumose marginal setae; endopod bulb-like, with an apical setae; mandible (Fig. 2E) with no palp; incisor process with three teeth; molar process with two rows of small teeth and three spines towards incisor process; maxillule (Fig. 2F) with three plumose and five pappose setae on the coxal endite, and two simple and five cuspidate setae on the basal endite; endopod two-jointed, with 2,3 pappose setae; maxilla (Fig. 2G) with four endites that bear 6,3,3,3 pappose setae; exopod with ten plumose marginal setae; endopod with seven (2,2,1,2) pappose setae; first maxilliped (Fig. 2H) with 16 pappose setae on the protopod and an outer small epipod; exopod with five apical plumose setae; endopod four-jointed, with one simple and ten pappose setae (4,1,3,3); second maxilliped (Fig. 2I) with eight pappose setae on the protopod; exopod with six long, apical, plumose setae; endopod five-jointed, with four simple and six pappose setae (3,1,0,2,4); third maxilliped (Fig. 2J) with one simple and one pappose setae on the protopod; exopod with eight plumose setae; endopod five-jointed, with two simple and six pappose setae (1,1,0,3,3); first and second pereopods (Figs. 2K, 2L) biramous but not chelate, and with 6 plumose setae on the exopod; endopod of first and second pereopods five-jointed, the first with two simple and five pappose setae (1,0,0,3,3), and the second with two simple and four pappose setae (1,0,0,3,2); third to fifth pereopods absent; uropod (Fig. 2M) as long as telson; lateral margin of telson (Fig. 2N) parallel and bearing two spines; posterior margin with 6+6 spines.

– *Zoea* V? (Fig. 3), TL=4.8 mm; RL=0.7 mm; larva very similar to previous stage, except the degree of appendages development; antennule (Fig. 3A) with a two-jointed peduncle; ventral margin with a curved spine; exopod shorter than endopod and bearing five aesthetascs; endopod with three apical simple setae; antenna (Fig. 3B) shorter than the antennules; peduncle with an apical spine, that bears one median small spinulle; exopod scale-like with an outer spine and 19 marginal plumose setae; endopod bulb-like, with an apical setae; maxillule (Fig. 3C) with three plumose and five pappose setae on the coxal endite, and 3 simple and 5 cuspidate setae on the basal endite; endopod two-jointed, with 2,3 pappose setae; maxilla (Fig. 3D) with four endites that bear 6,4,3,5 pappose setae; exopod with 13 plumose marginal setae; endopod with eight (3,2,1,2) pappose setae; first maxilliped (Fig. 3E) with 17 pappose setae on the protopod and an outer epipod; exopod with five apical plumose setae; endopod four-jointed, with 11 pappose setae (4,1,3,3); second maxilliped (Fig. 3F) with ten pappose setae on the protopod; exopod with six long, apical, plumose setae; endopod five-jointed, with one apical serrated, three simple and eight pappose setae (3,1,0,3,5); third maxilliped (Fig. 3G) with two simple and one pappose setae on the protopod; exopod with eight plumose setae; endopod five-jointed, with one apical serrated, seven simple and six pappose setae (2,1,2,5,4); first pereopod (Fig. 3H) with two simple and one pappose setae on

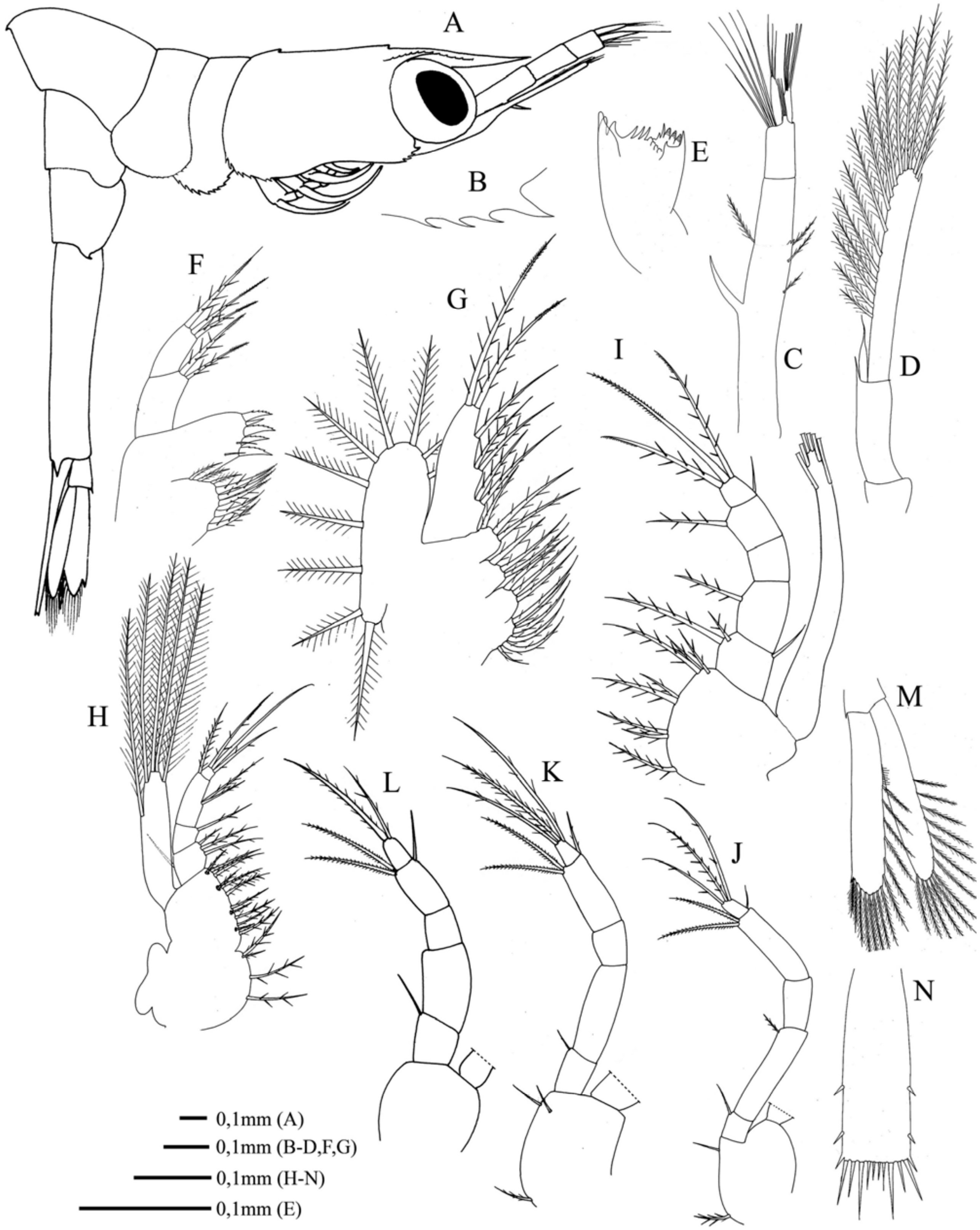

Figure 2. *Acanthephyra* sp.1, *zoea* IV (DZUFRJ817). A, lateral view; B, carapace, antero-ventral margin; C, antennule; D, antenna; E, mandible; F, maxillule; G, maxilla; H, first maxilliped; I, second maxilliped; J, third maxilliped; K, first pereopod; L, second pereopod; M, uropod; N, telson.

the protopod; exopod with eight plumose setae; endopod five-jointed, with one apical serrated, four pappose and five simple setae (1,0,2,4,3); second pereopod (Fig. 3I) with three simple setae on the protopod; exopod with six plumose setae; endopod five-jointed, with seven one apical serrated, two pappose and four simple setae (2,0,0,3,2); third pereopod (Fig. 3J) biramous but unjointed, the exopod with three plumose setae and the endopod with one simple and one pappose setae; fourth and fifth pereopods (Fig. 3K) as small buds.

– *Zoea* VIII? (Fig. 4), TL=6.0 mm, RL=0.8 mm; larva larger than previously, the body bent in about 180° (Fig. 4A); pterygostomian spine followed by five small spines; rostrum with 2/3 of the length of antennules; antennule (Fig. 4B) with a two-jointed peduncle; ventral margin with a curved spine; exopod shorter than endopod and bearing four

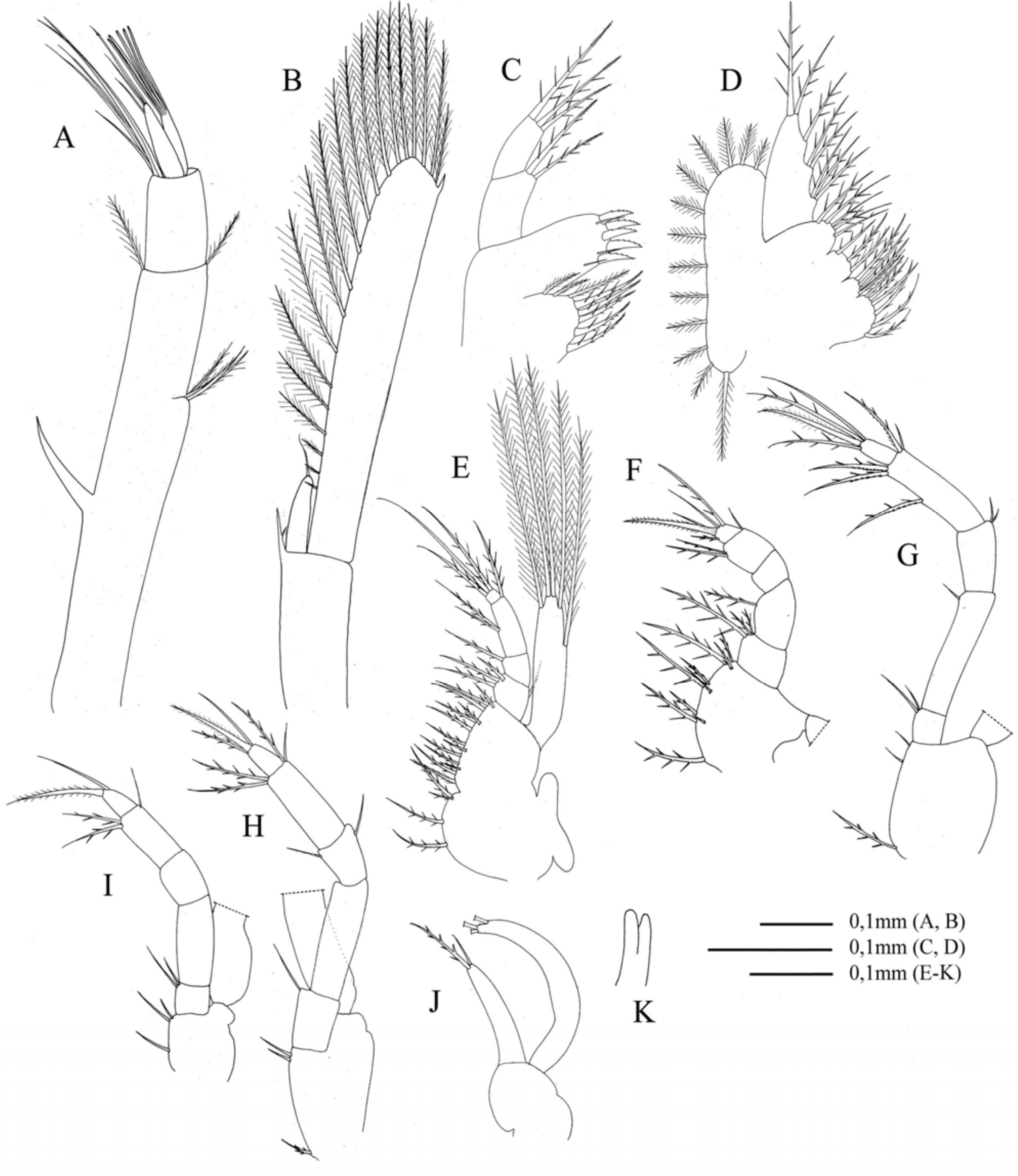

Figure 3. *Acanthephyra* sp.1, *zoea* V? (DZUFRJ386). A, antennule; B, antenna; C, maxillule; D, maxilla; E, first maxilliped; F, second maxilliped; G, third maxilliped; H, first pereopod; I, second pereopod; J, third pereopod; K, fourth and fifth pereopods.

aesthetascs; endopod damaged; antenna (Fig. 4C) as long as antennules; peduncle with an apical spine; exopod scale-like with an outer spine and 22 marginal setae; endopod stout, about half length of exopod; maxillule (Figs. 4D, E) with ten pappose setae on the coxal endite, and three simple and six cuspidate setae on the basal endite; endopod two-jointed, with 2,3 pappose setae; maxilla (Fig. 4F) with four endites that bear 7,4,6,5 pappose setae; exopod with 27 marginal plumose setae; endopod with nine pappose setae (3,2,1,3); first maxilliped (Fig. 4G) with 17 pappose setae on the protopod and an outer epipod; exopod with five apical plumose setae; endopod four-jointed, with ten pappose setae (3,1,3,3); second maxilliped (Fig. 4H) with nine pappose setae on the protopod; exopod with six plumose setae; endopod five-jointed, with six simple and seven pappose setae (3,1,1,3,5); third maxilliped (Fig. 4I) with one simple setae on the protopod; exopod with eight plumose setae; endopod five-jointed, with seven simple and four pappose setae (1,1,1,5,3); endopod of first pereopod (Fig. 4J) with

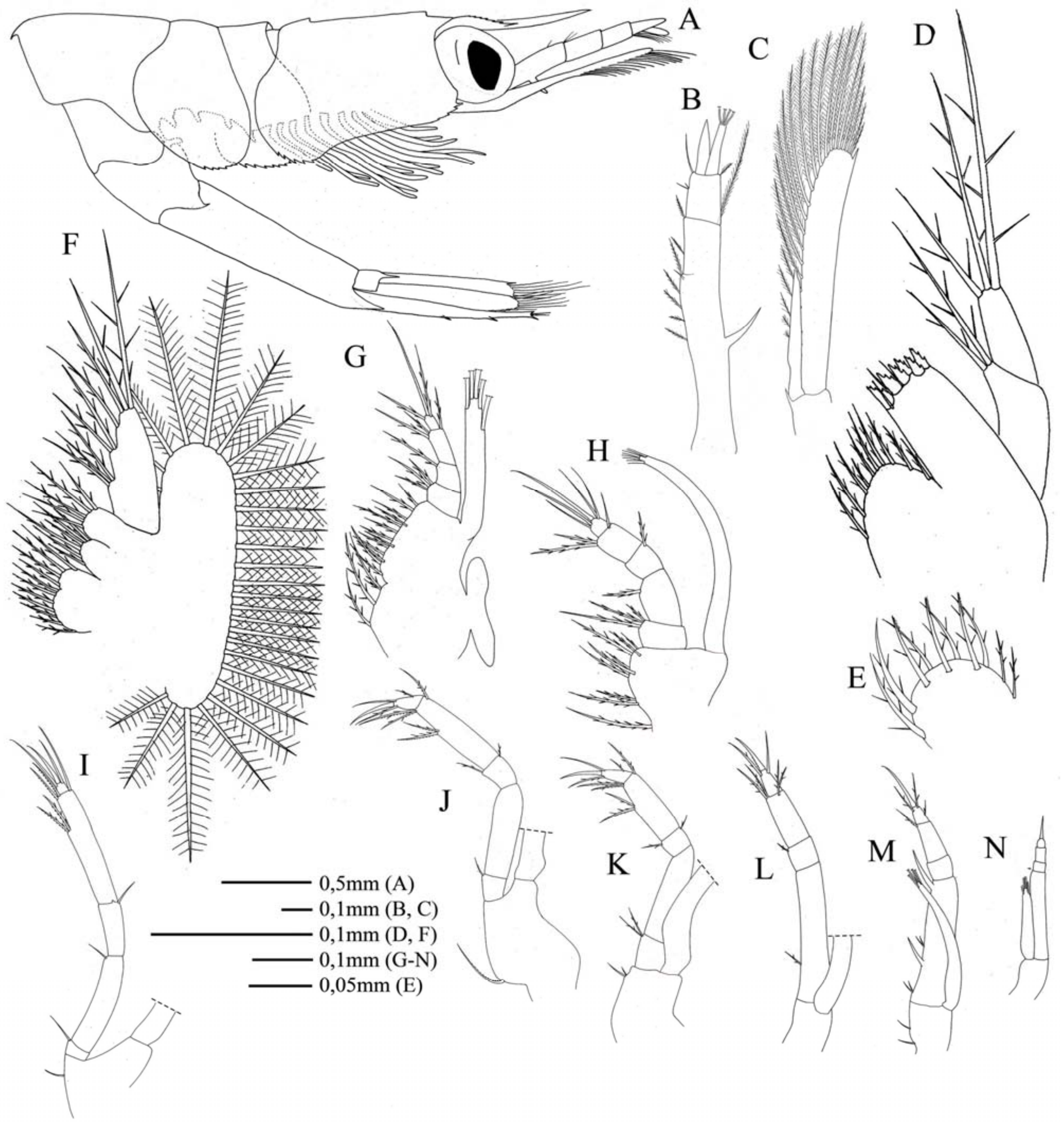

Figure 4. *Acanthephyra* sp.1, *zoea* VIII? (DZUFRJ1215). A, lateral view; B, antennule; C, antenna; D, maxillule; E, maxillule, coxal endite; F, maxilla; G, first maxilliped; H, second maxilliped; I, third maxilliped; J, first pereopod; K, second pereopod; L, third pereopod; M, fourth pereopod; N, fifth pereopod.

12 pappose setae (1,0,2,5,4); endopod of second pereopod (Fig. 4K) with 13 pappose setae (2,0,2,5,4); exopod of first and second pereopods with 12 plumose setae each; third pereopod (Figure 4L) larger than previously, the exopod with two additional plumose setae; endopod four-jointed, with nine pappose setae (1,1,3,4); fourth and fifth pereopods (Figs. 4M, N) biramous and with four plumose setae on the exopod; endopod of fourth pereopod with two strong curved spines and three apical pappose setae; pleopods as small buds; telson laterally compressed, with no spines on its lateral margin, and with 5+5 spines on posterior margin.

– *Zoea* X? (Figs. 5 and 6), TL=6.6 mm, RL=1.2 mm; larva very similar to previously (Fig. 5A); pterygostomian spine followed by five small spines (Fig. 5B); postero-ventral margin of carapace with 11 small spines; antennule (Fig. 5C) with a three-jointed peduncle, that bear six plumose and eight simple setae; ventral margin with a curved spine; exopod the same length of endopod and smooth; antenna (Fig. 5D) as long as antennules; peduncle with no apical spine; exopod scale-like with an outer spine and 30 marginal plumose setae; endopod damaged but longer than exopod; mandible (Fig. 5E) with seven spines and three teeth on incisor process; maxillule (Fig. 5F, G) with two simple, three plumose and eight pappose setae on the coxal endite; basal endite with three simple and six cuspidate setae; endopod two-jointed, with 2,3 pappose setae; maxilla (Fig. 5H) with four endites that bear 6,4,6,5 pappose setae; exopod with 30 marginal plumose setae; endopod with nine pappose setae (3,2,1,3); first maxilliped (Fig. 5I) with 22 pappose setae on the protopod and an outer epipod; exopod with five apical plumose setae; endopod four-jointed, with tenpappose setae (3,1,3,3); second maxilliped (Fig. 6J) with two simple, two plumose and eight pappose setae on the protopod; exopod with six plumose setae; endopod five-jointed, with two simple and 11 pappose setae (3,1,1,3,5); third maxilliped (Fig. 6K) with one simple and two pappose setae on the protopod; exopod with 11 plumose setae; endopod five-jointed, with two simple and eight setae (2,0,0,5,3); first pereopod (Fig. 6L) with one simple and one pappose setae on the protopod; exopod with 16 plumose setae; endopod five-jointed, with two simple and ten pappose setae (2,0,1,6,3); second pereopod (Fig. 6M) with one pappose and two simple setae on the protopod; exopod with 11 plumose setae; endopod five-jointed, with an inner spine on the second article, and two simple and 14 pappose setae (2,2,2,6,4); third pereopod (Fig. 6N) with no setae on the protopod; endopod five-jointed, with a spine on the third article, and two simple and six pappose setae (0,1,0,4,3); fourth pereopod (Fig. 6O) with three simple setae on the protopod; endopod five-jointed, with one spine on the first and second articles, and two simple and eight pappose setae (2,0,2,3,3); exopod of third and fourth pereopods with six plumose setae; fifth pereopod (Fig. 6P) with one simple seta on the protopod; endopod four-jointed, with one spine on the first and second articles, and two simple and four pappose setae (0,1,2,3); exopod with four plumose setae; pleopods biramous, but not setose; uropod (Fig. 6Q) biramous and setose; telson (Figs 6R, S) with 5+5 spines on posterior margin and 3+3 small spines near the margin.

***Acanthephyra* sp.2**

(Figures 7 and 8)

MATERIAL EXAMINED – Espírito Santo State, REVIZEE, R.V. Thalassa, st. T5096, 20.10°S, 037.45°W, 1 *zoea* (DZUFRJ 1213). Davis seamount, st. T5098, 20.54°S, 038.10°W, 0-50 m, 2 *zoea* (DZUFRJ 893).

DIAGNOSIS – Rostrum smooth, dorsally compressed, and longer than antennules; third somite humped but with no dorsal spine; fifth somite with no postero-lateral spine; sixth somite with no dorso-lateral spine.

DESCRIPTION – *Zoea* IV (Fig. 7), TL=6.5 mm; RL=1.1 mm; body bent in about a right angle (Fig. 7A); carapace with a dorsal organ immediately after the insertion of rostrum and serrated on the posterior margin; supraorbital spine absent; pterygostomian spine followed by three small spines; rostrum smooth, dorsally compressed, and longer than antennules; first somite with ventral margin of pleura serrated; third somite humped but with no dorsal spine; fifth somite with no postero-lateral spine; sixth somite with no dorso-lateral spine; antennule (Fig. 7B) with a three-jointed peduncle; ventral margin with a curved spine; exopod shorter than endopod; antenna (Fig. 7C) as long as antennules; peduncle with an apical spine; exopod scale-like with an outer spine and 22 marginal plumose setae; endopod stout, with an apical setae and about 2/3 the length of exopod; maxillule (Fig. 7D) with seven pappose setae on the coxal endite and four cuspidate setae on the basal endite; endopod two-jointed, with 2,3 pappose setae; maxilla (Fig. 7E) with three endites that bear 6,5,5 pappose setae; exopod with 13 marginal plumose setae; endopod with seven pappose setae (2,2,1,2); first maxilliped (Fig. 7F) with 12 pappose setae on the protopod and an outer epipod; exopod with four plumose setae; endopod four-jointed, with seven pappose setae (2,1,1,3); second and third maxilliped damaged; first to third pereopods biramous and with setose exopods (this appendages were damaged and the number of setae in each exopod could not be seen); fourth and fifth pereopods as small buds; pleopods absents; telson laterally compressed with

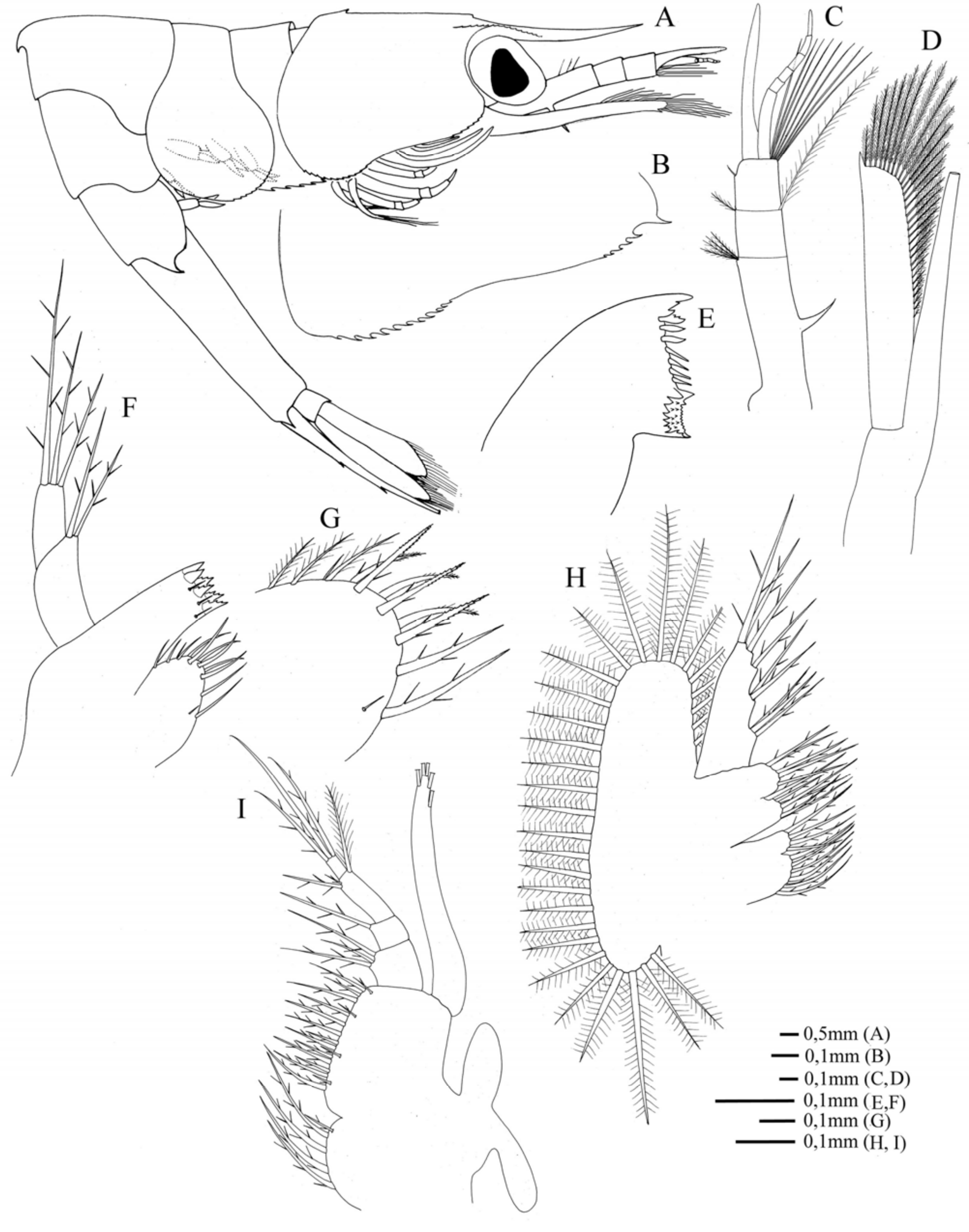

Figure 5. *Acanthephyra* sp.1, *zoea* X? (DZUFRJ1028). A, lateral view; B, carapace, antero-ventral margin; C, antennule; D, antena; E, mandible; F, maxillule; G, maxillule, coxal endite; H, maxilla; I, first maxilliped.

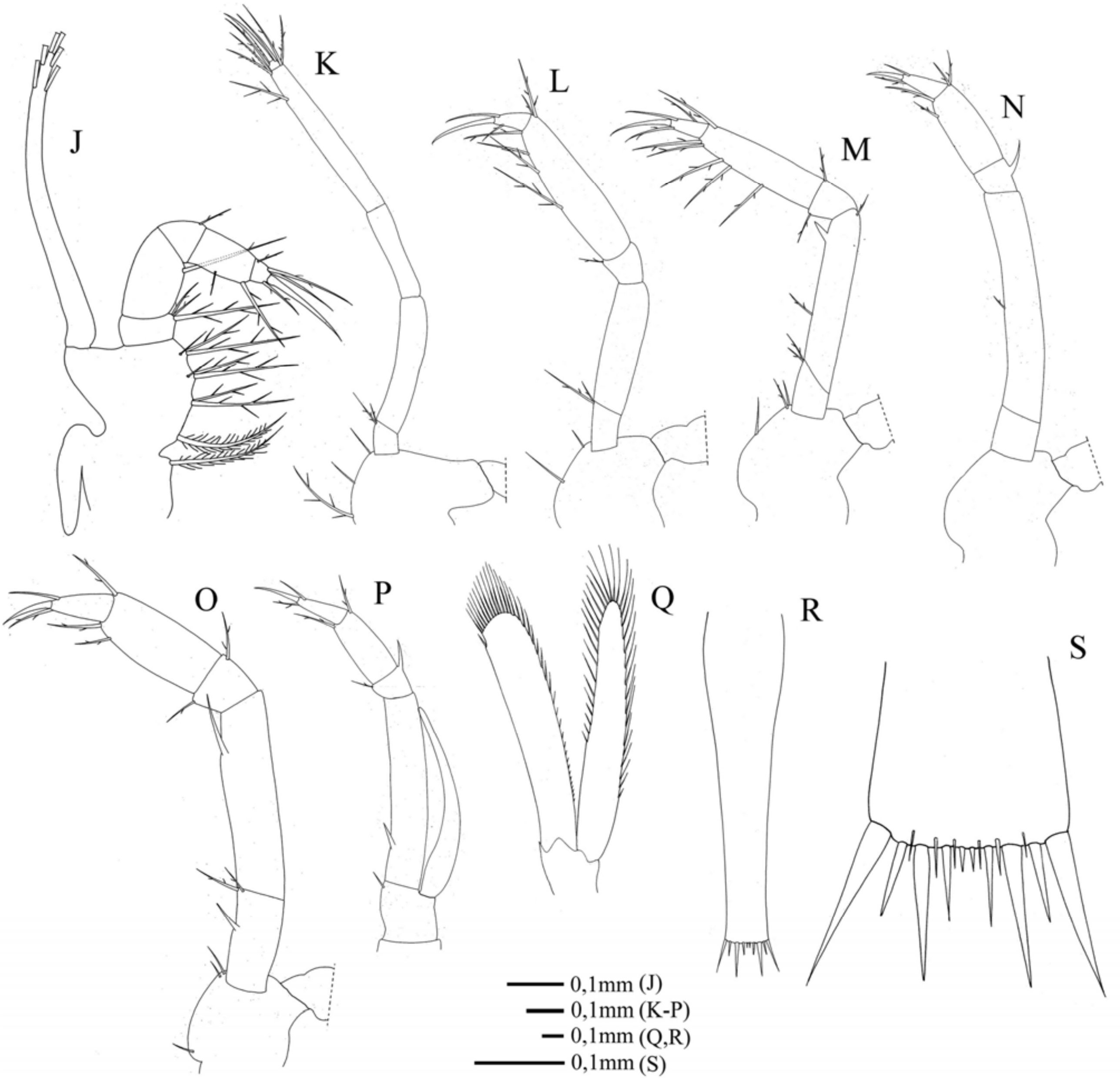

Figure 6. *Acanthephyra* sp.1, *zoea* X? (DZUFRJ1028). J, second maxilliped K, third maxilliped; L, first pereopod; M, second pereopod; N, third pereopod; O, fourth pereopod; P, fifth pereopod; Q, uropod; R, telson; S, telson, posterior margin.

two lateral spines and 6+6 on the posterior margin.

– *Zoea* VII? (Fig. 8), TL=9.8 mm, RL=2.0 mm; larva very similar to previous stage (Fig. 8A); all the appendages, except pleopods, well developed and biramous; antennule (Fig. 8B) with a three-jointed peduncle; ventral margin with a serrated spine; exopod shorter than endopod; antenna (Fig. 8C) shorter than antennules; peduncle with an apical spine; exopod scale-like with an outer spine and 35 marginal plumose setae; endopod stout, with an apical setae and about half the length of exopod; mandible (Fig. 8D) with 14 and 11 teeth respectively on the molar and incisor processes; maxillule (Fig. 8E) with six simple and eight pappose setae on the coxal endite, and three simple and five cuspidate setae on the basal endite; endopod two-jointed, with 2,3 pappose setae; maxilla (Fig. 8F) with three endites that bear 13,7,5 pappose setae; exopod with 32 marginal plumose setae; endopod with nine pappose (2,2,1,4) setae; first maxilliped (Fig. 8G) with one plumose, seven simple, and 12 pappose setae on the protopod; exopod with eight plumose setae; endopod four-jointed, with eight pappose setae (3,1,1,3); second maxilliped (Fig. 8H) with one plumose and six pappose setae on the protopod; exopod with four plumose setae; endopod five- jointed, with two simple and 11 pappose setae (4,2,0,2,5); third maxilliped (Fig. 8I) with two pappose setae on the protopod; exopod with ten plumose setae; endopod five-jointed, with two simple and 11 pappose setae (2,2,0,5,4); first pereopod (Fig. 8J) with one simple seta on the protopod; exopod with ten plumose setae; endopod five-jointed, with two simple and four pappose setae (2,0,0,2,2); second pereopod (Fig. 8K) with eight plumose setae on the exopod; endopod five-jointed with two simple and four pappose (2,0,0,2,2); third pereopod (Fig. 8L) with no setae on the protopod; exopod with eight plumose setae; endopod five-jointed, with two simple and three pappose setae (1,0,0,2,2); fourth and fifth pereopods (Figs. 8M, N) biramous but non-setose; pleopods absents; telson (Fig. 8O) parallel-side, with two lateral spines and 6+6 posterior.

Acanthephyra sp.3

(Figures 9 – 11)

MATERIAL EXAMINED – Bahia State, REVIZEE, R.V. Thalassa, st. T5054, 18.77°S, 037.95°W, 0-60 m, 1 *zoea* (DZUFRJ 428); st. T5056, 17.64°S, 037.84°W, 0-200 m, 2 *zoea* (DZUFRJ 724). – Espírito Santo State, REVIZEE, R.V. Thalassa, st. T5045, 19.27°S, 037.7°W, 0-200 m, 1 *zoea* (DZUFRJ 828). Davis seamount, st. T5114, 20.36°S, 034.78°W, 0-200 m, 4 *zoea* (DZUFRJ 947, 1216).

DIAGNOSIS – Rostrum dorsally compressed, longer than antennules and serrated on lateral margin from the base to the middle point; third somite humped but with no dorsal spine; postero-lateral spine on fifth somite curved; dorso-lateral spine on sixth somite absent.

DESCRIPTION – *Zoea* V? (Fig. 9), TL=7.4 mm; RL=1.3 mm; body bent on the third somite in about a right angle (Fig. 9A); carapace short with two small dorsal process and serrated on the posterior margin; supraorbital spine absent; pterygostomian spine followed by five small spines; rostrum dorsally compressed, longer than antennules, and serrated on lateral margin from the base to near the middle point; pleura of first and second abdominal somites serrated; third somite humped but with no dorsal spine; postero-lateral spine on fifth somite curved; dorso-lateral spine on sixth somite absent; antennule (Fig. 9B) with a three-jointed peduncle; ventral margin with a serrated spine; exopod shorter than endopod; antenna (Fig. 9C) shorter than antennules; peduncle with a long, apical spine; exopod scale-like with an outer spine and 13 marginal plumose setae; endopod stout, with an apical setae and about half the length of exopod; mandible (Fig. 9D) with nine and five teeth respectively on the molar and incisor processes; maxillule (Fig. 9E) with six pappose setae on the coxal endite; basal endite with three simple and three cuspidate setae; endopod two-jointed, with 2,3 pappose setae; maxilla (Fig. 9F) with four endites that bear 8,4,4,3 pappose setae; exopod with eight marginal plumose setae; endopod with nine

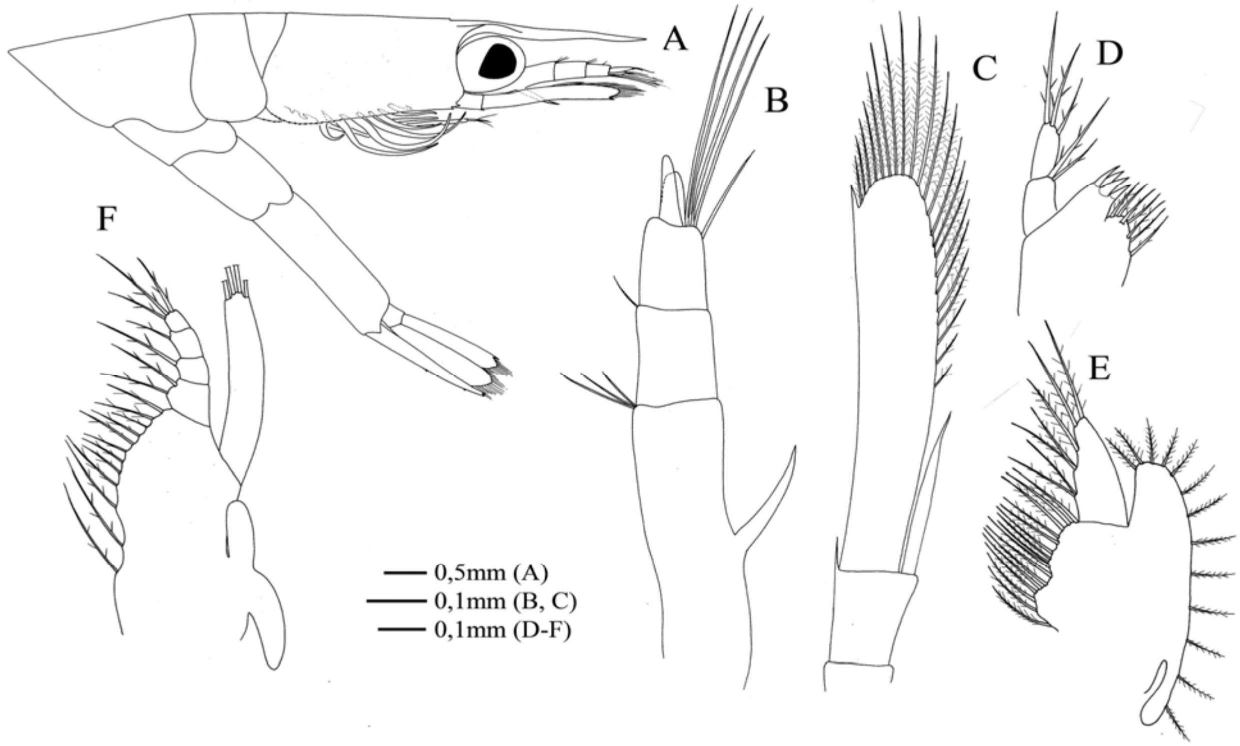

Figure 7. *Acanthephyra* sp.2, *zoea* IV (DZUFRJ006). A, lateral view; B, antennule; C, antenna; D, maxillule; E, maxilla; F, first maxilliped.

pappose setae (3,2,1,3); first maxilliped (Fig. 9G) with one plumose and 11 pappose setae on the protopod; exopod with four apical plumose setae; endopod four-jointed, with two simple and five pappose setae (2,1,1,3); second maxilliped (Fig. 9H) with one plumose and nine pappose setae on the protopod; exopod with five plumose setae; endopod five-jointed, with two simple and nine pappose setae (3,1,0,2,5); third maxilliped (Fig. 9I) with one simple setae on the protopod; exopod with five plumose setae; endopod five-jointed, with one simple and seven pappose setae (2,1,0,2,3); first

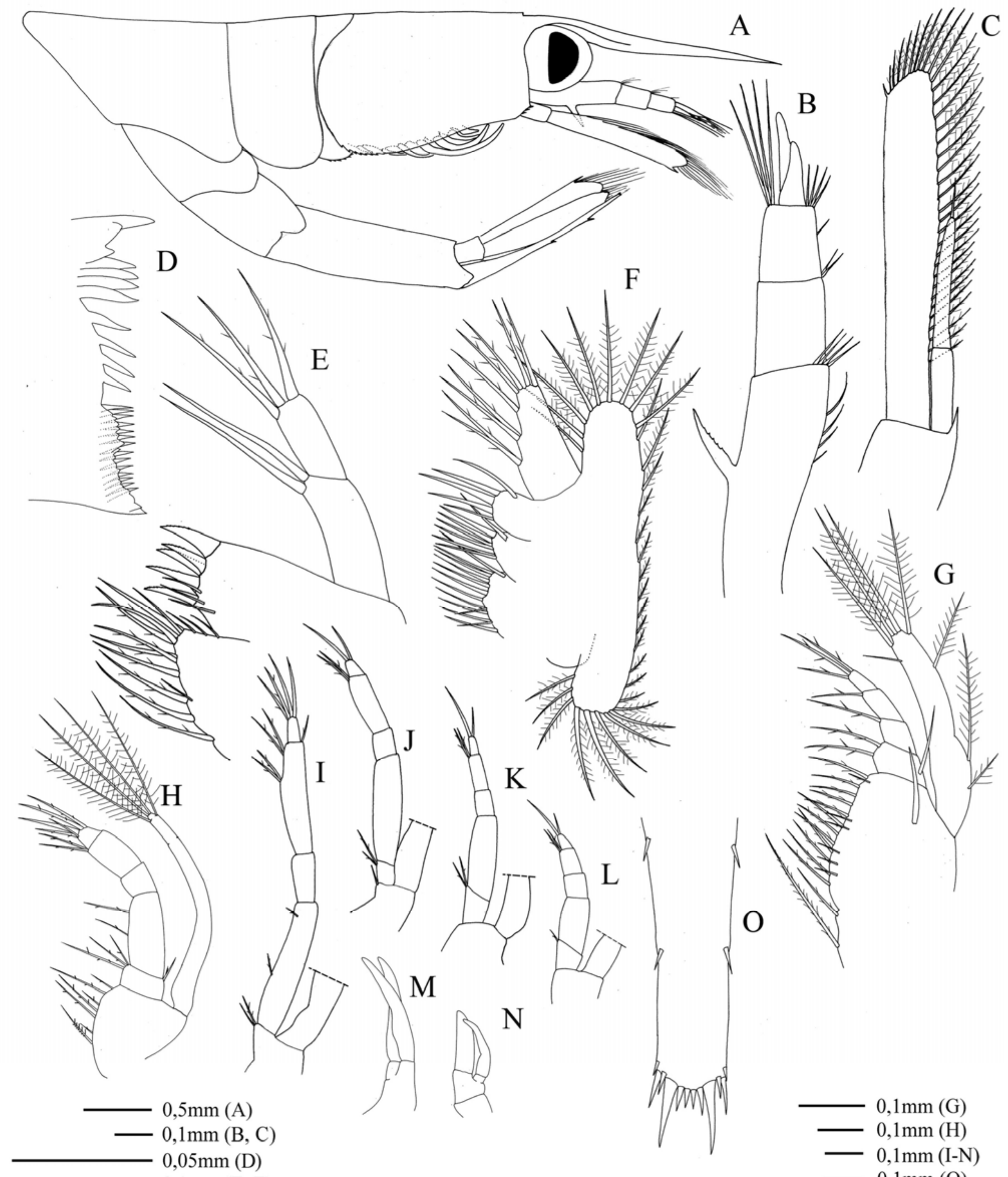

Figure 8. *Acanthephyra* sp.2, *zoea* VII? (DZUFRJ1447). A, lateral view; B, antennule; C, antenna; D, mandible; E, maxillule; F, maxilla; G, first maxilliped; H, second maxilliped; I, third maxilliped; J, first pereopod; K, second pereopod; L, third pereopod; M, fourth pereopod; N, fifth pereopod; O, telson.

pereopod (Fig. 9J) biramous but not chelate, and with six plumose setae on the exopod; endopod five-jointed, with one simple and seven pappose setae (2,1,0,2,3); second pereopod damaged; third pereopod (Fig. 9K) biramous but not completely developed; exopod with four plumose setae; endopod single-jointed with two apical simple setae; fourth and fifth pereopods absent; pleopods (Fig. 9L) as small buds; uropod (Fig. 9M) as long as telson; lateral margin of telson (Fig. 9N) parallel and bearing two spines; posterior margin with 6+6 spines.

– *Zoea* VI? (Fig. 10), TL=9.4 mm; RL=1.7 mm; larva very similar to previous stage (Fig. 10A), but larger and with more developed appendages; antennule (Fig. 10B) with a three-jointed peduncle; ventral margin with a serrated spine; exopod shorter than endopod; antenna (Fig. 10C) as long as antennules; peduncle with an apical spine; exopod scale-like with an outer spine and 27 marginal plumose setae; endopod stout, two-jointed, with an apical simple setae and about half the length of exopod; maxillule (Fig. 10D) with two simple and nine pappose setae on the coxal endite; basal endite with four simple and four cuspidate setae; endopod two-jointed, with 2,3 pappose setae; maxilla (Fig. 10E) with four endites that bear 11,4,7,6 pappose setae; exopod with 34 marginal plumose setae; endopod with nine pappose setae (3,2,1,3); first maxilliped (Fig. 10F) with seven simple and 13 pappose setae on the protopod; exopod with seven plumose setae; endopod four-jointed, with seven pappose setae (2,1,1,3); second maxilliped (Fig. 10G) with 11 pappose setae on the protopod; exopod with eight plumose setae; endopod five-jointed, with two simple and 11 pappose setae (4,2,0,2,5); third maxilliped (Fig. 10H) with no setae on the protopod; exopod with 14 plumose setae; endopod five-jointed, with two simple and nine pappose setae (0,1,0,5,5); first pereopod (Fig. 10I) with one simple setae on the protopod; exopod with 16 plumose setae; endopod five-jointed, with six pappose setae (2,0,0,1,3); second pereopod (Fig. 10J) with no setae on the protopod; exopod with 12 plumose setae; endopod five-jointed, with four pappose setae (1,0,0,1,2); third pereopod (Fig. 10K) with no setae on the protopod; exopod with eight plumose setae; endopod four-jointed, with one simple seta on the third article; fourth pereopod (Fig. 10L) biramous and with two plumose setae on the exopod; fifth pereopod (Fig. 10M) small and uniramous; telson (Fig. 10N) with two lateral and 5+5 posterior spines.

– *Zoea* VII? (Fig. 11), TL=10.0 mm; RL=1.8 mm; similar to previous stage (Fig. 11A); antennule (Fig. 11B) with a three-jointed peduncle; ventral margin with a serrated spine; exopod shorter than endopod and with one apical setae; endopod with three apical setae; antenna (Fig. 11C) longer than antennules; peduncle with no apical spine; exopod scale-like with an outer spine and 31 marginal plumose setae; endopod stout, two-jointed, with two apical setae and about half the length of exopod; maxillule (Fig. 11D) with five simple and six pappose setae on the coxal endite, and four simple and five cuspidate setae on the basal endite; endopod two-jointed, with 2,3 pappose setae; maxilla (Fig. 11E) with four endites that bear 9,4,7,5 pappose setae; exopod with 31 marginal plumose setae; endopod with eight pappose setae (2,2,1,3); first maxilliped (Fig. 11F) with 21 pappose setae on the protopod; exopod with one simple and five plumose setae; endopod four-jointed, with 2,1,2,3 pappose setae; second maxilliped (Fig. 11G) with 11 pappose setae on the protopod; exopod with eight plumose setae; endopod five-jointed, with two simple and ten pappose setae (4,2,0,2,4); third maxilliped (Fig. 11H) with one simple setae on the protopod; exopod with 12 plumose setae; endopod four-jointed, with one simple and seven pappose setae (0,0,4,4); first pereopod (Fig. 11I) with no setae on the protopod; exopod with 14 plumose setae; endopod five-jointed, with one simple and five pappose setae (0,0,0,3,3); second pereopod (Fig. 11J) with no setae on the protopod; exopod with 12 plumose setae; endopod five-jointed, with one simple and five pappose setae (1,1,0,2,2); third and fourth pereopod (Figs. 11K, L) biramous and with no setae on the protopod; exopods with six plumose setae; endopod of third pereopod four-jointed, with two apical simple setae; endopod of fourth pereopod two-jointed, with two apical simple setae; fifth pereopod (Fig. 11M) uniramous but longer than before; pleopods biramous; telson similar to previously.

***Acanthephyra* sp.4**

(Figures 12 and 13)

MATERIAL EXAMINED – Bahia State, “Arquipélago dos Abrolhos”, REVIZEE, R.V. Thalassa, st. T5052, 18.30°S, 037.68°W, 0-200 m, 2 *zoea* (DZUFRJ 753). – Espírito Santo State, st. T5078, 21.08°S, 040.21°W, 0-200 m, 1 *zoea* (DZUFRJ 2061); st. T5095, 19.96°S, 037.47°W, 1 *zoea* (DZUFRJ 2062); st. T5096, 20.10°S, 037.45°W, 1 *zoea* (DZUFRJ 1449). Jaseur seamount, st. T5107, 20.40°S, 035.73°W, 0-200 m, 1 *zoea* (DZUFRJ 2063). Davis seamount, st. T5113, 20.87°S, 034.71°W, 0-200 m, 1 *zoea* (DZUFRJ 813). – Rio de Janeiro State, “Cabo de São Tomé”, st. T5072, 21.82°S, 040.00°W, 0-200 m, 1 *zoea* (DZUFRJ 2060).

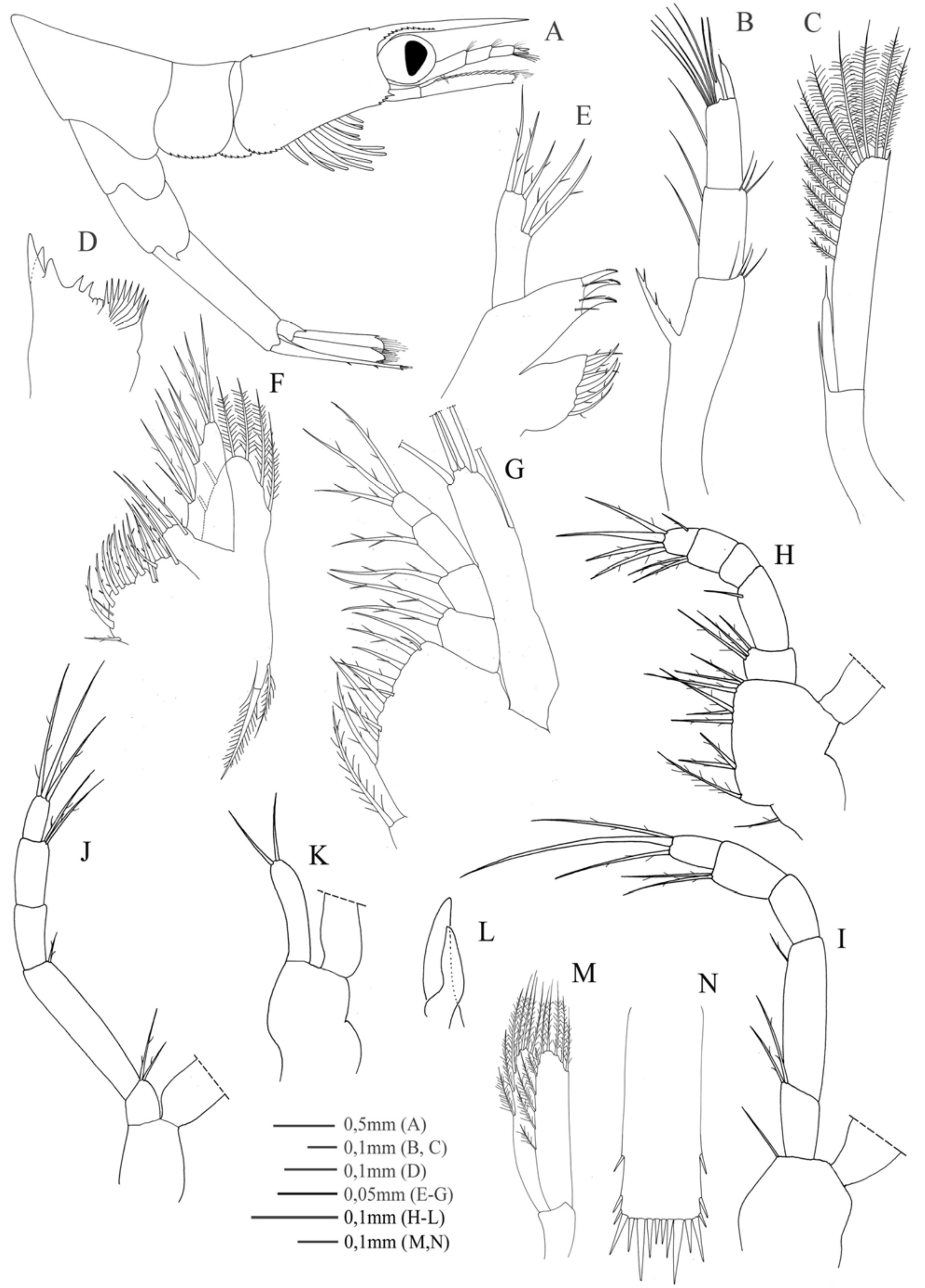

Figure 9. *Acanthephyra* sp.3, *zoea* V? (DZUFRJ724). A, lateral view; B, antennule; C, antenna; D, mandible; E, maxillule; F, maxilla; G, first maxilliped; H, second maxilliped; I, third maxilliped; J, first pereopod; K, second pereopod; L, third pereopod; M, uropod; N, telson.

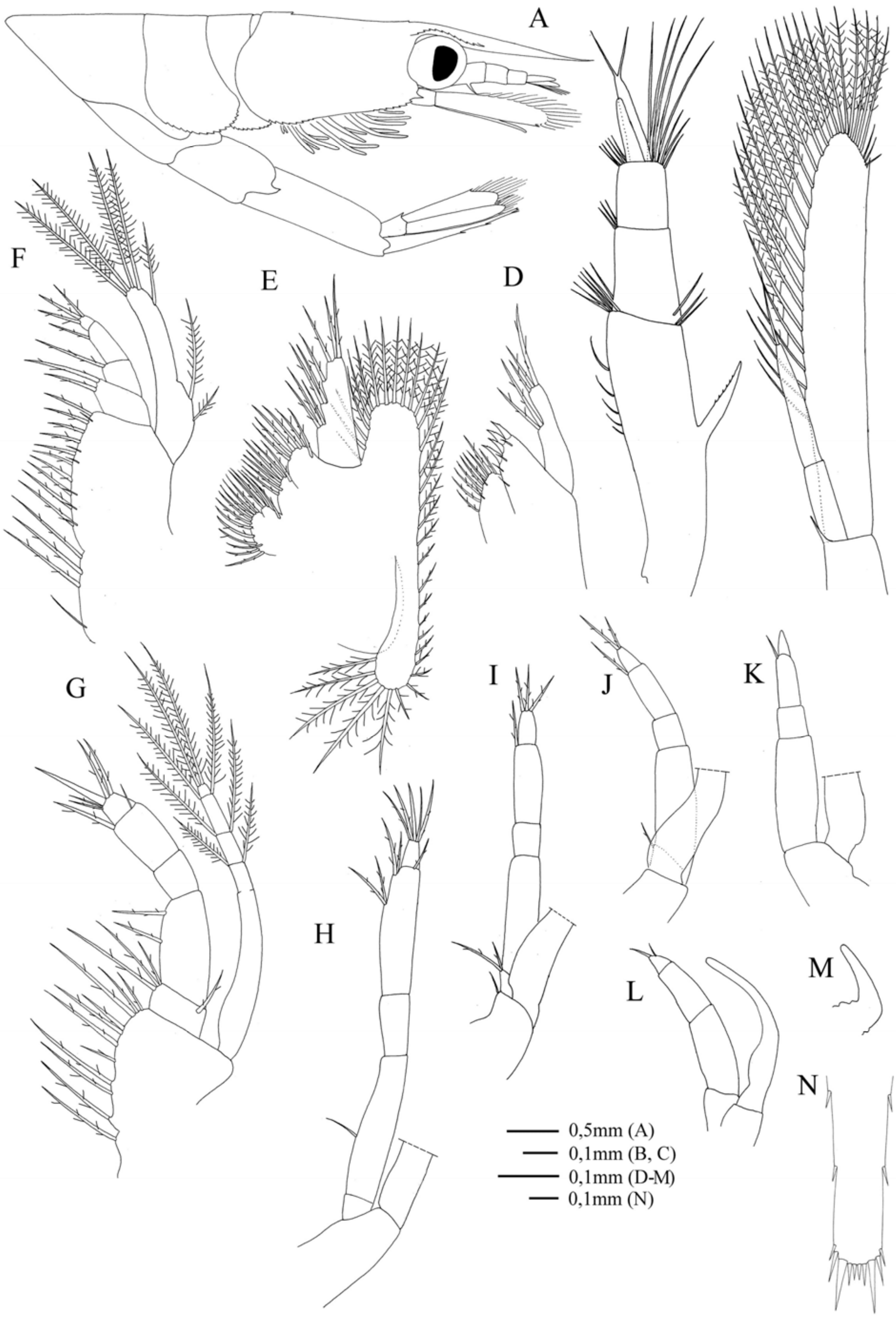

Figure 10. *Acanthephyra* sp.3, *zoea* VI (DZUFRJ149). A, lateral view; B, antennule; C, antenna; D, maxillule; E, maxilla; F, first maxilliped; G, second maxilliped; H, third maxilliped; I, first pereopod; J, second pereopod; K, third pereopod; L, fourth pereopod; M, fifth pereopod; N, telson.

Figure 11. *Acanthephyra* sp.3, *zoea* VII? (DZUFRJ576). A, lateral view; B, antennule; C, antenna; D, maxillule; E, maxilla; F, first maxilliped; G, second maxilliped; H, third maxilliped; I, first pereopod; J, second pereopod; K, third pereopod; L, fourth pereopod; M, fifth pereopod.

DIAGNOSIS – Rostrum dorsally compressed, shorter than antennules and serrated on lateral margin from the base to the tip; third somite humped but with no dorsal spine; postero-lateral spine on fifth somite absent; dorso-lateral spine on sixth somite small.

DESCRIPTION – *Zoea* III (Fig. 12), TL=3.4 mm; RL=0.5 mm; body bent on the third somite in about a right angle (Fig. 12A); carapace short with two small dorsal process and serrated on the posterior margin; supraorbital spine absent; pterygostomian spine followed by five small spines; rostrum dorsally compressed, longer than antennules, and serrated on lateral margin from the base to near the middle point; pleura of first and second abdominal somites serrated; third somite humped but with no dorsal spine; postero-lateral spine on fifth somite absent; dorso-lateral spine on sixth somite small;antennule (Fig. 12B) with a three-jointed peduncle; ventral margin with a spine; exopod shorter than endopod (the tip of appendage was damaged so the setae could not be seen); antenna (Fig. 12C) shorter than antennules; peduncle with an apical serrated spine; exopod scale-like with an outer spine and 11 marginal plumose setae; endopod stout, single-jointed, with an apical simple setae and about one third the length of exopod; mandible (Fi. 12D) with five teeth on the incisor process; maxillule (Fig. 12E) with five pappose setae on the coxal endite and five cuspidate setae on the basal endite; endopod two-jointed, with 2,3 pappose setae; maxilla (Fig. 12F) with four endites that bear 5,3,3,4 pappose setae; exopod with nine marginal plumose setae; endopod with nine pappose setae (3,2,1,3); first maxilliped (Fig. 12G) with 11 pappose setae on the protopod; exopod with four plumose setae; endopod four-jointed, with nine pappose setae (2,1,2,4); second maxilliped (Fig. 12H) with two simple, two pappose and three plumose setae on the protopod; exopod with five plumose setae; endopod five-jointed, with ten pappose setae (3,1,0,3,3); third maxilliped (Fig. 12I) with no setae on the protopod; exopod with five plumose setae; endopod five-jointed, with two simple and three pappose setae (0,0,0,2,3); first pereopod (Fig. 12J) biramous but not chelate, and with four plumose setae on the exopod; second to fifth pereopods absent; pleopods absents; uropod not fully developed, the endopod shorter than exopod; lateral margin of telson (Fig. 12K) parallel and bearing one spine; posterior margin with 6+6 spines.

– *Zoea* IV (Fig. 13), TL=6.1 mm; RL=1.0 mm; body bent on the third somite in about a right angle (Fig. 13A); carapace short with two small dorsal process and serrated on the posterior margin; supraorbital spine absent; pterygostomian spine followed by five small spines; rostrum dorsally compressed, longer than antennules, and serrated on lateral margin from the base to near the middle point; pleura of first and second abdominal somites serrated; third somite humped but with no dorsal spine; postero-lateral spine on fifth somite curved; dorso-lateral spine on sixth somite absent; antennule (Fig. 13B) with a three-jointed peduncle; ventral margin with a serrated spine; exopod shorter than endopod and with two apical aesthetascs; endopod with two apical simple setae; antenna (Fig. 13C) shorter than antennules; peduncle with one apical serrated spine; exopod scale-like with an outer spine and 18 marginal plumose setae; endopod stout, single-jointed, with one apical simple setae and about one third the length of the exopod; maxillule (Fig. 13D) with seven pappose setae on the coxal endite and five cuspidate setae on the basal endite; endopod two-jointed, with 2,3 pappose setae; maxilla (Fig. 13E) with four endites that bear 6,4,4,4 pappose setae; exopod with 13 marginal plumose setae; endopod with ten pappose setae (3,2,2,3); first maxilliped (Fig. 13F) with three plumose, six simple and eight pappose setae on the protopod; exopod with five plumose setae; endopod four-jointed, with five simple and six pappose setae (4,1,3,3); second maxilliped (Fig. 13G) with one plumose and seven pappose setae on the protopod; exopod with five plumose setae; endopod five-jointed, with five simple and seven pappose setae (4,1,0,3,4); third maxilliped (Fig. 13H) with no setae on the protopod; exopod with six plumose setae; endopod five-jointed, with two simple and four pappose setae (0,0,0,2,4); first pereopod (Fig. 13I) biramous but not chelate, and with six plumose setae on the exopod; second pereopod damaged; third pereopod (Fig. 13J) biramous but not completely developed; fourth and fifth pereopods absent; pleopods as small buds; uropod as long as telson; lateral margin of telson (Fig. 13K) parallel and bearing two spines; posterior margin with 6+6 spines.

REMARKS – The first larval description in the Oplophoridae was done by Bate (1888), who described a new species – *Caricyphus serramarginis* – based upon a larva very similar to that of *Acanthephyra* sp.1. Both larvae had a pterygostomian spine followed by three small spines, the posterior margin of the carapace was serrated, the pleural margin was serrated on the first and second somites, third somite humped and with small dorsal spine, rostrum dorsally compressed and serrated from the base to the middle length, lateral margin of telson with two spines, postero-lateral

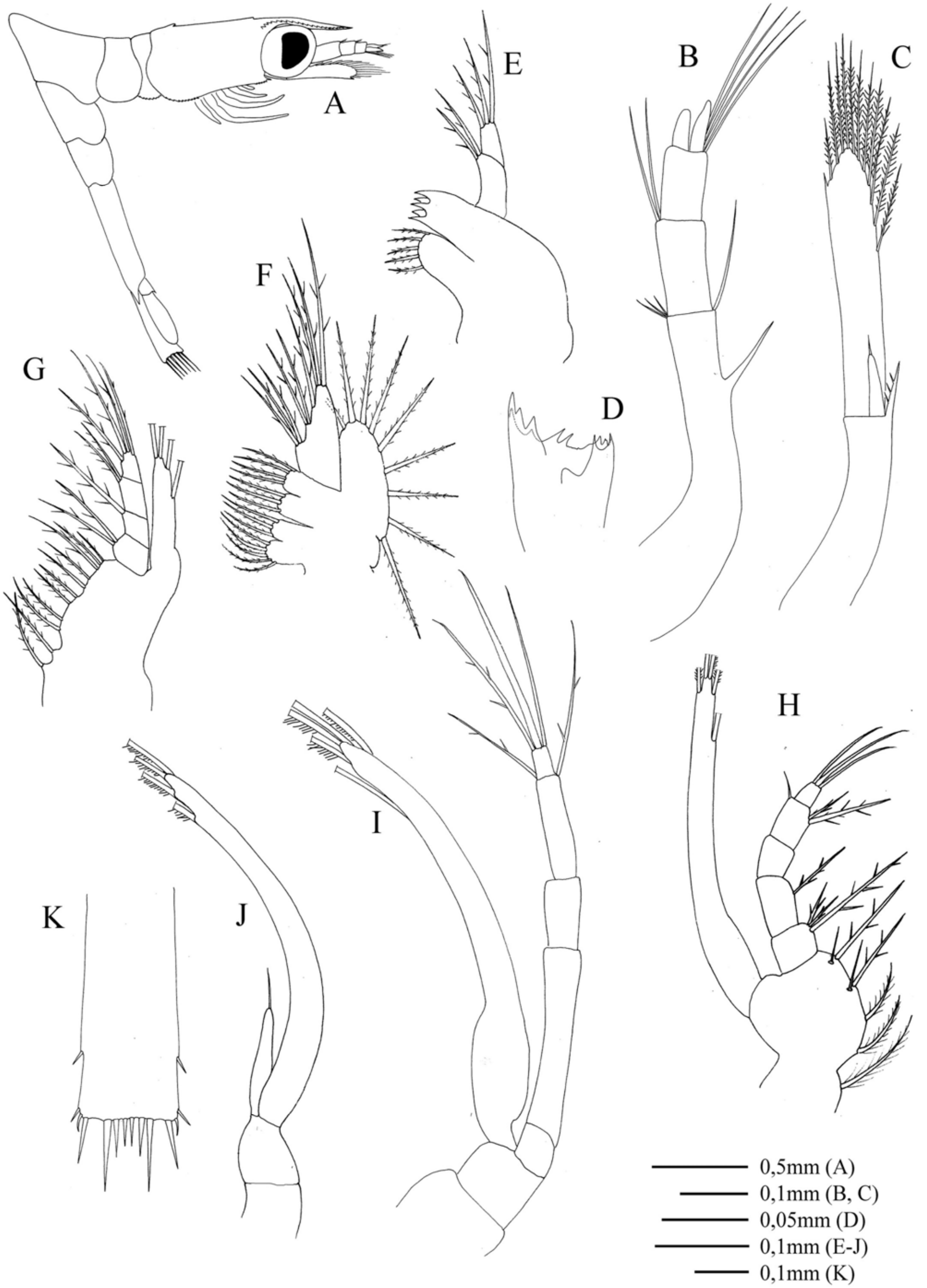

Figure 12. Acanthephyra sp.4, zoea III (DZUFRJ753). A, lateral view; B, antennule; C, antenna; D, mandible; E, maxillule; F, maxilla; G, first maxilliped; H, second maxilliped; I, third maxilliped; J, first pereopod; K, telson.

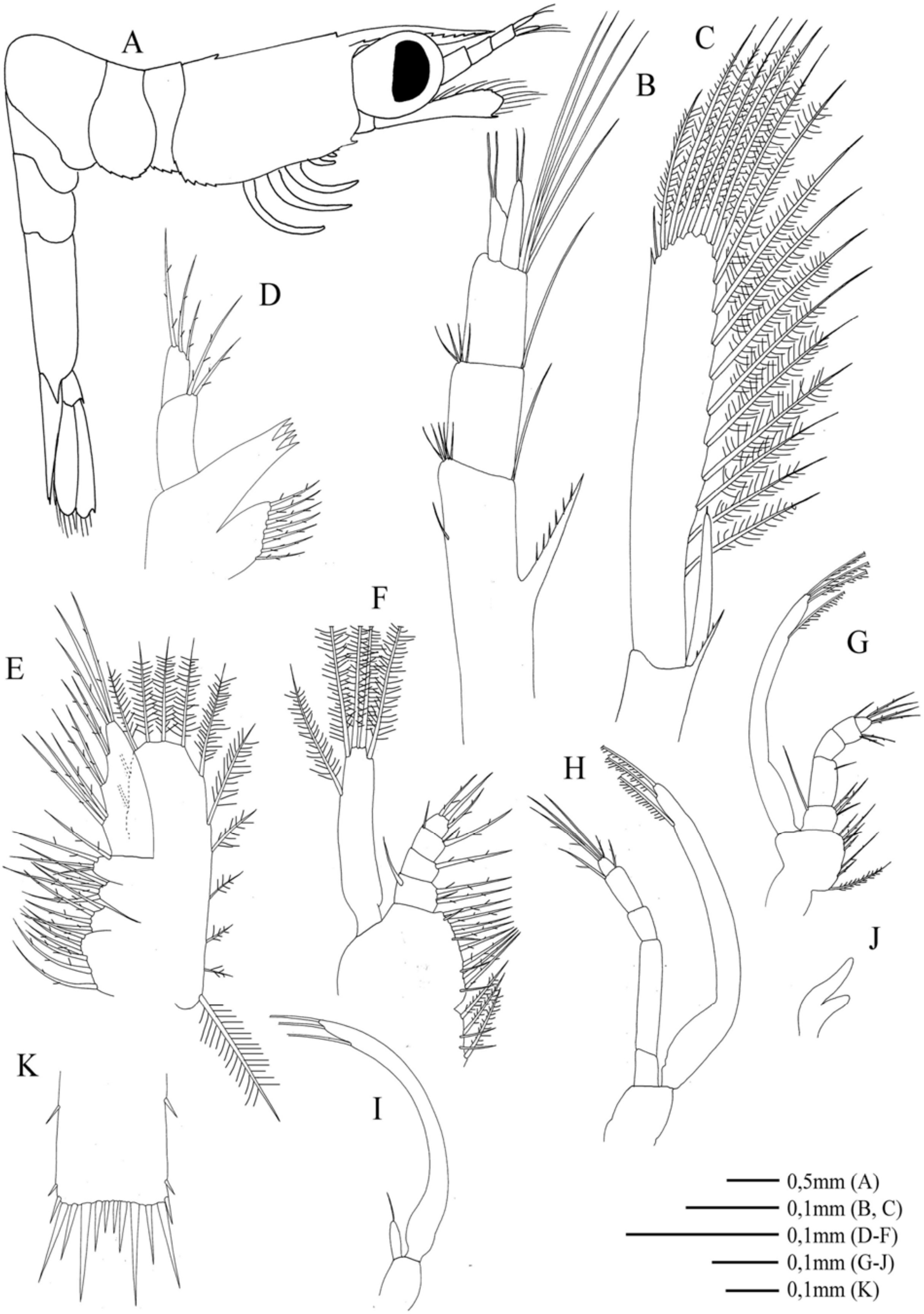

Figure 13. *Acanthephyra* sp.4, *zoea* IV (DZUFRJ1449). A, lateral view; B, antennule; C, antenna; D, maxillule; E, maxilla; F, first maxilliped; G, second maxilliped; H, third maxilliped; I, first pereopod; J, second pereopod; K, telson.

spine present on the fifth somite and dorso-lateral spine present on the sixth somite. The other *Acanthephyra* larvae described here are also very similar, but have no dorsal spine on third somite. Dorsal spine on the hump of third somite is also present in the larvae described by Gurney & Lebour (1941) as *Species C*, besides all the diagnostic characters for *Acanthephyra* sp.1. Gurney & Lebour (1941) also noted the similarity between these larvae of *Species C* and that of *Acanthephyra purpurea* and *Discias* sp. (Family Bresiliidae). The larvae of Bresiliidae share many similarities with those of Oplophoridae (*Acanthephyra*), mainly regarding to the rostrum, the carapace and the abdominal somites. For example, Ortmann (1893) described *Anisocaris dromedaries* as a new species of Oplophoridae based upon a larva of Bresiliidae, and Holthuis (1993) in reviewing the Oplophoridae considers the genus *Anisocaris* as a junior synonym of the genus *Discias*. According to Gurney & Lebour (1941) and Gurney (1942), the genus *Discias* has a modified chela on the first pereopod, what puts the larvae of *Species C* closest to *Acanthephyra*.

The larval development is partially known until now for two species of *Acanthephyra*: *A. purpurea* A. Milne-Edwards, 1881 and *A. pelagica* (Risso, 1816) (Kemp 1906, 1907, Lebour 1941). These larvae share the following characters with those larvae described here: third somite humped, rostrum dorsally compressed and serrated (exc. *Acanthephyra* sp.2), two dorsal process present in the carapace, posterior margins of carapace serrated (exc. *A. pelagica*), ventral margin of pleura on first and second somites serrated (exc. *A. pelagica*), ventral spine present on the antennal peduncle (exc. *A. pelagica*), pterygostomian spine present and followed by three to five small spines, supraorbital spine absent, postero-lateral spine on fifth somite (exc. *Acanthephyra* sp.2 and sp.4), small epipods on the first and second maxillipeds. Besides the lack of registers of *Acanthephyra purpurea* and *A. pelagica* in Brazil, the larvae of such species can be distinguished from those described herein by the absence of dorsal spine on third somite (present in *Acanthephyra* sp.1), the presence of postero-lateral spine on fifth somite (absent in *Acanthephyra* sp.2 and sp.4), and the presence of dorso-lateral spine on sixth somite (absent in *Acanthephyra* sp.3).

There are six other genera of Oplophoridae registered in Brazil (Cardoso & Young 2005). The larvae of *Janicella spinicauda* (=*Oplophorus spinicauda* A. Milne-Edwards, 1883), *Oplophorus spinosus* (=*H. grimaldii* Coutiere, 1905 (=*Palaemon spinosus* Brullé, 1839)) and *Systellaspis debilis* were described by Gurney & Lebour (1941) and do not resemble those of *Acanthephyra*. The long rostrum, compressed laterally and not dorsally, and serrated on the dorsal and ventral margins instead of lateral ones, the triangular scaphocerite, and the abbreviated development, with early appearance of appendages normally found latter, are useful characters to diagnostic these larvae. Unfortunately, larvae of *Ephyrina*, *Meningodora* and *Notostomus* remain unknown. The high amount of yolk in the eggs of *Ephyrina* and *Meningodora* suggest abbreviated development like *Oplophorus* and *Systellaspis* (Williamson 1962). The eggs of *Notostomus* have little yolk as *Acanthephyra*, but the former genus is not as abundant as the latter and has only one species registered until now in Brazil (*N. elegans* A. Milne-Edwards, 1881) against four species in *Acanthephyra* (Cardoso & Young 2005). The most abundant larvae found in the present study – *Acanthephyra* – could be ascribed to the most abundant species of Oplophoridae in Brazil – *A. eximia* Smith, 1884. The other three larvae of *Acanthephyra* (sp.2, sp.3 and sp.4) remain unidentified and probably belong to the other three species registered in the same area: *A. acutifrons* Bate, 1888; *A. quadrispinosa* Kemp, 1939; and *A. stylorostratis* (Bate, 1888).

Genus *Janicella* Chace, 1986

Janicella Chace 1986, 432: 43. – Holthuis 1993: 36, fig. 15. Type-species: *Oplophorus spinicauda* A. Milne-Edwards, 1883, by original designation.

REMARKS. – *Janicella* includes only one species until now: *J. spinicauda* (A. Milne-Edwards, 1883) (Chace 1986). The occurrence of this species in Brazil was done for the first time by Cardoso & Young (2005), when the total number of Oplophoridae increases to thirteen. The larval development was described by Gurney & Lebour (1941).

***Janicella spinicauda* (A. Milne-Edwards, 1883)**

(Figures 14 and 15)

Oplophorus spinicauda A. Milne-Edwards 1883: pl. 30. – Chace 1940, *25*(2): 184, fig. 54.

Janicella spinicauda – Chace 1986: 44, figs. 23, 24. – Cardoso & Young 2005, *1031*: 39, figs. 29-33.

MATERIAL EXAMINED. – Espírito Santo State, REVIZEE, R.V. Thalassa, st. T5077, 21.13°S, 039.94°W, 0-200 m, 1 *zoea* (DZUFRJ 838).

DIAGNOSIS – Carapace short; supraorbital spine absent; rostrum laterally compressed, longer than

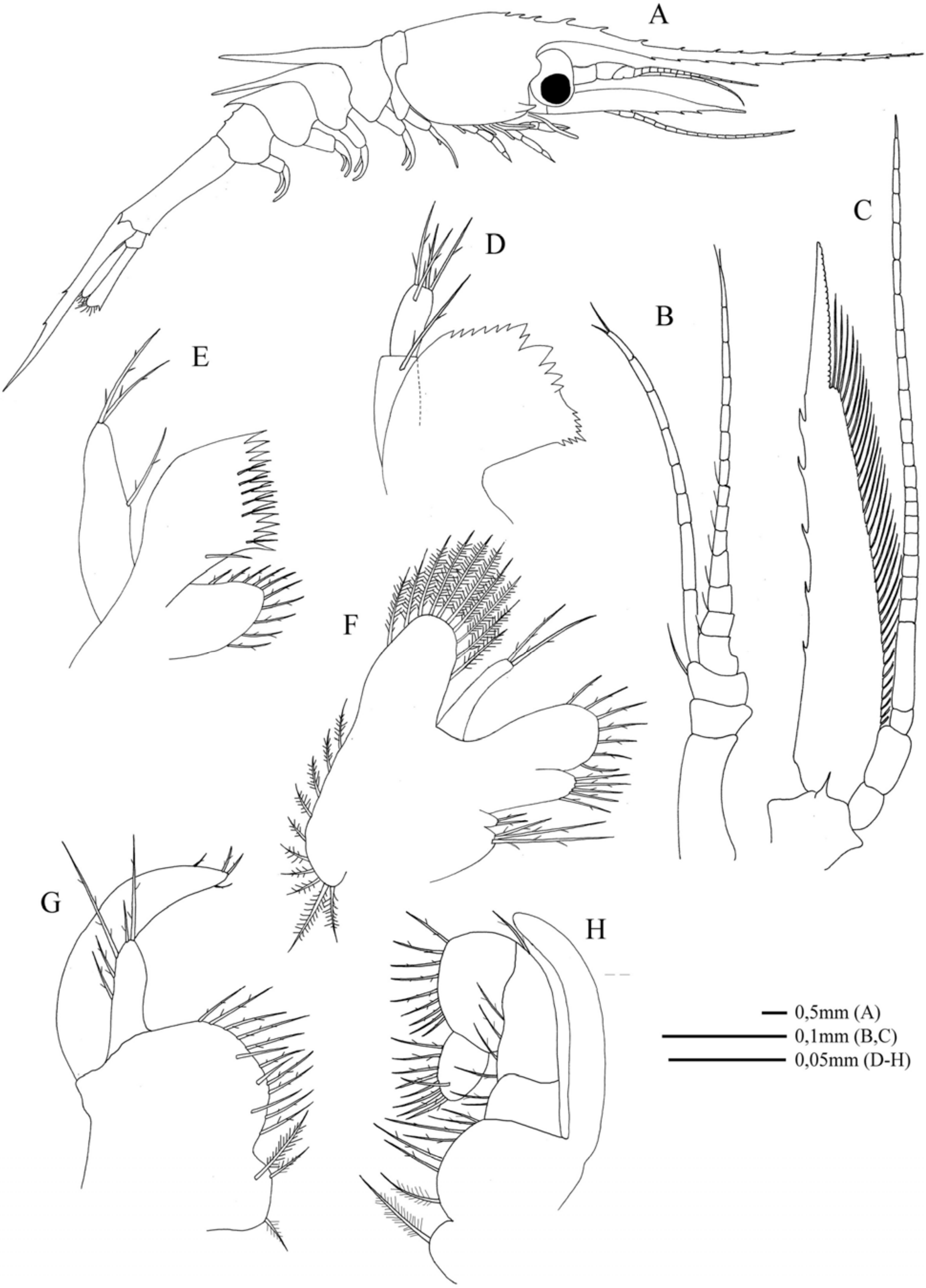

Figure 14. *Janicella spinicauda* (A. Milne-Edwards), decapodid (DZUFRJ838). A, lateral view; B, antennule; C, antenna; D, mandible; E, maxillule; F, maxilla; G, first maxilliped; H, second maxilliped.

antennules and serrated on ventral and dorsal margins; mandibular palp present; dorsal spine on second to fourth abdominal somites, that on the second the longest; first to fourth pereopod with exopodit.

DESCRIPTION – Decapodid (Figs. 14 and 15), TL=18.3 mm; RL=6.7 mm; body straight or little curved (Fig. 14A); carapace short, strong, with three dorsal spines immediately after the insertion of rostrum; pterygostomian spine strong; supraorbital spine absent; rostrum laterally compressed, longer than antennules and serrated on ventral and dorsal margins; first somite shorter than second; sixth somite the longest and with dorso-lateral spine; dorsal spine on second to fourth somites, that on the second the longest; fifth somite with two dorsal small teeth; scaphocerite triangular; antennules (Fig. 14B) with a three-jointed peduncle, the last article with a simple seta on the inner margin; endopod and exopod with many small articles and with two small simple setae on the last articles; antenna (Fig. 14C) well developed, with an apical spine on the peduncle; exopod triangular, with five small spines on the outer margin, one apical strong and serrated spine; and 34 marginal plumose setae; endopod longer than exopod and with many small articles; mandible (Fig. 14D) with a two-jointed palp that bears five pappose setae (1,4); maxillule (Fig. 14E) with ten pappose setae on the coxal endite and seven simple and 12 cuspidate setae on the basal endite; endopod well developed, with three pappose setae; maxilla (Fig. 14F) with four endites, that bear 3,2,5,7 pappose setae; first maxilliped (Fig. 14G)

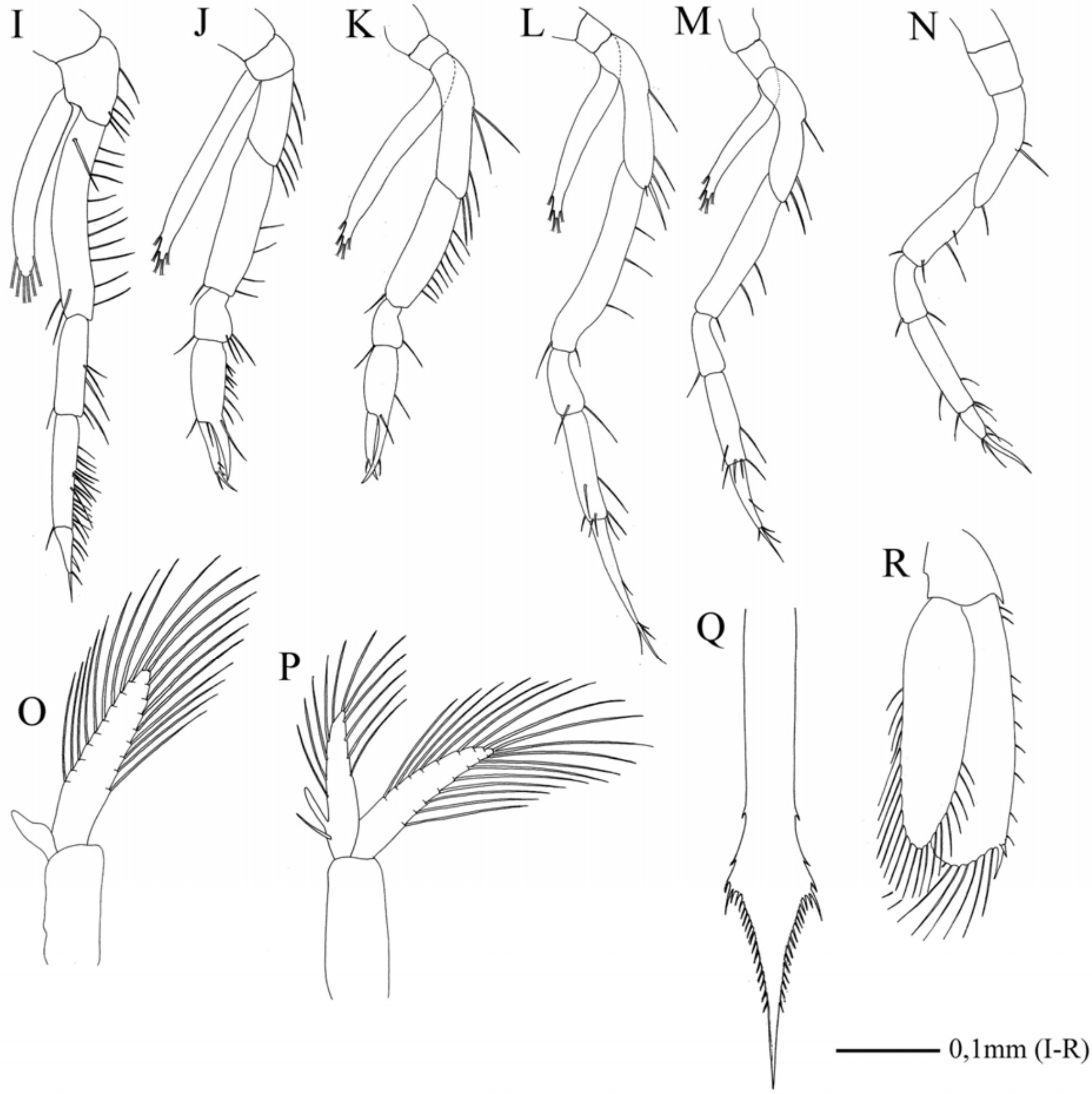

Figure 15. *Janicella spinicauda* (A. Milne-Edwards), decapodid (DZUFRJ838). I, third maxilliped; J, first pereopod; K, second pereopod; L, third pereopod; M, fourth pereopod; N, fifth pereopod; O, first pleopod; P, second pleopod; Q, telson; R, uropod.

with three plumose and 13 pappose setae on the protopod; exopod with four small simple setae; endopod uniramous and bearing five pappose setae; second maxilliped (Fig. 14H) with two plumose and six pappose setae on the protopod; exopod with no setae; endopod four-jointed with 25 pappose setae (2,5,9,9); third maxilliped (Fig. 15I) biramous, with five pappose setae on the protopod; exopod with six plumose setae; endopod four-jointed, with five pappose setae on the distal article; first (Fig. 15J) and second pereopod (Fig. 15K) chelate, the exopodit bearing five plumose setae; third pereopod (Fig. 15L) the longest; exopodit of third and fourth pereopod (Fig. 15M) with five plumose setae; fifth pereopod (Fig. 15N) uniramous; first pleopod (Fig. 15O) with reduced endopod and well developed exopod; second (Fig. 15P) to fifth pleopods setose and well developed; uropod (Fig. 15R) biramous, the endopod smaller than the exopod; telson (Fig. 15Q) with divergent margin in the middle and with convergent ones toward the end; divergent margins with three spines; convergent margins with 16 spines.

REMARKS – The larval development of *Janicella spinicauda* was described by Gurney & Lebour (1941) as *Hoplophorus spinicauda* A. Milne-Edwards, 1883 [=*Oplophorus spinicauda*] from larvae collected in the oceanic region of Rio de Janeiro, during the *Discovery Plankton Expedition* (station 710: 21° 45’S, 039° 50’; 0 – 294m). According to Gurney & Lebour (1941) the larvae of distinct species of *Oplophorus* (including in that time those larvae of *Janicella*) share many characters and are not easily distinguished. Chace (1986) in reviewing the diagnosis of the *Oplophorus* has created the new genus *Janicella* to accommodate *Oplophorus spinicauda* mainly because the presence of one dorsal spine on second somite, absence of dorsal tooth on fifth somite and absence of appendix masculina on the male second pleopod. Of these three characters, the appendix masculina could not be seen in larvae and only the other two characters are useful. The absence of tooth in the fifth somite on the adults could be exclusive of such stage, since the larvae exhibit two small dorsal teeth. The presence of one dorsal spine on the second somite is the single character among those used by Chace (1986) to distinguish *Janicella spinicauda* that can be seen in the larval stages. In addition, the three dorsal spines on carapace, the proportion between dorsal spines on abdomen (that on the second the longest), the telson and the rostrum of larvae and adults are very similar and useful to distinguish the species.

According to Chace (1986), there are many characters shared between adults of the genera *Janicella* and *Oplophorus*, like absence of postero-lateral spines on the fourth and fifth somites, and presence of a spine on the outer margin of antennal scale. These characters can also be found in the larvae described here. Gurney & Lebour (1941) also described a larva of *Oplophorus spinosus* (Brullé, 1839) that has rostrum at least twice the length of carapace, the dorsal and ventral margins serrated; dorsal papillae on the eyestalk; scaphocerite triangular with five outer spines; palp of mandibles two-jointed; and telson ending in a spine flanked by small spines. In contrast, *Janicella spinicauda* larvae can be distinguished from those of *Oplophorus spinosus* mainly by the presence of dorsal spine on second somite and absence of exopodit on fifth pereopod.

Similarities between adults of *Janicella* and *Systellaspis* were also revealed by Chace (1986), like sixth abdominal somite twice the length of fifth and telson ending in a spinous process. *Systellaspis debilis* larvae described by Gurney & Lebour (1941) and that of *Janicella spinicauda* have rostrum laterally compressed and serrated on ventral and dorsal margin, but not in the first, second and third stages. Larvae of *S. debilis* distinguish from those of *J. spinicauda* also in the length of rostrum smaller than length of carapace, scaphocerite without outer spines and presence of setose exopodite from first to fifth pereopods.

Family BRESILIIDAE Rathbun, 1902
Genus *Discias* Rathbun, 1902

Anisocaris – Ortmann 1893, 2: pl. IV, fig.3.

Discias Rathbun 1902, 4: 290, figs. 1-4, pl. 12. Type-species: by monotypy, *Discias serrifer* Rathbun, 1902.

REMARKS. – According to Martin & Davis (2001), the family Bresiliidae is traditionally grouped with Disciadidae, Agostocarididae, Alvinocarididae and Mirocarididae to form a merophyletic clade – Bresilioidea. Holthuis (1993) considers Disciadidae as a junior synonym of Bresiliidae, which included the genera *Bresilia* Calman, 1896, *Discias* Rathbun, 1902, *Lucaya* Chace, 1939, *Tridiscias* Kensley, 1983 and *Pseudocheles* Chace & Brown, 1978. The family Bresiliidae can also be related to the Oplophoridae if we consider larval characthers (Gurney 1942). Until now in Brazil, only one genus

– *Discias* – and two species (*D. atlanticus* Gurney, 1939 and *D. serratirostris* Lebour, 1949) have been recorded, mainly in the northeastern coastal areas (Coelho *et al.* 2006).

The larvae of Bresiliidae are much similar to those of *Acanthephyra* and can be distinguished by the following characters: rostrum smooth, as long as the carapace; first to fifth pereopod with well-developed exopodit; and chela of first pereopod with a modified dactylus.

***Discias* sp.**

(Figures 16 – 18)

MATERIAL EXAMINED – Bahia State, REVIZEE, R.V. Thalassa, st. T5032, 16.95°S, 037.58°W, 0-200 m, 1 *zoea* (DZUFRJ 736). – Espírito Santo State, Vitória Seamount, REVIZEE, R.V. Thalassa, st. T5098, 20.54°S, 038.10°W, 0-50 m, 1 *zoea* (DZUFRJ 1452)

DIAGNOSIS – rostrum smooth and as long as carapace; pterygostomian spine followed by small spines; posterior margin of carapace serrated; pleural margin of first and second somites serrated; third abdominal somite with an oil-filled hump, but with no dorsal spine; dactylus of first pereopod rounded and with four apical setae.

DESCRIPTION – *Zoea* IV (Fig. 16), TL=4.9 mm; RL=0.8 mm; body bent about 180° on third somite (Fig. 16A); carapace with two small dorsal organs and serrated on the posterior margin; pterygostomian spine followed by four small spines (Fig. 16B); supra-orbital spine absent; pleural margin of first and second somites serrated; third abdominal somite with an oil-filled hump, but with no dorsal spine; fifth somite with postero-lateral spine; sixth somite with no dorso-lateral spine; antennule (Fig. 16C) with a three-jointed peduncle; ventral margin with a serrated spine; exopod shorter than endopod and with two apical setae; endopod damaged and with no setae; antenna (Fig. 16D) shorter than antennules; peduncle with one apical spine; exopod scale-like with an outer spine and 20 marginal plumose setae; endopod stout, single-jointed, with one apical simple setae and about one third the length of exopod; maxillule (Fig. 16E) with three cuspidate setae on the basal endite (coxal endite damaged); endopod two-jointed, with 2,3 pappose setae; maxilla (Fig. 16F) with four endites that bear 5,3,4,4 pappose setae; exopod damaged; endopod with nine pappose setae (3,2,1,3); first maxilliped (Fig. 16G) with one plumose, four simple and eight pappose setae on the protopod; exopod with five plumose setae; endopod four-jointed, with two simple and seven pappose setae (3,1,2,3); second maxilliped (Fig. 16H) with two plumose and six pappose setae on the protopod; exopod with six plumose setae; endopod five-jointed, with ten pappose setae (3,0,0,3,4); third maxilliped (Fig. 16I) with one simple setae on the protopod; exopod with six plumose setae; endopod five-jointed, with one simple and five pappose setae (0,0,0,2,4); first pereopod (Fig. 16J) biramous but with non-setose exopod; second (Fig. 16K) and third pereopod (Fig. 16L) uniramous and as small buds; fourth and fifth pereopods absents; uropod (Fig. 16M) biramous and setose; telson (Fig. 16N) parallel-side and with three lateral spines; posterior margin of telson with 6+6 spines.

– *Zoea* IX? (Figs. 17 and 18), TL=14.1 mm; RL=2.3 mm; larva similar to previously (Fig. 17A); pterygostomian spine followed by five small spines; antennule (Fig. 17B) with a three-jointed peduncle; ventral margin with a serrated spine; exopod the same length of endopod; antenna (Fig. 17C) with one apical spine on the peduncle; exopod scale-like with an outer spine and 47 marginal plumose setae; endopod three-jointed, longer than exopod and with no setae; maxillule (Fig. 17D) with two simple, six pappose and 14 plumose setae on the coxal endite; basal endite with 12 simple and six cuspidate setae; endopod two-jointed, with 3,3 pappose setae; maxilla (Fig. 17E) with four endites that bear 12,4,10,9 pappose setae; exopod with 51 plumose setae; endopod with ten pappose setae (3,3,1,3); first maxilliped (Fig. 17F) with 26 pappose setae on the protopod; exopod with four apical, one sub-apical and nine proximal plumose setae; endopod four-jointed, with one simple and eight pappose setae (3,1,2,3); second maxilliped (Fig. 18G) with two plumose and nine pappose setae on the protopod; exopod with six plumose setae; endopod five-jointed, with one simple and 11 pappose setae (2,3,0,2,5); third maxilliped (Fig. 18H) with one simple setae on the protopod; exopod with 14 plumose setae; endopod five-jointed, with one simple and 14 pappose setae (1,2,0,7,5); first pereopod (Fig. 18I) with a modified chela, the dactylus rounded and the propodus broader; exopod with 13 plumose setae; endopod five-jointed, with one simple and 11 pappose setae (2,2,0,4,4); second pereopod (Fig. 18J) biramous, chelate, with one simple seta on the protopod and 14 plumose setae on the exopod; endopod five-jointed, with one simple and nine pappose setae (1,0,0,5,4); third pereopod (Fig. 18K) biramous, the five-jointed endopod bearing seven pappose setae (0,2,0,3,2); fourth pereopod (Fig. 18L) biramous and with no

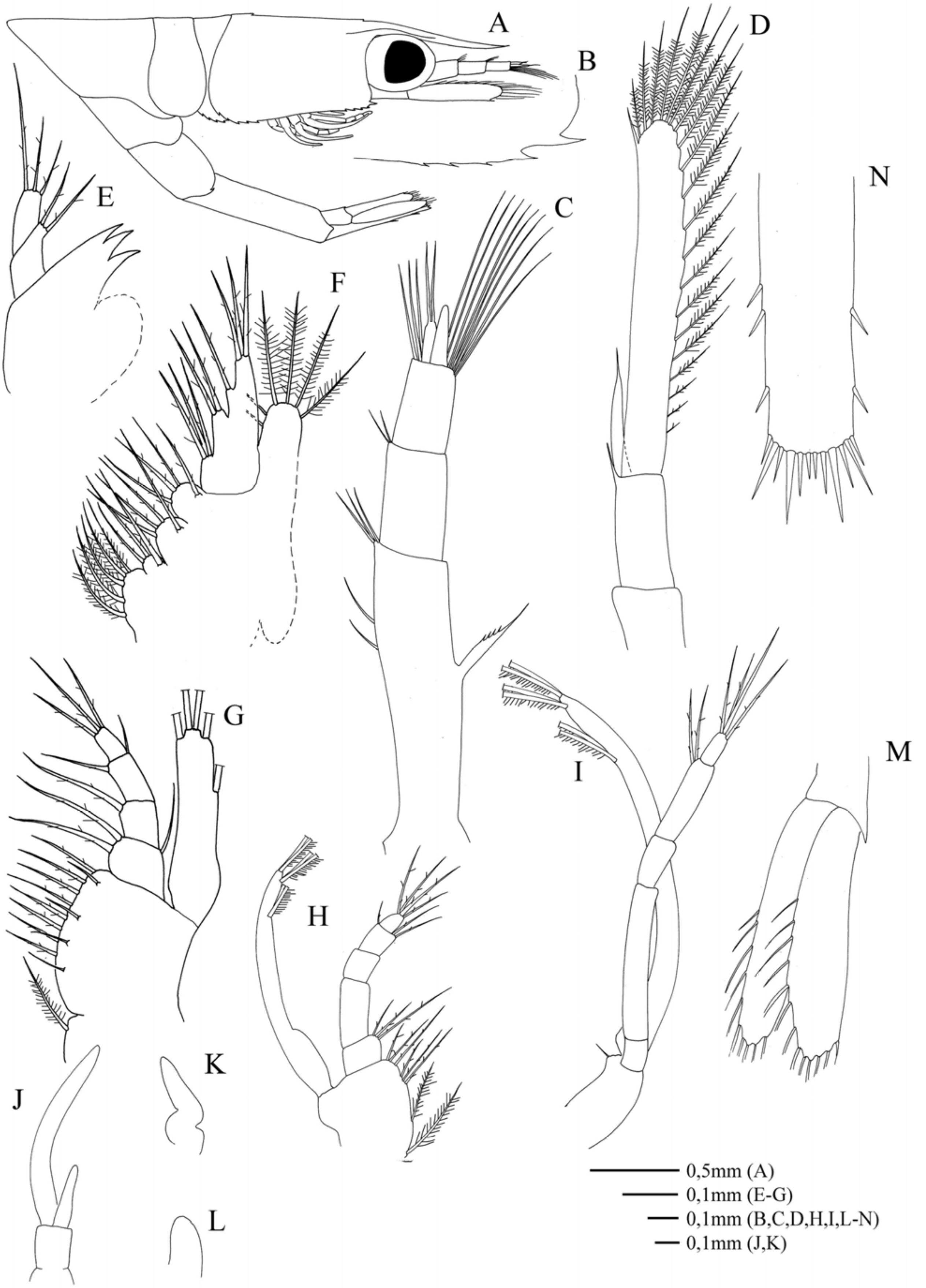

Figure 16. *Discias* sp., *zoea* IV (DZUFRJ1452). A, lateral view; B, carapace, antero-ventral margin; C, antennule; D, antenna; E, maxillule; F, maxilla; G, first maxilliped; H, second maxilliped; I, third maxilliped; J, first pereopod; K, second pereopod; L, third pereopod; M, uropod; N, telson.

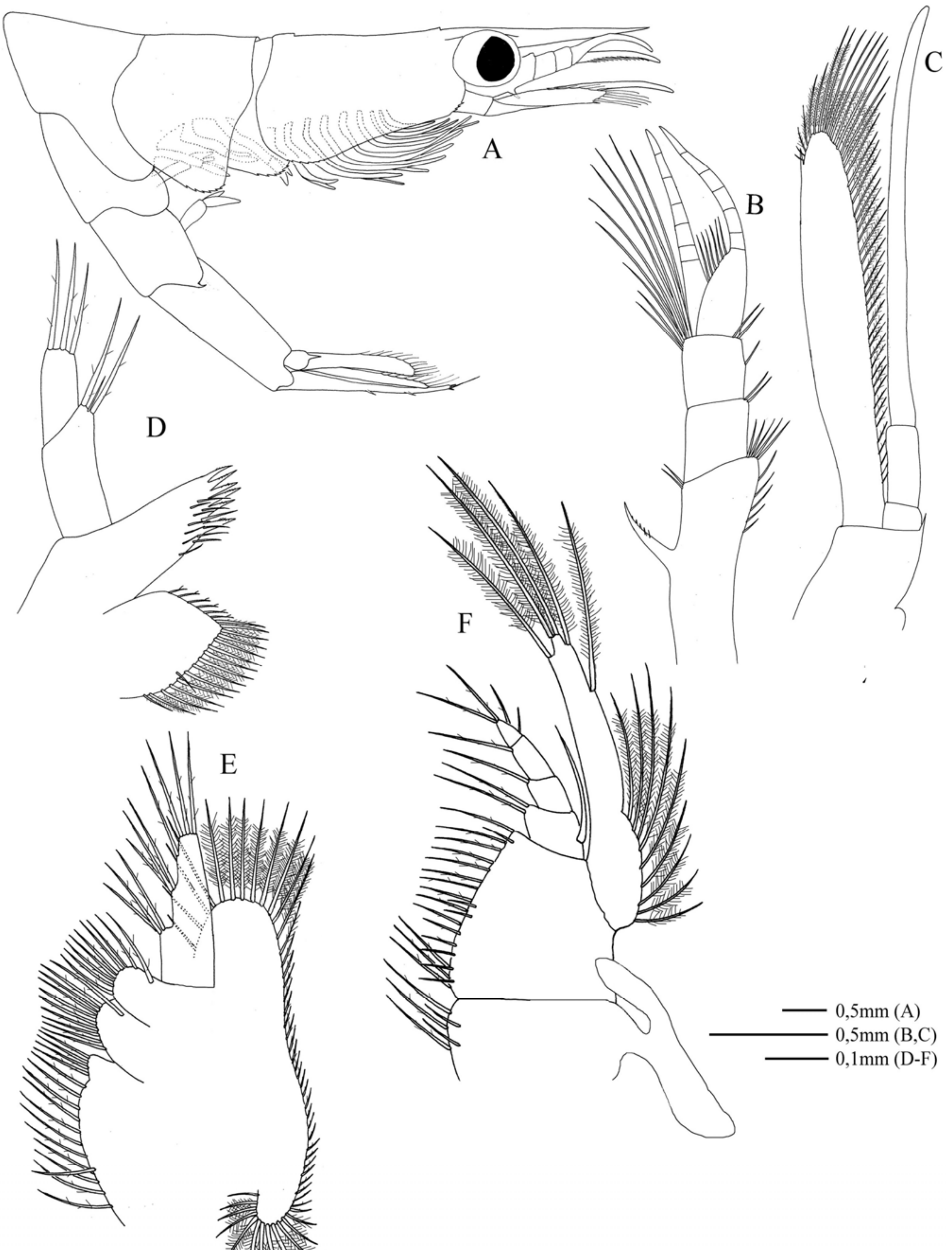

Figure 17. *Discias* sp., *zoea* IX? (DZUFRJ736). A, lateral view; B, antennule; C, antenna; D, maxillule; E, maxilla; F, first maxilliped.

setae on the protopod; endopod four-jointed, the first article with two strong spines and the second article with one strong spine; fifth pereopod (Fig. 18M) biramous; endopod with two strong spines on the first article; first pleopod (Fig. 18N) non-setose and with reduced endopod; uropod (Fig. 18O) well developed and setose; telson (Fig. 18P) parallel-side, with three lateral and 4+4 posterior spines.

Figure 18. *Discias* sp., *zoea* IX (DZUFRJ736). G, second maxilliped; H, third maxilliped; I, first pereopod; J, second pereopod; K, third pereopod; L, fourth pereopod; M, fifth pereopod; N, first pleopod; O, uropod; P, telson.

REMARKS – Gurney & Lebour (1941) and Gurney (1942) described the larvae of *Discias atlanticus* and revealed many characters also present in the larvae described herein, such as rostrum smooth reaching the antennal tip; third somite humped; fifth somite with small postero-lateral spine; and, sixth somite with no dorso-dorsal spine. Differences with the species described here include the number of apical setae on the modified dactylus; the number of spines on posterior margin of telson; and number of spines on the endopod of fourth and fifth pereopods. Gurney & Lebour (1941) also described a larva of Species D which resembles those of *Discias* sp. mainly because the presence of hump on the third somite, postero-lateral spine on fifth somite, modified dactylus of first pereopod, posterior margin of carapace and pleural margin on first and second somites serrated. In contrast, the larvae of Species D have a rostrum with lateral margin serrated against a smooth rostrum in *Discias atlanticus* and *Discias* sp.

Other larvae described before share important characters with the larvae of *Discias* sp. Ortmann (1893) described the larvae of *Anisocaris dromedarius* collected during the *Plankton Expedition* and noted a modified dactylus on the chela of the first pereopod. This modified chela is one distinctive character of the genus *Discias* (Criales & Lemaitre 1997) and according to Holthuis (1993) the genus *Anisocaris* is a junior-synonym of *Discias*. Two other larvae resemble that described herein as *Discias*: Species C of Gurney & Lebour (1941) and *Anisocaris* sp. of Gurney (1942), although that described by Gurney & Lebour (1941) do not have a modified chela on first pereopod (Table I). In the description of Species C and D, Gurney & Lebour (1941) argued that there are distinct resemblances between the larvae of *Discias* and that of *Acanthephyra*, although there are very important differences. Gurney (1942) suggested that these two larvae belong to the same family, though to different genera. The absence of a modified chela in Species C – diagnostic character of *Discias* – and the presence in Species D suggest these larvae do not belong to the same family and the similarities are convergences among Oplophoridae (*Acanthephyra*) and Bresiliidae (*Discias*).

Table I. Morphological comparison between zoea larvae described before and that of *Discias* described in the present study.

Species	Species C	Species D	*Discias atlanticus*	*Discias* sp.	*Anisocaris dromedarius*	*Anisocaris* sp.
Author	Gurney & Lebour (1941)	Gurney & Lebour (1941)	Gurney & Lebour (1941)	Present study	Ortmann (1893)	Gurney (1942)
Rostrum	Serrated	Serrated	Smooth	Smooth	Smooth?	Serrated
Ch1	Non- modified	Modified	Modified	Modified	Non-modified	Non-modified
DS3	Present	Absent	Absent	Absent	Present?	Present
PL5	Present	Present	Present	Present	Absent?	Present
Epipods	Presents	Presents	Absents	Absents	?	Absents

Ch1: Chela of first pereopod; DS3: Dorsal spine on third abdominal somite; PL5: Postero-lateral spine on fifth abdominal somite: Epipods: epipods on 1-5 pereopods. "?": Characters not fully described in the text by the author.

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Desempenho de dois índices biológicos na avaliação da qualidade das águas do Córrego Vargem Limpa, Bauru, SP, através de macroinvertebrados bentônicos

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Abstract. Performance of two biological indices in the water quality assessment of Vargem Limpa's stream, Bauru, SP, through benthics macroinvertebrates. This study evaluated the performance of two biological index used water quality assessment through benthics macroinvertebrates. The chosen indices had been: Biological Monitoring Working Party (BMWP) and Sequential Comparision Index (SCI). The results had indicated one better performance of the SCI in the water quality assessment of Vargem Limpa's stream.

Key words: BMWP, SCI, Biomonitoring, Bioindicators.

Resumo. Este estudo avaliou o desempenho de dois índices biológicos utilizados na avaliação da qualidade da água através de macroinvertebrados bentônicos. Os índices escolhidos foram: o Biological Monitoring Working Party (BMWP) e o Sequential Comparision Index (SCI). Os resultados indicaram um melhor desempenho do SCI na avaliação da qualidade das águas do Córrego Vargem Limpa.

Palavras-chave: BMWP, SCI, Biomonitoramento, Bioindicadores.

A idéia de utilizar os próprios organismos existentes nos ecossistemas aquáticos é antiga e surgiu na Europa, onde Kolenati (1848) e Cohn (1853) notificaram a existência da relação entre os organismos e a poluição da água (Liebmann, 1962 *apud* Junqueira *et al.*, 2000).

Atualmente a avaliação da qualidade da água por programas de biomonitoramento é feita através do estudo de organismos bentônicos, os quais refletem as alterações que ocorrem em um ecossistema aquático ao longo do tempo, visto que estes estão continuamente expostos no ambiente. Além disso, podem ser citadas algumas vantagens na utilização de indicadores biológicos: rapidez e eficiência na obtenção de resultados; baixo custo e avaliação da qualidade da água de um ecossistema sem recorrer a análises dos parâmetros físicos e químicos (Queiroz *et al.*, 2000).

Os macroinvertebrados bentônicos constituem um instrumento adequado para estudos de impactos sobre ambientes aquáticos, pois refletem o estado de conservação ou degradação do ecossistema. Dentre as características que tornam estes organismos eficazes neste tipo de estudo destacam-se: abundância nos sistemas aquáticos, baixa mobilidade; maior permanência no ambiente, pois vivem de semanas a alguns meses no sedimento, possibilitando a explicação de padrões temporais de alterações causadas por perturbações; ampla variedade de tolerância a vários graus e tipos de poluição, funcionalidade como integradores das condições ambientais, estando presentes antes e após eventos perturbadores (Rosenberg & Resh, 1993).

O uso de bioindicadores de qualidade de água, para monitorar bacias hidrográficas, é amplamente utilizado nos países desenvolvidos, tendo se constituindo inclusive em normas técnicas nacionais em vários países da Europa e na América do Norte (Junqueira *et al.*, 2000). No Brasil, alguns estudos recorrem à ictiofauna como indicador ecológico (Galves *et. al.*, 2007). No caso da fauna de macroinvertebrados bentônicos seu emprego ainda é incipiente, estando, porém, em ampla expansão.

Levantamentos minuciosos dos organismos são necessários, porém difíceis ou até mesmo impossíveis de realizar quando os recursos financeiros são escassos, quando são feitos em áreas de proteção ambiental e quando o tempo disponível é pequeno. Assim, muitas vezes levantamentos de curta duração são feitos para que seja possível um conhecimento preliminar da diversidade e das condições da biota. Esses levantamentos possibilitam, então, verificar os valores biológicos e de conservação do ecossistema estudado (Willink *et al.* 2000 *apud* Galves *et. al.*, 2007).

Dessa forma, o objetivo deste trabalho foi avaliar o desempenho de dois índices biológicos utilizados na avaliação da qualidade da água através de macroinvertebrados bentônicos. Os índices escolhidos foram: o Biological Monitoring Working Party, BMWP (Junqueira & Campos, 1998) e o Sequential Comparision Index, SCI (Cairns & Dickson, 1971), por serem de fácil implementação e não requererem identificações específicas.

Este estudo foi realizado no Córrego Vargem Limpa, no município de Bauru (22º 19’18”S e 49º04’13”W), situado na região centro-oeste do Estado de São Paulo. O corpo aquático em questão atravessa uma reserva ecológica e, ao longo de seu curso pela cidade, recebe elevadas quantidades de esgoto doméstico e de produtos químicos provenientes de atividades industriais da região.

Em dezembro de 2004, 7 amostragens consecutivas (dias) foram realizadas em quatro pontos do Córrego Vargem Limpa: Ponto 1 (P1) (22º20’25”S e 49º00’51”W), no interior do Jardim Botânico Municipal de Bauru, corresponde a uma das nascentes do córrego; Ponto 2 (P2) (22º20’18”S e 49º00’52”W), trecho de caráter lêntico, tem comunicação com a lagoa do Zoológico Municipal de Bauru; Ponto 3 (P3) (22º19’52”S e 49º00’48”W), situado no km 231 da Rodovia SP-225, ao lado de uma indústria de acumuladores, apresenta diversas áreas de deposição, devido ao assoreamento. Ponto 4 (P4) (22º18’28”S e 49º00’45”W), situa-se em área urbana industrial, neste local foi observado grande perturbação devido o despejo de esgoto doméstico e efluentes industriais.

O sedimento foi coletado em tréplicas, com auxílio de uma draga de Ekman-Birge. Em laboratório o substrato foi lavado e peneirado, sendo que o material retido nas peneiras passou por triagem e os macroinvertebrados bentônicos foram isolados e preservados em etanol 70%. Posteriormente, os organismos foram identificados até a família, pois segundo Corbi & Trivinho-Strixino (2006) o mesmo é adequado para este tipo de investigação, por avaliar com eficácia a qualidade das águas de córregos de baixa ordem. Os índices biológicos BMWP e SCI foram calculados utilizando-se metodologia descrita por Junqueira & Campos (1998) e Cairns & Dickson (1971), respectivamente.

No índice SCI, valores baixos indicam menor complexidade e estabilidade, do ecossistema, do que altos valores. Já o índice BMWP atribui valores (*scores*) para cada espécie com base na sua tolerância ao impacto, os valores variam entre 1 e 10 e são atribuídos de acordo com a sensibilidade das espécies a poluentes orgânicos. Famílias sensíveis a altos níveis de poluentes recebem valores mais altos, enquanto famílias tolerantes recebem valores mais baixos.

Para avaliar a qualidade das águas foram aferidas algumas variáveis abióticas (pH, condutividade elétrica e oxigênio dissolvido) utilizando aparelhos portáteis.

De acordo com Esteves (1998), a maioria dos ecossistemas aquáticos continentais apresenta pH variando entre 6 e 8, podendo-se, no entanto, encontrar ambientes mais ácidos ou mais alcalinos. Os valores médios de pH registrados no Córrego Vargem Limpa variaram entre 5,65 e 6,9 (tabela I), caracterizando o ambiente como de águas levemente ácidas.

O menor valor de condutividade elétrica foi registrado em P1 e o maior valor em P4, sendo 35,14 µs/cm, em P1, e 312,86 µs/cm, em P4. Os valores de condutividade elétrica são mais influenciados por fatores físicos (clima, hidrologia) e químicos (geologia local, solubilidade de minerais) e por impactos humanos (uso de fertilizantes, alterações da vegetação e outros) do que por fatores biológicos (Pedrosa & Rezende, 1999). Porém, uma alta concentração de matéria orgânica em decomposição aumenta a quantidade de íons dissociados na água, que resulta no aumento da condutividade elétrica. Em P4, uma grande quantidade de material alóctone pode ter contribuído para os altos valores desta variável (ver tabela I). P2 e P3 apresentaram, respectivamente, 51,57µs/cm e 44,14µs/cm; valores maiores que em P1 e bem

Tabela I – Valores médios de pH, condutividade elétrica (CE) e oxigênio dissolvido (OD) registrados nos pontos de amostragem do Córrego Vargem Limpa, em dezembro de 2004.

Pontos	pH	CE (µs/cm)	OD (mg/L)
1	6,02	35,14	6,41
2	5,65	51,57	2,86
3	6,3	44,14	4,88
4	6,9	312,86	1,29

menores que P4. P2 e P3 são áreas que sofrem ação antrópica, no entanto, em menor quantidade que P4, pois são locais de mais difícil acesso. P2 é uma área de águas calmas, enquanto P3 é uma área de maior correnteza, facilitando o transporte de materiais encontrados em seu curso para outros lugares, resultando na menor condutividade.

A concentração de oxigênio dissolvido (OD) na água depende de dois fatores principais: a temperatura da água e a pressão atmosférica. Quanto menor a temperatura e maior a pressão, maior é a oxigenação da água. As principais fontes de perda de OD são o consumo pela decomposição de matéria orgânica, perdas para a atmosfera, respiração de organismos aquáticos e oxidação de íons metálicos como o ferro e o manganês (Esteves, 1998). Em relação a esta variável, os valores mais baixos foram registrados em P4, localizado em área urbana industrial e com maior alteração das características físicas e químicas da água (tabela I), e os mais altos em P1, localizado no Jardim Botânico Municipal de Bauru, que é o ponto mais próximo às nascentes e, conseqüentemente, com menor possibilidade de entrada de efluentes de natureza antrópica, por ser uma área de proteção ambiental e de difícil acesso.

As composições das famílias de macroinvertebrados bentônicos encontradas nos pontos de amostragem do Córrego Vargem Limpa, são apresentadas na tabela II, bem como os índices biológicos obtidos com a aplicação do método BMWP e SCI.

O SCI é empregado para propósitos comparativos e, portanto, somente um índice individual tem pouco significado. No cálculo deste índice a riqueza de espécies é um fator importante, uma vez que a aplicação do índice tem mostrado que ambientes com uma riqueza de espécies reduzida apresentam um baixo valor do SCI, o que indicaria menor complexidade e estabilidade, do ecossistema.

Tabela II – Valores dos índices BMWP e SCI e composição das famílias de macroinvertebrados bentônicos encontradas no Córrego Vargem Limpa, Bauru, SP, em dezembro de 2004.

Pontos	Famílias de organismos	BMWP	SCI
1	Tubificidae-Naididae-Glossiphoniidae-Ceratopogonidae-Chironomidae-Tipulidae-Limnephilidae	23	3,61
2	Tubificidae-Naididae-Glossiphoniidae-Chironomidae-Tabanidae-Tipulidae-Piscicolidae	19	2,28
3	Tubificidae-Naididae-Glossiphoniidae-Chironomidae	7	1,78
4	Tubificidae-Naididae-Chironomidae	4	1,61

Neste estudo os valores do SCI foram decrescentes ao longo dos pontos de amostragem. O menor valor obtido para P2, em comparação com P1, pode ser atribuído ao fato deste local possuir comunicação com a lagoa do Zoológico Municipal de Bauru, que recebe descargas de matéria orgânica proveniente da lavagem das jaulas dos animais. Em P3 o decréscimo, provavelmente, relaciona-se com a localização do ponto (ao lado da Rodovia SP-225), visto que esta área recebe um grande aporte de matéria orgânica e de sedimento, o que provavelmente influenciou na integridade do ecossistema. O ponto 4, como esperado, foi o que apresentou o menor valor para o índice, o local é bastante degradado e poluído, com águas apresentando odor característico e coloração variavelmente acinzentada. Tais características podem ter contribuído para a menor diversidade do ambiente.

Em relação ao índice BMWP, os valores também apresentaram-se decrescentes ao longo dos pontos de amostragem. No entanto, quando se utiliza os valores de BMWP, obtidos neste estudo, para determinar classes de qualidade de água, todos os pontos são classificados como de qualidade péssima, o que não permite interpretações sobre as condições ambientais do ecossistema em estudo.

Os resultados obtidos neste estudo, provavelmente, estejam relacionados com as densidades dos organismos amostrados, pois Oligochaeta (Tubificidae e Naididae) e Chironomidae representaram 98,04% da fauna amostrada. Estes organismos são considerados tolerantes a poluição, e, portanto, servem como indicadores de má qualidade da água do ecossitema em estudo.

Neste estudo os resultados sugerem uma maior eficácia do SCI, como índice biológico, devido sua fácil implementação e sua representatividade ao registrar diferenças sutis entre os diferentes pontos de amostragens.

No entanto, o emprego de índices biológicos na avaliação da qualidade de água deve ser utilizado com a devida cautela, considerando-se as diferentes características ambientais dos ecossistemas estudados.

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Larval fish composition of a tropical estuary in northern Brazil (2º18'-2º47'S/044º20'- 044º25'W) during the dry season

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Abstract. Ichthyoplankton was collected in São Marcos Bay, in six sampling stations during the dry season (July 2000). Oblique hauls were done using a bongo net with 330 and 500 µm mesh sizes. Samples were taken during the day and ebb tide, except for one sample collected during flood tide. A total of 15 families and 17 species were identified. Members of the families Engraulidae and Sciaenidae were most abundant, and occurred in all stations. The largest number of taxa (14) were recorded in the inner region of the estuary, whereas the fewest taxa (4) occurred in the port area and near the fishery terminal. The families Auchenipteridae (*Pseudauchenipterus nodosus*), Clupeidae (*Rhinosardinia amazonica*), Engraulidae (*Anchoa spinifer*, *Anchoviella lepidentostole*), Sciaenidae (*Macrodon ancylodon*, *Stellifer rastrifer*) and Paralichthyidae (*Citharichthys* sp.) were dominant. Of these, *Anchoviella lepidentostole* was the most abundant, representing more than 84 % of the total catch.

Key words: Ichthyoplankton, estuary, São Marcos Bay, Brazil.

Resumo. Composição das larvas de peixes de um estuário tropical no nordeste do Brasil (2º18'-2º47'S - 044º20'44º25'W) durante a estação seca. O ictioplâncton foi coletado na baía de São Marcos, em seis estações, durante a estação seca (julho de 2000). Foram realizados arrastos oblíquos, utilizando-se rede bongô com aberturas de malha de 330 e 500 µm. As amostras foram coletadas durante o dia e na maré de vazante, com exceção de uma amostra coletada durante a maré de enchente. Foram identificadas um total de 15 famílias e 17 espécies. As famílias Engraulidae e Sciaenidae foram as mais abundantes e ocorreram em todas as estações. O maior número de táxons (14) foi encontrado nas estações mais internas do estuário, enquanto que o menor número (4) ocorreu nas áreas próximas ao porto e ao terminal pesqueiro. As famílias Auchenipteridae (*Pseudauchenipterus nodosus*), Clupeidae (*Rhinosardinia amazonica*), Engraulidae (*Anchoa spinifer*, *Anchoviella lepidentostole*), Sciaenidae (*Macrodon ancylodon*, *Stellifer rastrifer*) e Paralichthyidae (*Citharichthys* sp.) foram dominantes nesse estudo. Entre elas, a espécie *Anchoviella lepidentostole* foi a mais abundante representando mais de 84% do total de larvas coletadas.

Palavras-chave: Ictioplâncton, estuário, baía de São Marcos, Brasil.

Introduction

Estuaries are coastal ecotones that play a fundamental role in enriching the adjacent areas. These ecosystems have singular characteristics according to their geomorphology, water circulation, salinity and temperature variations. They comprise 15% of the coastal regions in the world (Yáñez-Arancibia 1987). Many estuaries are used for navigation and as repositories for industrial effluents and domestic waste (Raz-Guzman & Huidobro 2002, Ramos *et al*. 2006).

Estuarine regions are important areas for the reproduction and growth of many fish and crustacean species (Haedrich 1983, Neira & Potter 1992, Schwamborn & Bonecker 1996, Blaber *et al*. 2000, McLusky & Elliott 2004). Many fish species utilize estuaries as nurseries (Able & Fahay 1998, Barletta-Bergan *et al*. 2002, Joyeux *et al*. 2004) for feeding and growth during their planktonic phase.

The Brazilian coast has many estuarine regions of different origins and geomorphology (Sinque 1980, Sinque *et al.* 1982, Muelbert & Weiss 1991, Castro & Bonecker 1996, Joyeux *et al.* 2004, Castro *et al.* 2005, Mafalda Jr. & Silva 1996). São Marcos Bay is a tropical estuary located in northern Brazil, and is singular because of the wide range of tidal amplitude (Stride 1992). Similar characteristics to those of São Marcos Bay are found in the Rance estuary in northwest France, where tidal amplitude of 13 m was recorded; and also at Pico Island in the Azores.

Although São Marcos Bay has unusual characteristics, there is little information on its larval fish community. This study aimed to evaluate the larval fish community of the estuarine region of São Marcos Bay.

Study Area

São Marcos Bay is located on the central coast of the state of Maranhão, where the Maranhão Gulf is located (Figure 1). São Luís do Maranhão Island (02°38’12’’- 02°43’14’’S and 044°23’35’’- 044°17’50’’W) divides this gulf into two large bays: São Marcos Bay on the west side of the gulf, and São José Bay on the east (Stride 1992).

The climate is tropical, with a rainy season (November through June) and a dry season (July through October). Mangroves and marshes are dominant in this region (Juras *et al.* 1983, Camargo & Isaac 2003). The range of tidal amplitude can reach 7 m. In the bay mouth, the flood tide flows to the northwest and the ebb tide flows to the north, with a current speed of 3.9 knots (Stride 1992).

The mixing process of saline and continental waters, high primary and secondary production, high nutrient concentration and suspended matter characterize the waters of this region as typically estuarine (Juras *et al.* 1983). This is the largest and most important estuarine complex in the state of Maranhão.

The main source of fresh water to São Marcos Bay is a river that flows about 3.5 km from the bay (Stride 1992). A port and a fishery terminal are located in the bay (Figure 1).

Materials and Methods

Sampling was done during the dry season (July 2000) at six stations distributed over the estuary (Figure 1). The geographical locations of the sampling stations were provided by a GPS. Samples were collected during one day in the ebb tide, except for station 5 which was visited during flood tide because of logistic constraints (Table I). Stations 1 to 5 were considered estuarine and station 6 was named outer because it is more influenced by the adjacent coastal waters. Oblique hauls were done using a bongo net with 330 and 500 µm mesh sizes.

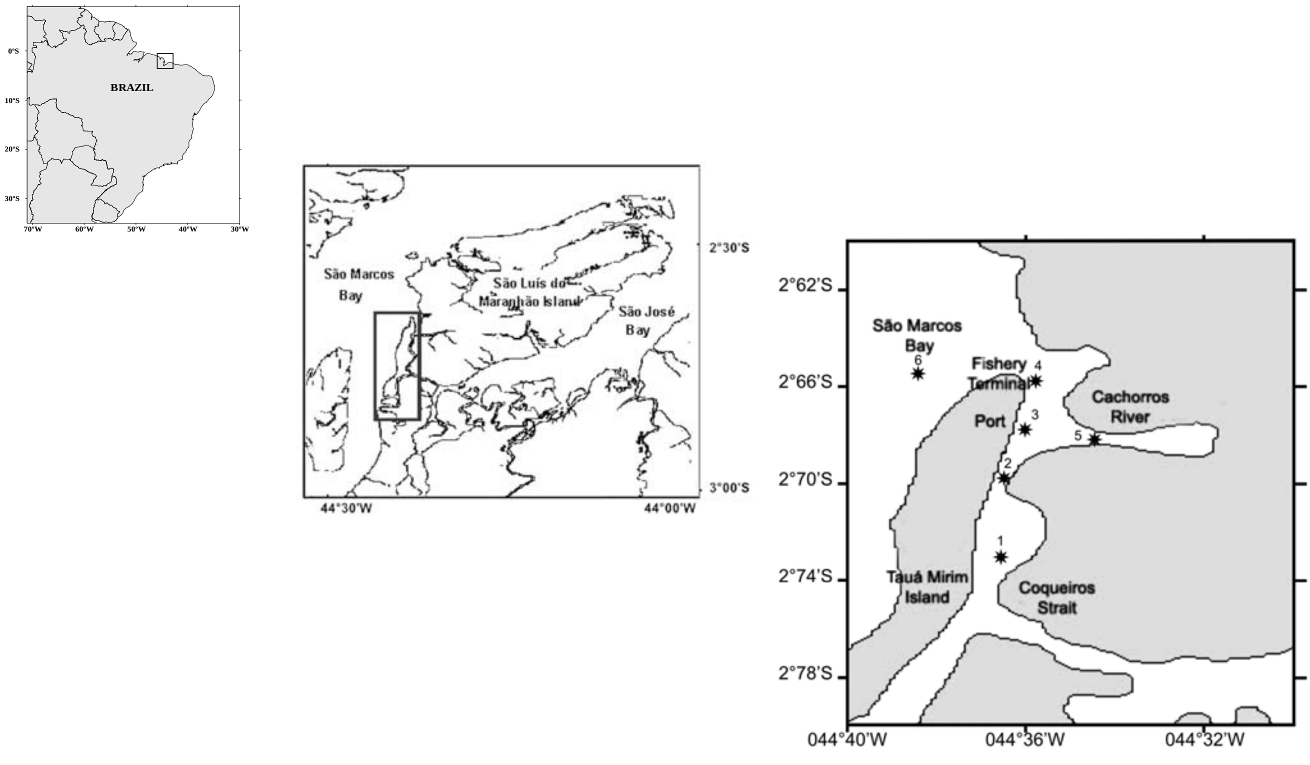

Figure 1. Estuarine region of São Marcos Bay and location of sampling stations.

The net was towed at approximately 2 knots for 10 minutes at each station. Samples were immediately fixed in 4% buffered formalin/seawater solution.

Water temperature and salinity were measured at each station, at three depths (surface, intermediate and bottom) using a thermosalinometer (Lab Comp). Water samples to determine the dissolved oxygen content were collected at the surface with a Van Dorn bottle; dissolved oxygen was measured according to Cnexo (1983).

Fish larvae were sorted from samples using a binocular microscope (Zeiss model SV6), and were identified to species level when possible, based on descriptions in the literature (Sinque 1980, Fahay 1983, Whitehead 1985, Whitehead *et al.* 1988).

All larvae identified were deposited in the larval fish collection of the Zooplankton and Ichthyoplankton Integrated Laboratory of the Federal University of Rio de Janeiro, Brazil (DZUFRJ).

Results

Environmental conditions

Salinity and temperature were homogeneous throughout the water column, and showed some variation between stations (Table II). Maximum and minimum values for temperature were observed respectively for stations 3 and 4. Salinity maximum and minimum values were observed for stations 4 and 1 respectively.

Most of the dissolved oxygen (DO) values recorded in the study area were low, except for station 6 which was located inside São Marcos Bay and showed the highest DO content (Table II).

Larval fish composition and distribution

A total of 1,098 larval fish were collected at the six stations, comprising 16 families and 17 species (Table III).

The highest number of taxa was recorded at station 1, located in the inner estuary (Table III). Larvae of *Anchoviella lepidentostole* and *Stellifer* sp. were the most frequent, occurring at all sampling stations (Table III). Although most taxa occurred at more than one sampling station, some were restricted to one part of the estuary: *Odontognathus mucronatus*, *Aspredinichthys* sp., Batrachoididae, *Scorpaena* sp., Serranidae, *Stellifer rastrifer, Psenes cyanophrys*, Eleotridae, *Trichiurus lepturus*, *Achirus lineatus*, *Trinectes paulistanus* and *Sphoeroides* sp. (Table III).

All taxa identified belong to demersal groups, except for *T. lepturus* and members of the families Pristigasteridae, Engraulidae and Clupeidae, which are pelagic. Most of the species that were collected only at the stations located inside the estuary are known to inhabit freshwater, estuarine and marine ecosystems. However, *Scorpaena* sp., Serranidae and *P. cyanophrys*, which were collected only inside the estuary, and *Citharichthys* sp., which occurred in both areas, are marine. Only *Achoa spinifer*, *Anchoviella lepidentostole*, *Macrodon ancylodon*, *Gobioides* sp., *Citharichthys* sp. and *Sphoeroides* sp. were recorded both inside and outside the estuary.

The family Engraulidae was the most abundant, representing more than 90% of the total larvae collected at station 4 (Figure 2). *Anchoviella lepidentostole* was the most abundant species, representing more than 84% of the total catch; it was most numerous (57%) at station 4, near the fishery terminal.

Members of the family Sciaenidae were also abundant, contributing more than 20% of the larvae collected at stations 1, 2 and 3 (Figure 2). Among the sciaenids, *Stellifer* sp. and *Macrodon ancylodon* were most abundant at stations 2 (5%) and 6 (3%), respectively.

Larvae of the families Auchenipteridae (*Pseudauchenipterus nodosus*), Paralichthyidae (*Citharichthys* sp.) and Clupeidae (*R. amazonica*) represented approximately 1% (Table III). The other taxa contributed less than 0.5% of the total larvae collected.

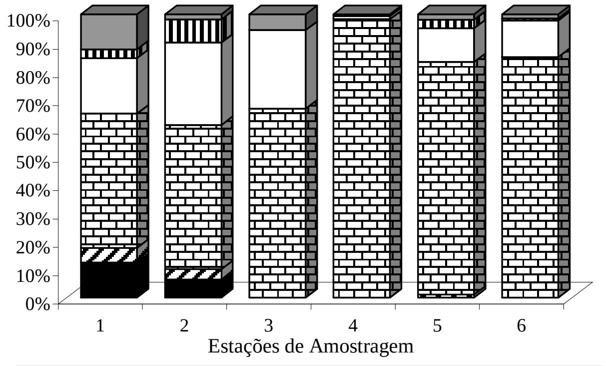

Figure 2. Percentage of the most abundant families collected with both meshes in each sampling station.

Discussion

Water temperature and salinity patterns obtained in this study are similar to those described for other tropical estuarine regions (Castro & Bonecker 1996, Barletta-Bergan *et al*, 2002, Joyeux *et al.* 2004, Barletta *et al.* 2005). The same pattern was also recorded in a previous study in São Marcos Bay (NUCLEBRAS 1984). According to Camargo & Isaac (2003), the water temperature in estuarine and coastal regions of the study area does not vary

Table I. Sampling stations, reference names, coordinates, hour of sampling, depth and tide of each station.

Station	Reference	Latitude	Longitude	Hour	Depth (m)	Tide
1	Coqueiros	2° 43’38.6”	044° 21’75.3”	12:30	7	ebb
2	Intermediate	2° 41’37.0”	044° 22’04.5”	13:30	6	ebb
3	Port	2° 40’39.7”	044° 21’53.1”	11:00	15	ebb
4	Fishery Terminal	2° 39’39.0”	044° 21’26.9”	10:10	13	ebb
5	Cachorros	2° 40’41.3”	044° 20’35.9”	09:05	7	flood
6	São Marcos Bay	2° 39’21.5”	044° 23’03.2”	15:10	20	ebb

Table II. Temperature (ºC), salinity and dissolved oxygen (DO) measured in six stations distributed in the estuarine region of São Marcos Bay in the dry season (July 2000).

Stations	Temperature (°C)			Salinity			DO
	surface	intermediate	Bottom	surface	intermediate	bottom	(mg.L^{-1})
1	28.5	28.5	28.4	16.4	16.5	16.6	3.86
2	28.8	28.5	28.5	17.0	17.2	17.2	4.37
3	28.9	28.5	28.4	21.9	21.9	22.0	3.6
4	22.7	28.5	28.2	22.7	23.8	24.1	3.89
5	25.0	28.3	28.4	22.5	22.4	21.6	4.11
6	28.5	28.5	28.3	20.3	20.9	21.1	5.14
Mean	27.07	28.47	28.37	20.13	20.45	20.43	4.16
Standard deviation	2.60	0.08	0.10	2.80	2.95	2.93	0.54

Table III. Taxa occurrence and percentage (%) along the six sampling stations located in the estuarine region of São Marcos Bay.

Taxa/Stations	1	2	3	4	5	6	%
Pristigasteridae (p)							
Odontognathus mucronatus Lacepéde, 1800	-	-	-	-	x	-	0.09
Engraulidae (p)							
Anchoa spinifer (Valenciennes, 1848)	x	x	-	-	-	x	0.46
Anchoviella lepidentostole (Fowler, 1911)	x	x	x	x	x	x	84.88
Clupeidae (p)							
Rhinosardinia amazonica (Steindachner, 1879)	x	x	-	-	-	-	0.91
Aspredinidae (d)							
Aspredinichthys sp.	x	-	-	-	-	-	0.18
Auchenipteridae (d)							
Pseudauchenipterus nodosus (Bloch, 1794)	x	x	-	-	-	-	1.73
Batrachoididae (d)	x	-	-	-	-	-	0.09
Scorpaenidae (d)							
Scorpaena sp.	x	-	-	-	-	-	1.18
Serranidae (d)	-	x	-	-	-	-	0.09
Sciaenidae (d)							
Macrodon ancylodon (Bloch & Schneider, 1801)	x	-	x	x	x	x	2.91
Stellifer sp.	x	x	x	x	x	x	3.37
Stellifer rastrifer (Jordan, 1889)	-	-	-	-	-	x	2.19
Nomeidae (d)							
Psenes cyanophrys Valenciennes, 1833	x	-	-	-	-	-	0.09
Eleotridae (d)	-	x	-	-	-	-	0.09
Gobiidae (d)							
Gobioides sp.	x	-	-	x	x	x	0.36
Trichiuridae (p)							
Trichiurus lepturus Linnaeus, 1758	-	-	-	x	-	-	0.09
Achiridae (d)							
Achirus lineatus (Linnaeus, 1758)	-	-	x	-	-	-	0.09
Trinectes paulistanus (Miranda-Ribeiro, 1915)	x	-	-	-	-	-	0.09
Paralichthyidae (d)							
Citharichthys sp.	x	x	-	x	x	x	1.55
Tetraodontidae (d)	-	-	-	x	x	x	0.27
Sphoeroides sp.	x	-	-	-	-	-	0.36

p = pelagic; d = demersal; x = presence; - = absence greatly during the year, and hence does not affect the spatial distribution of the adult fish community. On the other hand, in tropical regions, salinity changes seem to be the most important factor to explain much of the spatial and temporal dynamics of biotic communities (Pauly 1994).

The low dissolved oxygen values (< 5.0 $mg.L^{-1}$) obtained in this study are characteristic of regions that receive large amounts of organic waste (Lavrado *et al.* 1991). The highest dissolved oxygen value, obtained at the outermost station, was probably influenced by cleaner seawater from the coastal region. No direct relationship was found between dissolved oxygen values and species richness.

Most families recorded in this study are common in equatorial and tropical estuarine regions, and have previously been recorded in estuaries of northern Brazil, except for *P. cyanophrys* (Camargo & Isaac 2003). All the families are marine, except for Aspredinidae (*Aspredinichthys* sp.) and Auchenipteridae (*Pseudauchenipterus nodosus*), which occur in fresh and brackish waters (Nelson 2006). According to Haedrich (1983), the occurrence of coastal species in estuaries is due to the similarity of these ecosystems to coastal waters.

The observed dominance of demersal families at the stations located inside the estuary may be related to the water transparency, which is normally low in the inner portion of estuaries; and also to the abundant food at the bottom (Camargo & Isaac 2003). According to these authors, estuaries harbor a wide diversity of demersal families such as the Sciaenidae and Aspredinidae. Pelagic species, such as engraulids and *T. lepturus*, are more abundant in coastal habitats where the water is more transparent than in estuaries (Camargo & Isaac 2003).

Members of the family Engraulidae were the most abundant group in this study. According to published information, many species of this family are very abundant, having an important role in fishery production around the world (Baxter 1967, Bendazoli *et al*. 1990, FAO 1995). The adults of the most abundant engraulid in this estuary (*A. lepidentostole*) have a coastal habitat and migrate into inner estuarine waters to spawn (Cervigón 1985). They prefer low-salinity waters and are common in tropical and temperate estuaries (Froese & Pauly 2006).

During this study, this family was also represented by *A. spinifer*, which was considered an estuarine resident by Castro (1997), using the region of São Luís as a nursery area. According to Camargo & Isaac (2003), this species is strongly euryhaline, being found from the continental shelf (≅ 40 m) to the uppermost reaches of rivers.

Sciaenids that were also important in this study are also commonly found in neotropical estuaries (Camargo & Isaac 2005). Fishes of this family tolerate wide ranges of salinity, which allows them to inhabit estuaries strongly influenced by freshwater (Camargo & Isaac 2003). Among the sciaenids collected, *M. ancylodon* and *Stellifer rastrifer* are very euryhaline (Camargo & Isaac 2003). The former species is also classified as semi-anadromous, that is, the adults spawn near the mouth of estuaries and the eggs and larvae are carried by the tides into estuarine creeks (Barletta-Bergan *et al*. 2002, Camargo & Isaac 2003, 2005).

The larval fish community observed in this study is composed by families with different patterns of ecological uses of the estuarine environment. *Gobioides* sp., *A. lineatus* and *T. paulistanus* are considered strictly estuarine (Camargo & Isaac 2003). The Cocosoda catfish (*Pseudauchenipterus nodosus*) lives in freshwater environments, but occasionally migrates into brackish waters; and the Spicule anchovy (*Anchoa spinifer*), as discussed earlier, is typically estuarine and spends its entire life in this environment (Camargo & Isaac 2003).

The diversity of adult fish previously recorded from this region (Martins-Juras 1989, Camargo & Isaac 2003) and the number of taxa identified in this study, during only one sampling period, emphasize the importance of this estuary for the Brazilian coast. The north coast of Brazil, including the study area, contributes 28% of the marine and estuarine annual average landings of the country (between 2000 and 2003), considering only the pelagic and demersal teleosteans (Haimovici *et al*. 2006).

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Análise da ocorrência de lesões corporais em três espécies de peixe elétrico (Pisces: Gymnotiformes) do sul do Brasil

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Abstract. Analysis of lesions in three species of electric fish (Pisces: Gymnotiformes) from Southern Brazil. The frequency of body lesions in three gymnotiform species was verified and accounted for a 12 months period. *Gymnotus* aff. *carapo*, *Brachyhypopomus* sp. and *Eigenmannia trilineata* presented a frequency of lesions of 6.7%, 27.3% and 21.1% respectively. Chi-squared test (α = 0.05, g.l.=1) detected no significant difference between sex and number of lesions for the three analyzed species during the sampling periods. Independence test with contingency table didn't point out any relation between season and number of lesions in three species.

Key words: *Eigenmannia*, *Gymnotus*, *Brachyhypopomus*, regeneration, neotropical.

Resumo. A freqüência de lesões corporais em três espécies de gimnotiformes foram verificadas e contabilizadas para um período de 12 meses. *Gymnotus* aff. *carapo*, *Brachyhypopomus* sp. e *Eigenmannia trilineata* apresentaram uma freqüência de lesões de 6.7%, 27.3% e 21.1% respectivamente. O teste do qui-quadrado (α = 0.05, g.l.=1) demonstrou que não existe diferença significativa entre sexo e número de lesões nas três espécies analisadas, durante os períodos de amostragem. O teste de independência com tabela de contingência não demonstrou a existência de uma relação entre a época do ano e a quantidade de lesões das três espécies.

Palavras-chave: *Eigenmannia*, *Gymnotus*, *Brachyhypopomus*, regeneração, neotropical.

Introdução

Os peixes da ordem Gymnotiformes, comumente conhecidos como "peixes elétricos" ou "sarapós" têm como característica marcante a capacidade de produção de uma corrente elétrica que é gerada por um ou mais órgãos elétricos (Bennett 1971). Tal habilidade permite aos gimnotiformes explorar seu habitat e se comunicar com seus coespecíficos por meio dos potenciais elétricos, além de perceber objetos e outros seres no ambiente.

Segundo Mago-Leccia (1994), os gimnotiformes possuem uma grande capacidade de regeneração quando são lesados por predadores. De acordo com o trabalho de Ellis (1913) e Kirschbaum & Meunier (1981), estes peixes conseguem regenerar grandes porções de seu corpo como nadadeiras, tecidos musculares, órgãos elétricos, escamas e cromatóforos. Existem muitos estudos a respeito da regeneração de partes do corpo de teleósteos, como rins (Reimschuessel *et al.* 1990), raios de nadadeiras (Nabrit 1929) e regeneração de órgãos elétricos em gimnotiformes (Zakon & Unguez 1999), além de musculatura esquelética (Rowlerson *et al.* 1997) e retina (Raymond *et al.* 1988). Todos estes trabalhos foram realizados a partir de experimentos para observar o processo regenerativo.

No fenômeno da regeneração, o grau de inervação é um importante fator para que sejam reconstruídas as partes perdidas (Zakon & Unguez 1999). Sabe-se, por exemplo, que o sistema nervoso possui um papel essencial na regeneração dos barbilhões de peixes Siluriformes e nos membros dos urodelos, e, em ambos os casos, a remoção do sistema nervoso interrompe o processo regenerativo (Goss 1969, Singer 1974).

A maioria dos estudos sobre este tema é voltada para a descrição celular, histológica e morfológica do processo de regeneração. Tais trabalhos, com exceção do de Ellis (1913), nunca abordam a freqüência com que as lesões e as regenerações ocorrem no ambiente natural, e as possíveis explicações para a ocorrência delas.

Este trabalho tem como objetivos realizar uma análise dos tipos de lesões por freqüência de ocorrência, verificar se existe diferença significativa entre número de lesões e o sexo em cada espécie e estimar se existe correlação entre a estação do ano com o número de lesões para as espécies de peixe-elétrico *Gymnotus* aff. *carapo* Linnaeus, 1758, *Brachyhypopomus* sp. e *Eigenmannia trilineata* López & Castello, 1966.

Material e Métodos

Área de estudo

O material foi coletado no Parque Estadual de Itapuã, situado a 57 quilômetros do centro de Porto Alegre, no município de Viamão (30º05’00’’ S, 50º47’00’’ W). Possui mais de 5.550 hectares, que guardam uma grande biodiversidade de plantas e animais e representam a última amostra de ambientes naturais da região metropolitana de Porto Alegre.

Os exemplares de *G.* aff. *carapo* e *Brachyhypopomus* sp. foram coletados na lagoa Verde (30º22’52.4’’S, 51º01’25’’W), no Parque Estadual de Itapuã. Esta lagoa possui uma área aproximada de 4 hectares, profundidade não ultrapassando 1 metro, com fundo lodoso, água escura e parada e grande quantidade de matéria vegetal em decomposição. Está cercada por vegetação de mata psamófila com forte influência da Mata Atlântica e densa população de juncos *Scirpus* sp. em seu interior, que normalmente não ultrapassam 1.5 metro de altura.

Os exemplares de *E. trilineata* foram coletados na lagoa Negra, no Parque Estadual de Itapuã. Esta apresenta uma área de 1750 hectares, com características semelhantes à lagoa Verde, como água com baixa transparência, profundidade média de 1 metro e fundo lodoso. O ponto de coleta (30º 21’35.5’’S, 50º58’34’’W), um dos antigos canais de irrigação de arroz da área, apresenta algumas espécies de macrófitas aquáticas como *Pistia stratiotes* Linnaeus, 1753, *Salvinia auriculata* Aublet, 1775, *Nynphoides indica* O’ Kuntze, 1891 e *Eichornia crassipes* (Martius) Solms-Laubach.

Amostragem

As espécies foram amostradas mensalmente nos seguintes períodos: *E. trilineata* entre junho/2002 e maio/2003; *G. aff. carapo* entre maio/2003 e abril/2004 e *Brachyhypopomus* sp. entre setembro/2003 e agosto/2004. Todos os exemplares foram obtidos com o auxílio de uma rede do tipo puçá e um detector de peixes elétricos, que consiste em um amplificador diferencial, com alta sensibilidade e com resposta em freqüência dentro da faixa audível, auxiliando na localização dos exemplares. A captura ocorreu no período da manhã, sendo os exemplares transferidos para solução de formalina 10% imediatamente após a captura. Lotes dos espécimes foram depositados na coleção de peixes do Departamento de Zoologia, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brasil (*Brachyhypopomus* sp.: UFRGS 7685; *G.* aff. *carapo*: UFRGS 6854, UFRGS 6855, UFRGS 6856, UFRGS 6857, UFRGS 6858, UFRGS 6859; *E. trilineata*: UFRGS 5719, UFRGS 6635).

Análise

O termo “lesão” utilizado neste estudo se aplica a todos os animais nos quais foi observado algum tipo de amputação em partes do corpo. As lesões sofridas pelas três espécies foram classificadas em duas categorias: recentes: quando não existe sinal evidente de inicio de regeneração e em regeneração: quando já existe sinal evidente de que esteja ocorrendo o crescimento da parte que foi perdida.

Todos os indivíduos foram examinados a olho nu, onde foram observadas diferenças de pigmentação e protuberâncias que poderiam indicar regeneração, além de análise sob estereomicroscópio em busca de sinais de regeneração avançada para que, desta forma, tais indivíduos fossem incluídos na análise. Em seguida, todos os exemplares foram sexados através de dissecção para observação das gônadas sob estereomicroscópio.

Para determinar se houve diferença significativa no número de lesões entre os sexos em cada uma das três espécies estudadas, foi aplicado o teste qui-quadrado ($\alpha = 0.05$, g.l.=1) aos resultados, utilizando a seguinte fórmula (Callegari-Jacques, 2003): $\chi^2_{\text{calc}} = \sum (O-E)^2/E$, com $\alpha = 0.05$, g.l. = 1, onde: O = número observado e E = número esperado.

A relação do número de lesões recentes sofridas pelos sexos com as estações do ano foi testada através de teste de independência com tabela de contingência. Os dados foram agrupados por estação do ano e por sexo. Aos dados da tabela foi aplicado o teste do qui-quadrado. Para a interpretação deste teste, foi realizada, em caso de correlação positiva de estação do ano com número de lesões recentes, a análise de resíduos em tabelas, de acordo com as seguintes expressões: Resíduo padronizado: $R_p = (O-E)/\sqrt{E}$, onde: O = número observado e E = número esperado; Resíduo ajustado: $R_{aj} = R_p \,/\, \sqrt{\ } (1-(TC/TG)(1-(TL/TG))$, onde ($\alpha = 0.05$, $z = 1.96$): TC = total de ocorrências de lesão por espécie em cada estação; TL = total de ocorrências de lesão por sexo de cada espécie.

As estações do ano foram definidas da

seguinte forma: Primavera: outubro, novembro e dezembro; Verão: janeiro, fevereiro e março; Outono: abril, maio e junho; Inverno: julho, agosto e setembro.

Resultados

Foi analisado um total de 1172 indivíduos, sendo 389 de *G.* aff. *carapo* , 348 de *Brachyhypopomus* sp. e 435 de *E. trilineata* (Fig. 1). As três espécies apresentaram algum tipo de lesão, em diferentes porcentagens (Fig. 2). O número total de indivíduos com lesão por espécie, sexo e estação, aprecia-se na Tabela I. *Gymnotus* aff. *carapo* apresentou 2.3% de lesões recentes e 4.4% de lesões em regeneração, totalizando 6.7%. *Brachyhypopomus* sp. apresentou 5.2% de lesões recentes e 22.1% de lesões em regeneração, totalizando 27.3% . *E. trilineata* apresentou 11.7% de lesões recentes e 9.4% de lesões em regeneração, totalizando 21.1% (Fig. 3).

Figura 1. Espécies estudadas no presente trabalho. (A) *Gymnotus* aff. *carapo*, 131 mm.. (B) *Brachyhypopomus* sp., 146 mm. (C) *Eigenmannia trilineata*, 142 mm.

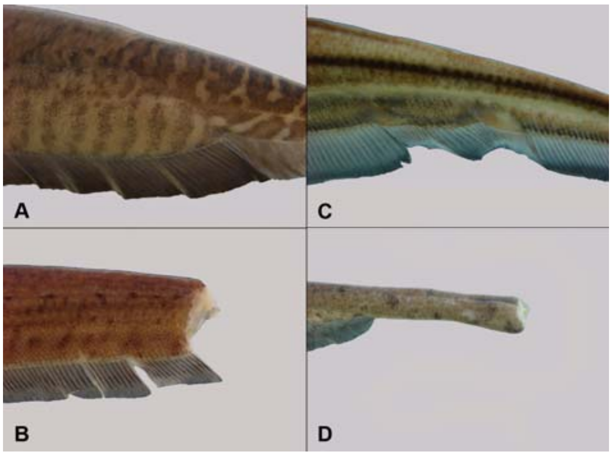

Figura 2. Tipos de lesões mais comuns, encontradas nas três espécies de gimnotiformes. (A) Lesão em regeneração, em estágio avançado, de *Gymnotus* aff. *carapo*. Note-se a diferença na intensidade de pigmentação na parte posterior, marcando a região regenerada. (B) Lesão recente em *Brachyhypopomus sp*. (C) Lesão em regeneração de *Eigenmannia trilineata*. (D) Lesão recente no filamento caudal de *Brachyhypopomus* sp.

O teste do qui-quadrado demonstrou a ausência de diferença significativa entre sexo e número de lesões nas três espécies analisadas, durante os períodos de amostragem. O teste de independência com tabela de contingência demonstra que não existe relação entre a época do ano e a quantidade de lesões recentes em *Brachyhypopomus* sp., *Gymnotus* aff. *carapo* e *E. trilineata* (χ^2_{calc} = 6.07; 0.31 e 0.31, respectivamente, g.l. = 3).

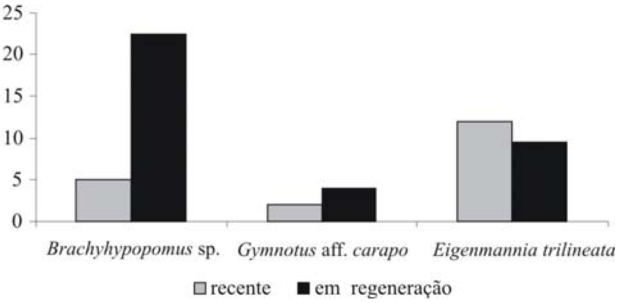

Figura 3. Porcentagens de lesões recentes e em regeneração encontradas nas três espécies de gimnotiformes estudadas no Parque Estadual de Itapuã, RS, Brasil.

Discussão

Ellis (1913) documentou que de um total de 27 espécies analisadas, 22 apresentavam algum tipo de lesão, entre elas espécies do gênero *Gymnotus*, *Eigenmannia*, e *Hypopomus*. O mesmo autor constatou que a cavidade celomática relativamente pequena em comparação com o comprimento total do corpo destes peixes permitiria que lesões na região posterior à cavidade, não resultassem em morte apesar da perda de tecido em muitos casos ser grande.

Gymnotus carapo, espécie estudada em três localidades da Guiana Inglesa, apresentou um percentual de 4.1% de lesões em 96 indivíduos (Ellis 1913). Esta taxa de lesões é consideravelmente mais baixa se comparada com as espécies do restante do estudo do mesmo autor, sendo muito próxima da encontrada para a população de *Gymnotus* aff. *carapo* do presente estudo (6.7%).

Segundo o próprio Ellis (1913), a baixa taxa de lesões sofridas por *G. carapo* poderia se explicar pelo padrão de colorido com bandas oblíquas, que poderia funcionar como camuflagem, já que essa espécie vive em meio à vegetação aquática. Além disso, esta espécie é uma nadadora muito rápida e vigorosa, o que poderia contribuir para fuga de predadores maiores. O ponto de coleta de *G.* aff. *carapo* é rico em vegetação aquática, o que contribuiria com a camuflagem da espécie para escapar de

Tabela I. Número total de indivíduos com lesões por espécie, sexo e estação do ano. Na fileira de totais por espécie indica-se o número de lesões recentes (em itálico), o número de indivíduos analisados por estação, entre parênteses e a porcentagem de lesões recentes na estação, em negrito. Na coluna de total por período encontram-se os dados de lesões recentes e em regeneração com as somas agrupadas. R= recente; RG= em regeneração.

		Primavera		**Verão**		**Outono**		**Inverno**		**Total período**
		R	**RG**	**R**	**RG**	**R**	**RG**	**R**	**RG**	
Eigenmannia trilineata n = 435	F	4	10	5	9	3	0	9	1	41
	M	5	8	8	6	3	12	9	0	51
	Total	*9* (100) - **9%**		*13* (145) - **8,9%**		*6* (92) - **6,9%**		*18* (98) - **18,3%**		92
Gymnotus* aff. *carapo n = 389	F	1	1	2	0	4	1	0	2	11
	M	2	1	1	1	4	2	1	3	15
	Total	*3* (100) - **3%**		*3* (95) - **3,1%**		*8* (90) - **8,9%**		*1* (105) - **0,9%**		26
***Brachyhypopomus* sp.** n = 348	F	4	10	5	3	3	1	9	3	38
	M	5	3	8	3	3	11	10	14	57
	Total	*9* (89) - **10,1%**		*13* (85) - **15,2%**		*6* (84) - **7,1%**		*19* (90) - **21,1%**		95

predadores. No entanto, Winemiller & Jepsen (1998) relatam que a traíra *Hoplias malabaricus* (Bloch, 1794) é responsável por uma considerável taxa de ataques a peixes associados à vegetação aquática, inclusive a *G. carapo*.

Albert & Crampton (2003) relatam que muitas espécies de *Gymnotus* são territoriais, e tal fato pode acarretar em ataques intraespecíficos para defesa de território. Estes ataques ocorrem quando exemplares desta espécie são colocados em um mesmo aquário (Cognato, Obs. Pess.). Logo, *G.* aff. *carapo* pode ser responsável tanto por ataques intraespecíficos quanto interespecíficos, inclusive a outros Gimnotiformes, gerando lesões.

A espécie *Hypopomus brevirostris* (Steindachner, 1868), agora considerada *Brachyhypopomus brevirostris* (Mago-Leccia 1994), estudada por Ellis (1913) na bacia amazônica, apresentou um percentual de 8% de lesões em um total de 56 indivíduos. Ainda que este autor considere que lesões sejam comuns nesta espécie, esta taxa de lesões é muito mais baixa do que as encontradas para a população de *Brachyhypopomus* sp. do presente estudo, que foi de 27.3%. Mesmo sendo espécies do mesmo gênero, uma diferença nestas taxas seria provável, pois os ambientes (bacia amazônica e sistema lagunar dos Patos) possuem características muito distintas em diversos aspectos, que determinam diferentes pressões ambientais.

A espécie *Eigenmannia virescens* (Valenciennes, 1842) também estudada por Ellis (1913) apresentou um percentual de 15% de lesões em um total de 482 indivíduos e *Eigenmannia macrops* (Boulenger, 1897) apresentou um percentual de 12% de lesões de um total de 56 indivíduos. No presente estudo foram encontradas taxas de lesões de 21.1% para *E. trilineata*.

Dufech (2004) encontrou na lagoa Negra espécies piscívoras que poderiam ser responsáveis pela predação de Gimnotiformes, como as espécies conhecidas como peixe-cachorro, *Oligosarcus jenynsii* (Günther, 1864) e *Oligosarcus robustus* Menezes, 1969; a traíra, *Hoplias malabaricus*; a Joana, *Crenicichla lepidota* Heckel, 1840 e o muçum *Synbranchus marmoratus* Bloch, 1795. Já na lagoa Verde, foi registrada a presença de duas espécies piscívoras que poderiam predar Gimnotiformes: *Hoplias malabaricus* e *Synbranchus marmoratus* (Cognato, obs. pess.).

Em escala local, muitos peixes movimentam-se freqüentemente entre habitats. Alguns predadores de emboscada maximizam o sucesso de forrageamento posicionando-se na interface desses habitats (Winemiller & Jepsen 1998). Segundo estes mesmos autores, duas espécies piscívoras dominantes, *H. malabaricus* e *Caquetaia kraussii* (Steindachner, 1878) foram capturadas freqüentemente próximas às margens de densos bancos de macrófitas. Acreditamos que muitas lesões encontradas nos gimnotiformes do presente estudo são causadas pelos predadores encontrados na lagoa Verde e lagoa Negra, que emboscam peixes que se movimentam entre os fragmentos de macrófitas aquáticas. No entanto, não há comprovação por estudos de conteúdo estomacal provando que estes predadores seriam responsáveis por tais ataques.

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Comparing the performance of two spatial interpolation methods for creating a digital bathymetric model of the Yucatan submerged platform

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Abstract. Bathymetry is one of the most conspicuous variables to consider in any study involving marine environments. In developing countries, accurate and up to date bathymetric charts are rare or in most cases limited to local areas, most of them available only in hardcopy format. This is the case of the Yucatan submerged platform. In this study, we compare and discuss the performance of two spatial interpolation techniques for creating a digital bathymetric model (DBM): Inverse distance functions and Kriging. The DBM for Yucatan Peninsula submerged platform was generated using 2650 depth point-data values digitized from navigational charts previously published by the Mexican "Secretaria de Marina" at a 1:850,000 scale. The exponential Kriging model produced the most accurate estimates, reducing the error in 18.2% compared with the inverse distance functions. Our results might become helpful to other researchers trying to decide the type of interpolation technique and selection of the model when elaborating digital elevation models for regional mapping purposes.

Key words: Inverse distance functions, kriging, geostatictics, bathymetry, Yucatan Platform.

Resumo. Comparación del desempeño de dos métodos de interpolación espacial para crear un modelo batimétrico digital de la plataforma sumergida de Yucatán. La batimetría es una de las variables más sobresaliente a considerar en estudios de medio ambientes marinos. En los países en desarrollo son raras las cartas batimétricas precisas y actualizadas o en la mayoría de los casos estas se limitan a áreas muy particulares. Muchas de estas cartas están disponibles solamente en formato impreso. Este es el caso particular de la plataforma de Yucatán. En este estudio comparamos y discutimos el desempeño de dos técnicas de interpolación espacial usadas para crear un modelo batimétrico digital (MBD): funciones de distancia inversa y kriging. El MBD fue generado usando 2650 valores puntuales de profundidad, los cuales fueron digitalizados de cartas de navegación publicadas por la Secretaria de Marina, a una escala de 1:850,000. El modelo de kriging exponencial produjo las estimaciones más precisas, reduciendo el error de estimación en al menos un 18.2% comparado con las funciones de distancia inversa. Nuestros resultados podrían ser útiles para otros investigadores tratando de decidir el tipo de técnica de interpolación y la selección del modelo a emplear cuando se elaboran modelos de elevación digital con propósitos de mapeo regional.

Palavras-chave: Funciones de distancia inversa, kriging, geoestadística, batimetría, plataforma de Yucatán.

Introduction

Bathymetry is the process of measuring seafloor water depths and producing realization of underwater topography. The development of bathymetric models is of great importance for the study of underwater environments, and they frequently are the only type of data available for inferring the geology over much of the ocean floor (Bowles *et al.* 1998).

The importance of having accurate bathymetry estimations is evident for a variety of scientific fields related with monitoring, evaluation and assessment of marine environments. The study of geology and structure of ocean floor (Wright *et al.* 2000, Ramírez-Herrera & Urrutia-Fucugauchi 1999), the study of physical oceanographic processes such as currents, tides, water mix, and nutrient transport (Klenke & Schenke 2002, Merino 1997) as well as the study of biological processes such as larval transport, algal blooms and species abundance and distribution, relies on the availability of accurate estimations of bathymetry (Carlon 2002, Epifanio & Garvine 2001). However, in most developing countries the availability of accurate and up to date bathymetric charts is rare or in most cases is limited to a few charts for local areas, most of them available only in hardcopy format.

Geostatistical techniques are useful in providing estimates of sample attributes at locations with sparse information (Burrough & McDonnell 1998). These methods work by defining the spatial structure of the phenomena (i.e. by autocorrelation or auto-covariance functions such as semi-variograms), then estimating values between measured points based on the degree of spatial autocorrelation or covariance found in the data (Robertson 1987, Isaak & Srivastava 1989). Kriging procedures and their required variography are not, however, without critics. It is argued that the structural analysis (variography) may be a rather involved and even a somewhat subjective process. Consequently, simpler alternatives to kriging, such as the inverse distance weighting have been used as interpolation methods (Merwade *et al.* 2006, Kravchenko & Bullock 1999). This technique is easier to implement due to the fact that the estimation of values does not require any measure of either spatial autocorrelation or spatial auto-covariance.

In this study, two spatial interpolation methods namely inverse distance weighting functions and kriging, were compared in terms of accuracy of the estimates for creating the best DBM for Yucatan submerged platform.

Methods

The Yucatan Peninsula is a large calcareous platform that extends into a submerged area called the “Campeche Bank”. It is located between 19^o 40’ and 21^o 37’ N and 87^o 30’ and 90^o 26’ W. Two bodies of water, the Gulf of Mexico and the Caribbean Sea, border the coast of the Yucatan Peninsula (Figure 1). The Peninsula attained its present shape in the late Pliocene; with important depositions on the coast during the Holocene, and platform reefs which are continually developing to its North and East ends. Variations in water depth have been documented, the maximum interglacial sea level was 30 m higher than today, at the Pliocene; and in the early Holocene sea level was some 100 m lower than today, and present sea level was attained only 5500 years ago. (Schmitter-Soto *et al.* 2002).

Depth data used in this study were obtained from the navigational charts S.M 800, and S.M. 900 published at a 1:850,000 scale by “Secretaria de Marina”, Mexico in 1994 and 1995, which updated the information from previous charts from the same source published during 1972 and 1977 respectively. The charts were acquired in hardcopy format and digitized to raster format using a personal scanner. Raster images were imported to the Idrisi GIS-software (Eastman 1999) and geometrically corrected to the Latitude-Longitude coordinates system using degrees and decimal degrees as units, referenced to the ellipsoid GRS 1980 and North America datum 1983. Figure 2 shows the distribution of 2650 punctual depth data values and the coast line, obtained from: http://crusty.er.usgs.gov/coast.getcoast.html.

To produce Digital Bathymetric Models that “best” represent the depth variability for the Yucatan submerged platform, we compare the performance of two spatial interpolation techniques: Inverse distance weighting and Kriging. All geostatistical analyses were made using the GS+ ^{TM} software (Robertson 2000) and then exported to Surfer 8 ^{TM} and Arc View 3.2 ^{TM} for final enhancement and display.

Inverse distance weighting functions is a nearest neighbor interpolation technique that combines both the neighborhood and gradual change notions (Burrough & McDonnell 1998). Estimates of depth values at unvisited points are obtained as a weighted average of his neighbors (sampled points), where the closest points have more weight (importance) than those that are far away. The weighted values are based on an inverse function of the distance to the neighbors. The inverse distance function is expressed with equation a):

$$Z = \sum_{i=1}^{n} \left(\frac{1/d_i^{\,p}}{\sum 1/d_i^{\,p}} Z_i \right) \qquad \text{a)}$$

Where Z is the estimated depth value, Zi is the depth value calculated at the location i, d is the separation between the estimated point and the sampled location, p is an analysis-defined power parameter and n represents the number of sampling points used for estimation.

The main factor affecting the accuracy of inverse distance interpolator is the value of the power parameter p (Isaak & Srivastava 1989). In this study, we compared estimates of inverse distance interpolator using different integer powers parameters 1, 2, 3, 4, 5 and 6, which are the most commonly used in literature (Kravchenco & Bullock 1999, Burrough & MacDonnell 1998). Since the goal of using inverse distance functions as estimators is giving more weight (importance) to the closest sampled points (Webster & Oliver, 2001), in this study we just considered integer values of p parameter, because the values lower than 1 are closest to a simple average estimation (Isaaks & Srivastava 1989). In addition, the size of the neighborhood and the number of neighbors are also relevant to the accuracy of the results. Here, the closest 16 sampling point in a radius of 1.7 decimal degrees were used to perform the estimations. The choice of neighborhood size was obtained as the maximum separation in which autocorrelation exists between two points located in space (Figure 3).

Kriging is a spatial interpolation technique based on the spatial structure of sampled points. Using kriging, estimates of depth values at unsampled locations are obtained from the information provided by the structures of spatial variability, as depicted by an autocorrelation function, in this case the semi-variogram of depth values. Such structures help in defining the size and shape of the neighborhood for interpolation (i.e. sampling points that are spatially auto-correlated to the point to be estimated). The semi-variogram is computed by using equation b):

$$\gamma(h) = \frac{1}{2n}\sum_{i=1}^{n}\left(Z(x_i) - Z(x_i + h)\right)^2 \qquad \text{b)}$$

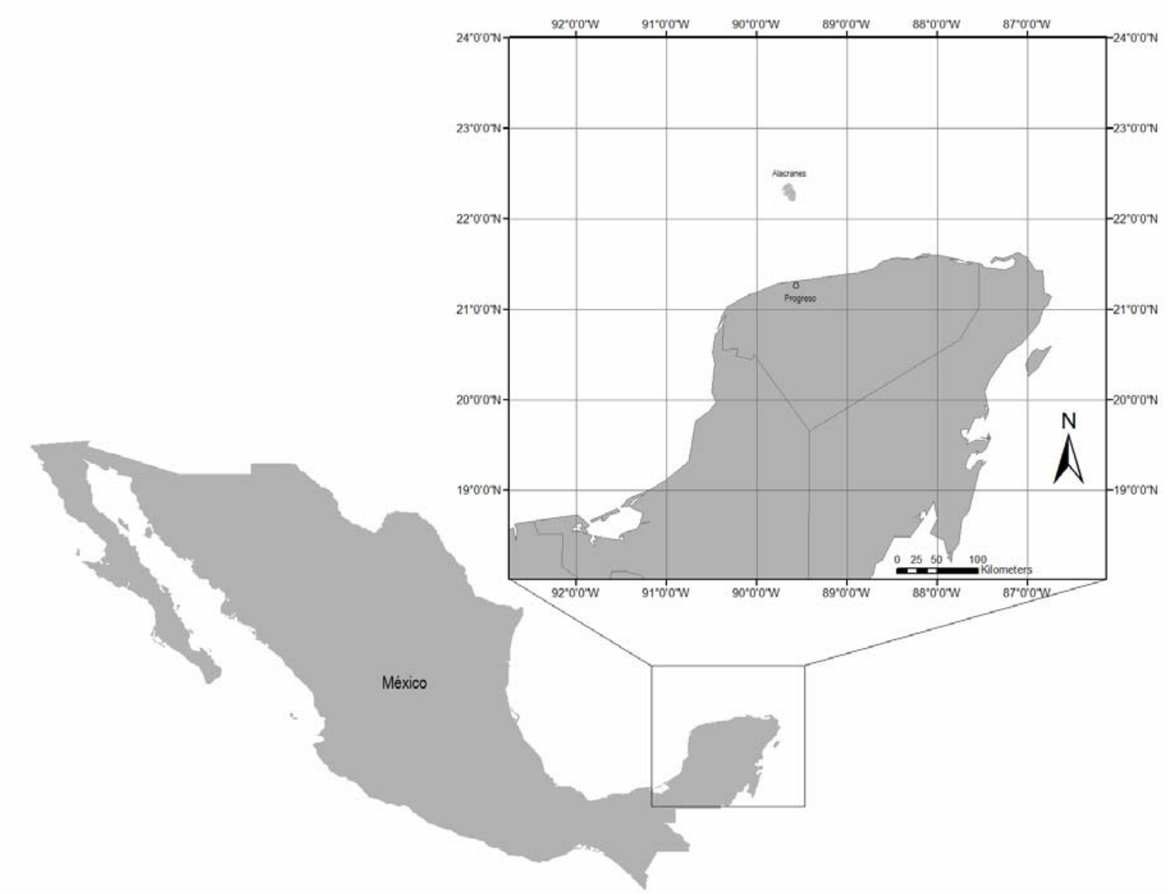

Figure 1. Geographic location of Yucatan peninsula.

Where $Z(x_i)$ is the depth in the location *i*, $Z(x_i + h)$ is the depth value of other points separated from x_i, by a discrete lag h; n represents the number of pairs of observations separated by *h*, and $\gamma(h)$ is the estimated or "experimental" semi-variance value for all pairs at lag *h*.

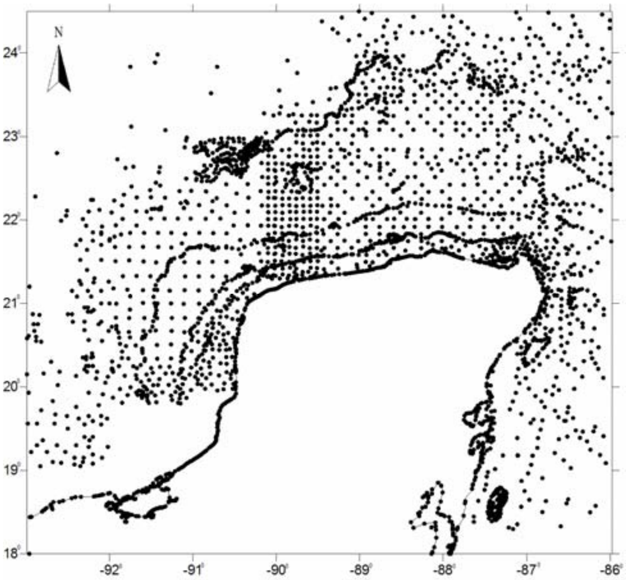

Figure 2. Distribution of punctual depth values as digitized from the navigational charts S.M 800, and S.M. 900 published by "Secretaria de Marina".

Semi-variances were calculated for each possible pair of sampling points, and the mean values of semi-variances were plotted for increasing lag intervals (*h*) to produce the experimental semi-variogram. Spherical, gaussian and exponential models were then fitted to experimental semi-variograms (Robertson 2000). The fitted models provided the following parameters; the total variance -also known as the "sill" variance- which defines the asymptotic value of semi-variance with respect to the lag separation. The sill variance is split in two, the variance due to spatial dependence and the random or "nugget" variance. In turn, the nugget variance, the *y* intercept in the semi-variogram model, reflects both, the spatial variation at shorter lags than the minimum sample spacing and the unexplained variance. The range of influence is the maximum separation at which depth values are still spatially dependent (Isaak & Srivastava 1989, Burrough & Mcdonnell 1998, Webster & Oliver 2001). The coefficient of determination (r^2) resulting from fitting of models to experimental semi-variograms, and cross-validation procedures described later on, were both used as criteria to select the best models in each situation.

Depth value estimates were obtained by using block kriging as expressed with the equation c):

$$Z(x_0)=\sum_{i=1}^{n}\lambda_i Z(x_i) \qquad \text{c)}$$

Where λ_i are the optimal weights selected to minimize the estimation variance (Webster y Oliver, 2001), $Z(x_i)$ are the observed values of depth and $Z(x_0)$ is the optimal and unbiased estimate of depth values. The bathymetric maps were obtained using at least 16 sampling locations within a maximum radius of 1.7 (Decimal degrees). Neighborhood characteristics were determined by the range of influence of the semi-variogram.

The performance of each interpolation technique, in terms of the accuracy of estimates, was assessed by comparing the deviations of estimates from the measured data through the use of a "jack-kniffing" technique or cross-validation (Isaak & Srivastava, 1989, Webster & Oliver 2001). In such a procedure, sample values are deleted from the data set, one at a time and then the value in turn is interpolated by performing the interpolation algorithm with the remaining sampling values. This yields a list of estimated values of depth data paired to those measured at sampled locations. Therefore, the comparison of performance between interpolation techniques was achieved by using the following statistics: correlation coefficient between measured and estimated depth values, the mean error (*ME*), the mean absolute error (*MAE*) and the root mean square error (*RMSE*) (Zar 1999).

The *ME* is used for determining the degree of bias in the estimates and it is calculated with equation d):

$$ME=\frac{1}{n}\sum_{i=1}^{n}\hat{Z}(x_i)-Z(x_i) \qquad \text{d)}$$

The MAE provides an absolute measure of the size of the error. MAE is calculated with the equation e):

$$MAE=\frac{1}{n}\sum_{i=1}^{n}\left|Z(x_i)-Z(x_i)\right| \qquad \text{e)}$$

The RMSE provides a measure of the error size that it is sensitive to outliers. RMSE values can be calculated with equation f):

$$RMSE=\sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(\hat{Z}(x_i)-Z(x_i)\right)^2} \qquad \text{f)}$$

Finally, the relative improvement of the best method compared with the other procedures is calculated with equation g):

$$RI = \frac{100\left(RMSE_{Best} - RMSE_{Currentl}\right)}{RMSE_{Best}} \qquad g)$$

Where $RMSE_{Best}$ are the minimum value of *RMSE* and $RMSE_{Current}$ represent the *RMSE* of the current model.

Results

The spatial variation depicted by the semi-variogram models are shown on Table I. Spherical, Gaussian and Exponential models were found to fit well the experimental semi-variograms, and to explain the spatial autocorrelation present in the depth variable (Figure 3), yielding an r^2 ranging from 0.95 to 0.97 (Table I). The structural variance, which determines the variance explained by the model and calculated as (total variance–nugget variance)/total variance*100, ranged from 85.0% to 99.9%. This not only suggests that most of the variability of depth values is explained by the models, but also that a small fraction of variability is attributable to the nugget variance, which was ranged from 0.1 to 15.0 %. The range of influence showed values between 1.4 and 3.0 decimal degrees, indicating that one would reasonably expect that the depth values in places separated as far as in between 1.4 and 3.0 decimal degrees are still somewhat related.

The results, in terms of the accuracy of estimates (estimated errors), obtained from the cross-validation procedures are presented in Table II. The mean error (*ME*) is generally lower for kriging methods as interpolators. The depth values when predicted by kriging resulted in average underestimations of 3.6 and 3.8, being this the lowest values compared with those of inverse distance procedures, which gave a mean underestimation higher than 12.2. The other two measures of error, i.e. *MAE* and *RMSE*, showed similar behavior for all methods. The highest values of these measures of errors were obtained with inverse distance methods. In the same way estimated depth values are more correlated with measured depth data when kriging is utilized (Figure 4). Therefore, there is evidence that the accuracy of depth values estimations is improved when kriging procedures are applied. The relative improvement of the best technique compared with the others is also showed in Table II. Kriging procedure allowed at least a reduction of 18.2% in the error compared with the inverse distance functions.

The results strongly suggest that the accuracy of estimates and therefore the accuracy of mapping depth values were improved by using kriging (Table II). Furthermore, it must be taken into account that the kriging technique has an intrinsic additional advantage over the other interpolation method since its estimates are unbiased and with minimum variance. Thus, they are accompanied by a measure of the error in each predicted value: the estimation variance (Webster & Oliver 2001). This measure of the estimation error is provided by most of the geostatistical software programs, including GS+™. The final DBM produced by using the exponential model with kriging, was imported to the software Surfer ™ for final enhancement and display. Figure 5 shows a 2.5-D representation of the final DBM.

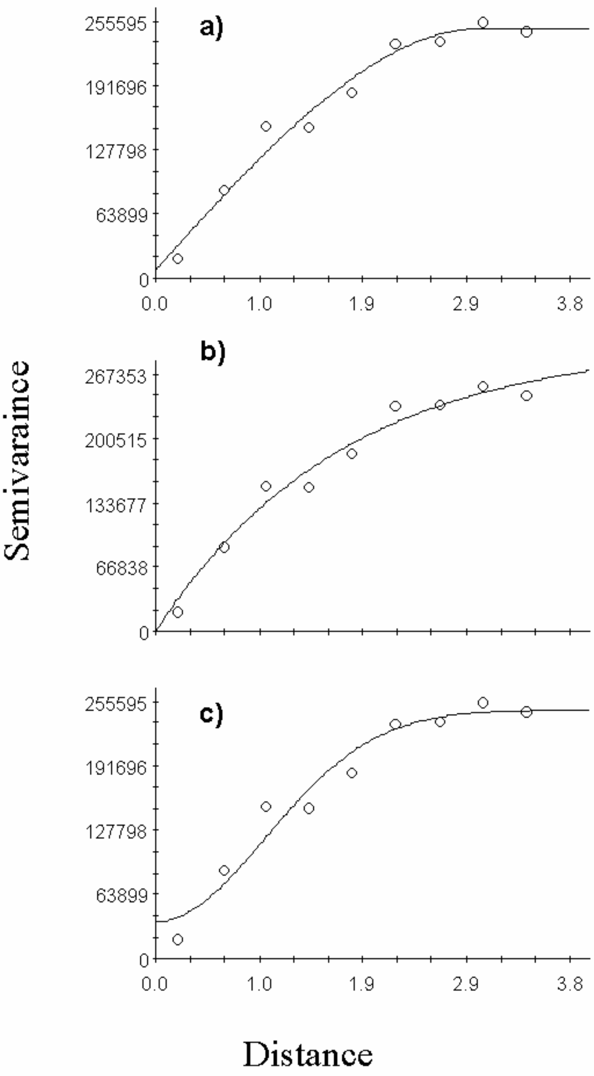

Figure 3. Experimental and model semi-variograms of depth values: a) spherical model, b) exponential model and c) gaussian model.

Table I. Parameters and statistics of semi-variogram models describing the spatial variability of depth values.

Model	Nugget Variance	Total Variance	Range	Relative Structural (%) Variance	r^2
Spherical	8500.00	248500.00	3.005	96.6	0.972
Exponential	100.00	300500.00	1.724	99.9	0.973
Gaussian	36900.00	246800.00	1.417	85.0	0.951

Table II. Results of mean error, mean absolut error, root mean square error, correlation coefficients between measured and estimated depth values.

Interpolation Procedure	ME	MAE	RMSE	Corr	RI (%)
Kriging (spherical)	-3.83	40.98	155.41	0.956	1.42
Kriging (exponential)	-3.55	36.68	153.21	0.957	0.00
Kriging (Gaussian)	-6.06	45.97	162.14	0.939	5.51
Inverse distance-1	-26.77	56.39	221.62	0.917	30.87
Inverse distance-2	-21.77	48.48	201.41	0.929	23.93
Inverse distance-3	-17.64	44.62	191.08	0.934	19.82
Inverse distance-4	-14.90	43.03	187.60	0.934	18.33
Inverse distance-5	-13.28	42.63	187.25	0.934	18.18
Inverse distance-6	-12.33	42.56	187.92	0.933	18.47

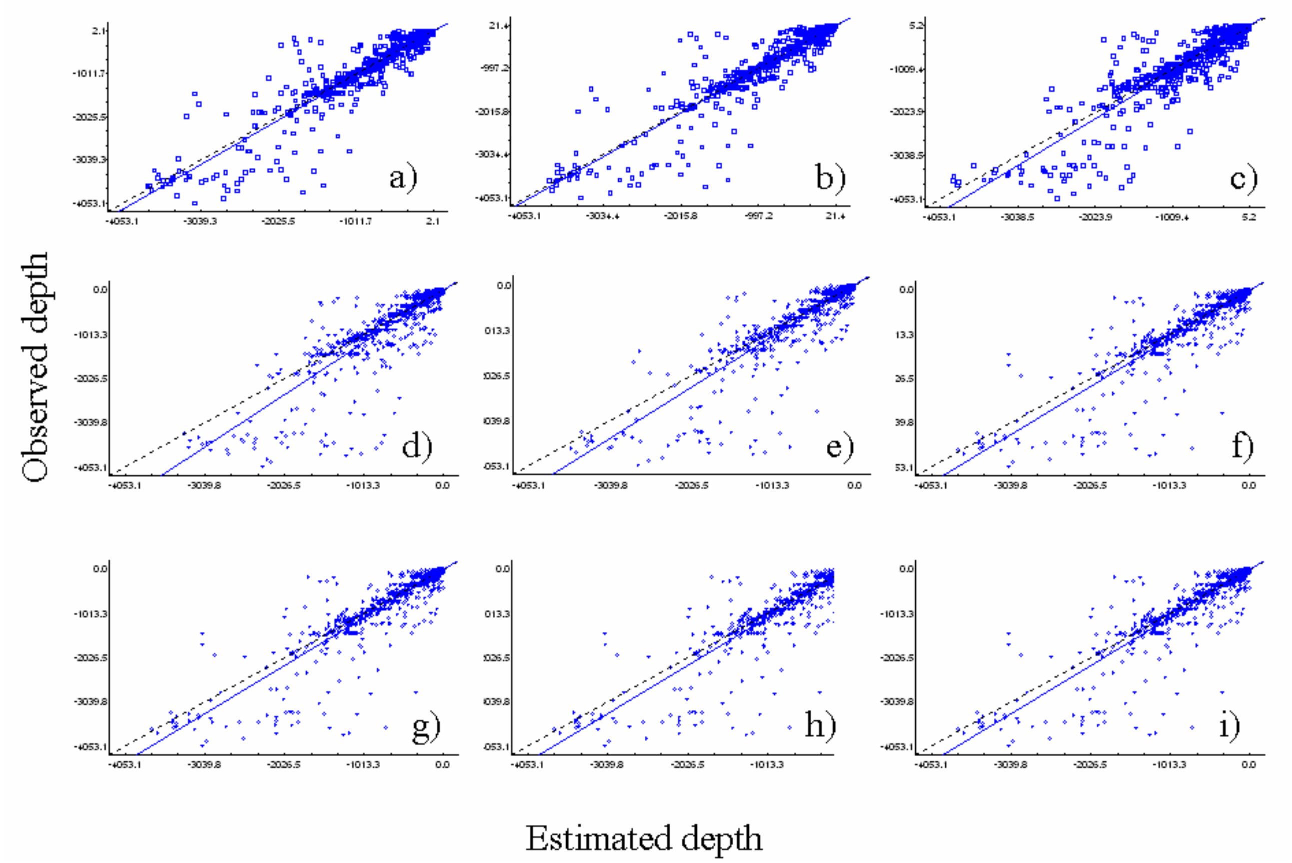

Figure 4. Results of cross validation analysis used to compare the interpolation methods: a) spherical kriging, b) exponential kriging, c) gaussian kriging, d) inverse distance-1, e) inverse distance-2, f) inverse distance-3, g) inverse distance-4, h) inverse distance-5, i) inverse distance-d (Dotted lines represent a perfect fit 1:1).

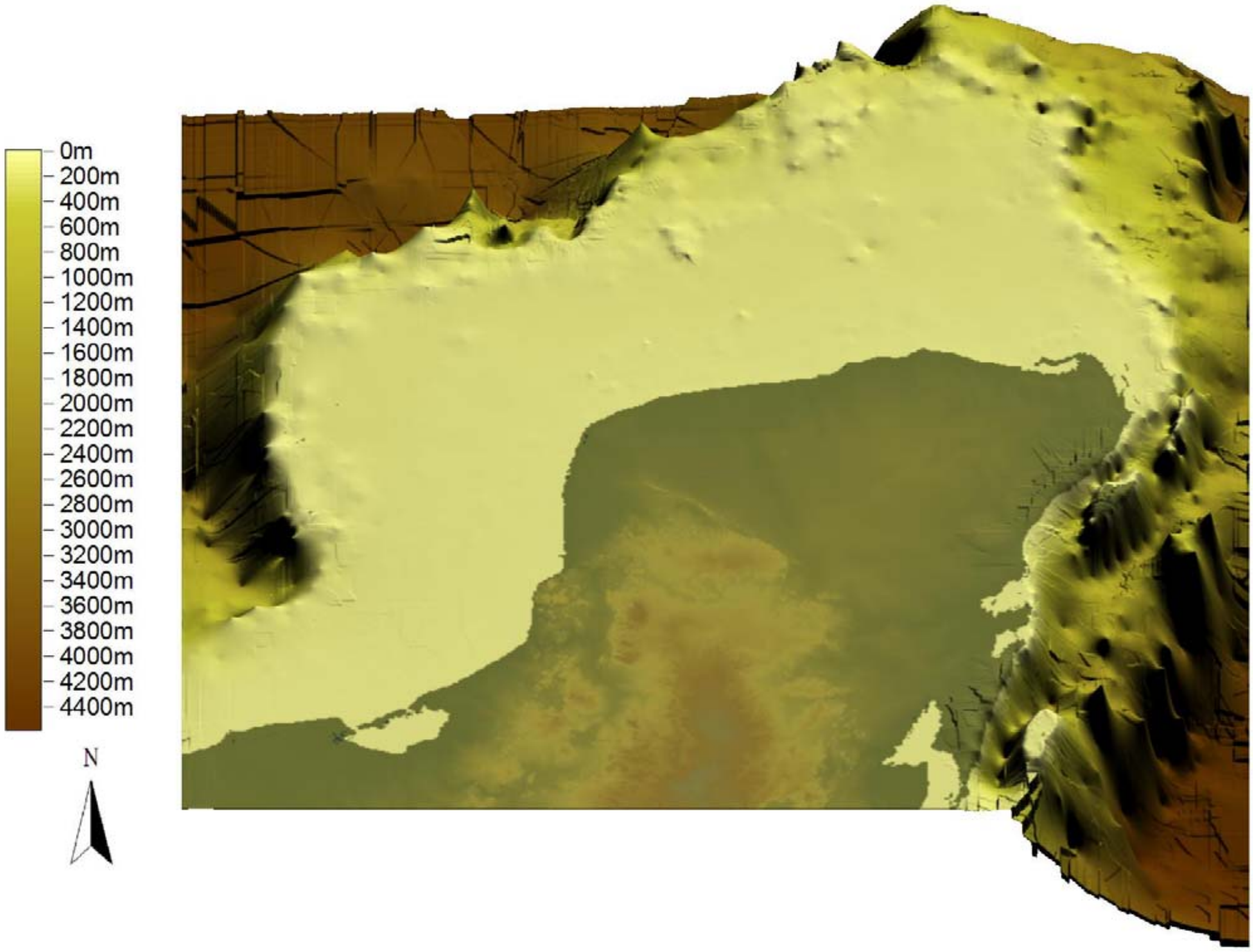

Figure 5. A 2.5-D illustration of the final digital bathymetric model (DBM) for the Yucatan submerged platform produced by using the spherical model with kriging.

Discussion

The results obtained from the comparison of the two interpolation methods analyzed in this study indicated that kriging was the most suitable method for mapping the spatial distribution of depth values at regional scale. The results also revealed that although the inverse distance method has the advantage of relative simplicity and ease of processing, this method is the least accurate, resulting with at least an increase of 18.2% in the error compared with kriging procedures. Other studies have reported similar results (Hernandez-Stefanoni & Ponce-Hernandez 2006, Nalder & Wein 1998, Voltz & Webster 1990), revealing that the estimation is improved when kriging is applied. However this improvement is given only if number of points is large enough to apply this technique and if a careful selection of the models of semi-variograms is undertaken (Kravchenko & Bullock 1999).

It is also important to notice that in addition to the better performance of kriging procedures, the semi-variogram analysis required for kriging interpolation provides interpretative values beyond its role in kriging estimation (Rossi *et al.* 1992). Such information is not produced and made available by using the inverse distance functions. For example, semi-variogram models were able to explain the nature, intensity and extent of the spatial distribution patterns of depth values. They also showed that such values are spatially structured from patches separated between 1.4 and 3.0 decimal degrees, which correspond to the “range of influence” parameter on the semi-variogram.

As a final remark and considering that in many developing countries the accuracy of bathymetric data in digital format are rare, our approach might constitute a suitable option not only to researchers in our region but to others trying to decide the type of interpolation technique and the model to choose when elaborating digital elevation models for regional mapping purposes.

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Geographic and bathymetric distribution of *Americominella duartei* (Neogastropoda: Buccinidae), a bathyal species from the Southwestern Atlantic

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Abstract. The accurate description of the geographic and bathymetric ranges of benthic species is a key issue for macroecological and biogeographical studies. However, it is usual to assume that a species bathymetric range does not vary with latitude. Besides, accurate information on bathymetric and latitudinal ranges is not the rule for South American benthic gastropods, due to several factors. We illustrated this issue by reviewing the existent data and reporting new information on the gastropod *Americominella duartei* Klappenbach & Ureta, 1972 in the Southwestern Atlantic shelf and slope, also providing precise references for its northernmost distribution limit. *A. duartei* is widely distributed along the Southern Atlantic shelf, from 36°51'00" to 54°51'00"S. It is a bathyal species, commonly found at depths between 300 and 400 m, although it can be found in depths ranging from 100 to 1250 m. The bathymetric range of the species increases with latitude, due to a shift of the species to deeper waters tracking the distribution of Subantarctic Waters over the northern portion of the area. Our results shows that the bathymetric ranges of benthic animals should be used with caution when searching for macroecological patterns.

Key words: Gastropoda, Buccinoidea, bathymetric range, macroecology.

Resumen. Distribución geográfica y batimétrica de Americominella duartei (Neogastropoda: Buccinidae), una especie batial del Atlántico Sudoccidental. La descripción precisa de los rangos geográficos y batimétricos de las especies bentónicas es un punto clave para estudios macroecológicos y biogeográficos. Sin embargo, es usual asumir que el rango batimétrico de una especie no varía con la latitud. Además, la existencia de información precisa sobre los rangos batimétricos y latitudinales no es la regla para los gasterópodos bentónicos de Sudamérica, debido a múltiples factores. Se ilustra esta cuestión revisándose los datos existentes y reportando nueva información sobre el gasterópodo *Americominella duartei* Klappenbach & Ureta, 1972 en la plataforma continental y borde de talud del Atlántico Sudoccidental, proveyendo registros precisos para el límite norte de distribución de la especie. *A. duartei* se encuentra ampliamente distribuida a lo largo de la plataforma continental y borde de talud del Atlántico Sudoccidental, desde 36°51'00" a 54°51'00"S. Es una especie batial, comúnmente encontrada en profundidades entre 300 y 400 m, aunque puede ser encontrada en profundidades desde 100 a 1250 m. El rango batimétrico se incrementa con la latitud, debido a un desplazamiento de la especie hacia aguas más profundas siguiendo la distribución de las Aguas Subantárticas en el norte del área. Nuestros resultados muestran que los rangos batimétricos de los animales bentónicos deben ser usados con cautela cuando se utilicen para detectar patrones macroecológicos.

Palabras clave: Gastropoda, Buccinoidea, rangos batimétricos, macroecología.

Introduction

The accurate description of the geographic and bathymetric ranges of benthic species is a key issue for macroecological and biogeographical studies. However, it is usual to assume that a species bathymetric range is geographically fixed, i.e. it does not vary with latitude (e.g. Fortes & Absalão 2004). In addition, precise distributional data are often unavailable for the southwestern Atlantic, due to poor taxonomic expertise and lack of reliable records based of material deposited in zoological collections, as well as the cryptic nature of some information sources (Carranza *et al.* in press; Scarabino 2006). This is often aggravated in molluscan species, where the records based on shells may lead to incorrect distribution and bathymetric ranges (Cantera & Arnaud 1984; Scarabino *et al.* 2006).

To illustrate this issue we reviewed the existent data on the southwestern Atlantic buccinoidean gastropod *Americominella duartei* Klappenbach & Ureta, 1972 (Figure 1). This species has a relatively complex nomenclatural and taxonomical history (see Bouchet & Warén 1986; Dell 1990; Scarabino 2004; see synonymy here presented), being described simultaneously by Castellanos & Fernández (1972a) as *Bathydomus longisetosus*. Later, Kaiser (1977) described the same species again, creating the new genus *Echinosipho*, further contributing to the dispersion of the available information.

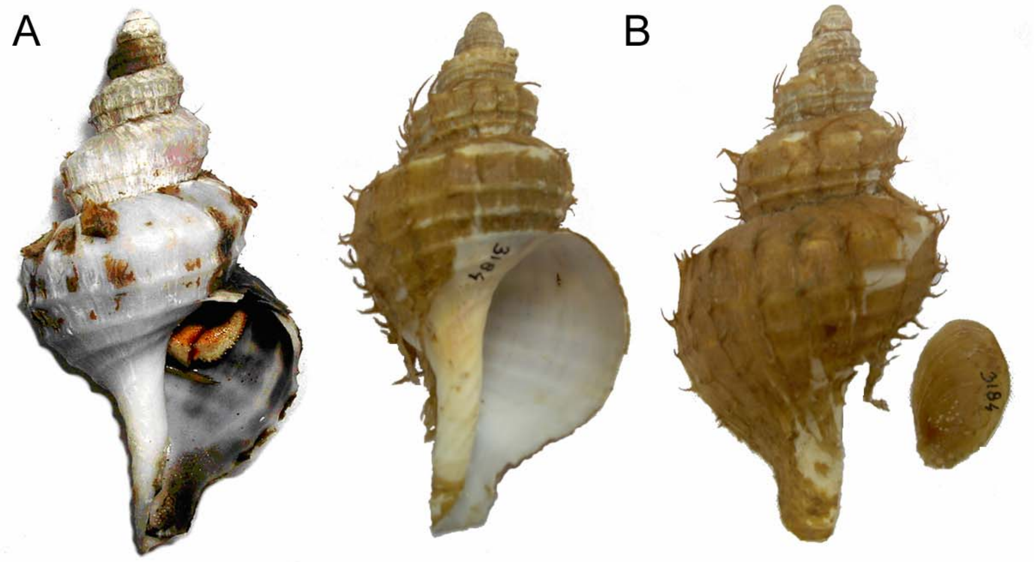

Figure 1. A. *Americominella duartei*, MNHNM 15542, continental slope off Río de la Plata, 610 m, (64 mm length). B. *Americominella duartei*, dorsal and ventral view of the holotype, including the operculum, MNHNM 3184 (78 mm length).

This species was originally described based on material provided by two different sources: Uruguayan fishermen collected the holotype (F/V “Cecilia”; Fig 1B) and one paratype (F/V “Florida”), while the remaining paratypes were obtained by the German research vessel “Walther Herwig” (Klappenbach & Ureta 1972). Castellanos & Fernández (1972a) and Kaiser (1977) based the description of *B. longisetosus* and *E. longisetosus* on material collected by the Walther Herwig campaigns. Part of the type material of *A. duartei* could be suspected as collected at the species northern distribution limit, constituting the only known records from Uruguayan waters, but lacked precise geographic and bathymetric references. This is the case for several species (see the discussion about *Adelomelon barattinii* Klappenbach & Ureta, 1966 in Scarabino 2004, a similar situation), since the bathyal malacofauna off Uruguayan continental shelf has been only scarcely studied. Considering the doubtful status of the northern distribution limit of *A. duartei*, as well as the imprecise shallower record and the dispersion of the existent information, here we reviewed data on the species, summarizing the available information and reporting an accurate distributional range.

Material and Methods

Study area

The geographic area covered in this study corresponds to the continental shelf and slope of the southern portion of South America (36ºS to 55ºS) (Figure 2). Between these latitudes, the wide of the shelf increases from ~200 km at the north to

~600 km at 50ºS. The shelf presents an uneventful topography, gently sloping toward the shelf edge without steep macro-gradients in substrate texture (Bogazzi *et al*. 2005). Most of the area is under the influence of the Malvinas Current (MC) which is part of the northern branch of the Antarctic Circumpolar Current (ACC) (Piola & Gordon, 1989) and Subantartic Waters (SAW). MC flows equatorward along the western edge of the Argentine Basin advecting SAW in the upper 500m (Bianchi *et al*. 1993). The shelf waters result from the mixing of ACC, MC and Patagonian Current (PC) waters and continental runoff, and are modified by water and energy exchange with the atmosphere (Guerrero & Piola 1997). The PC is characterized by low salinity contributed by Southeast Pacific watersand continental waters from Magellan Strait and Fueguian Channels moving northward along the coast (Guerrero & Piola 1997). In addition this area presents steep frontal systems, characterized by pronounced horizontal gradients e.g Argentine shelf-break front, Atlantic Patagonia cold estuarine front (Acha *et al*. 2004).

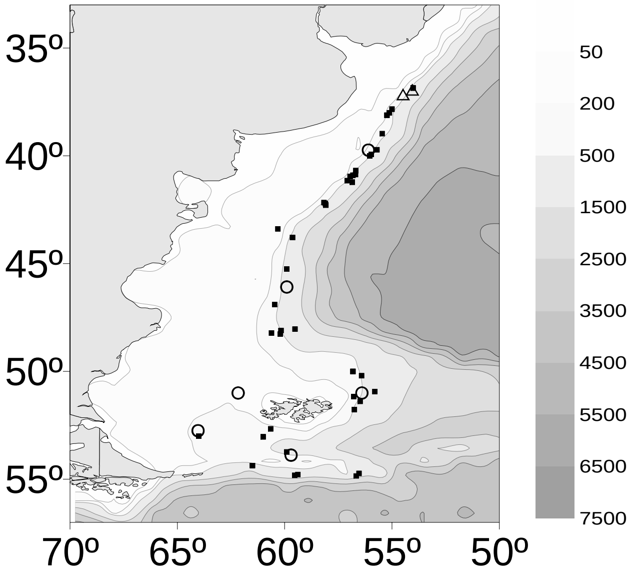

Figure 2. Records of *Americominella duartei.* Material trawled by R/V "Walther Herwig" (■), type specimens of *Bathydomus longisetosus* reported by Castellanos & Fernández (○) and pagurized shells reported in this paper (△) are indicated.

Analyzed material

We examined the holotype and five paratypes of *A. duartei* deposited at Museo Nacional de Historia Natural y Antropología (Montevideo, Uruguay, MNHNM) and checked for additional localities from the type series of *B. longisetosus* and *A. duartei* (Castellanos & Fernández 1972a, Klappenbach & Ureta 1972). In addition, information was gathered from the material deposited at the Zoologisches Museum der Universitaet Hamburg (Germany, ZMUH). This material includes 52 specimens (including holotype and paratypes for *E. aculeatum*), from 44 stations performed during the research surveys conducted in 1966, 1971 and 1978 by the R/V "Walther Herwig" along the Southwestern Atlantic. Additional uncatalogued material was collected during 1975 (one station, RV "Waser") and 1978 (33 stations, RV "Walther Herwig") added to a total of 121 specimens, all with precise bathymetric and geographical data. With these data, the geographical and bathymetric ranges of the species were determined.

Data analysis

Further, we analyzed a) trends associated with the maximum and minimum depth of occurrence along the latitudinal gradient and b) the modal depth for this species. To this end, the observations were grouped in 100 m depth bins and looked at the frequency distribution, in order to determine the depth category that comprised the higher number of observations. Depth distribution of the species in relation with latitude was assessed in terms of the minimum and maximum depth from which the species has been reported, with data grouped in 1º latitude bins. Relationships between maximum and minimum depth of occurrence within each category (dependent variable) and latitude bins (independent variable) were assessed by means of simple linear regression.

Results

Systematics

Class Gastropoda Cuvier, 1791
Subclass Ortogastropoda Ponder & Lindberg, 1996
Superorder Caenogastropoda Cox, 1959
Order Sorbeoconcha Ponder and Lindberg, 1996
Infraorder Neogastropoda Wenz, 1938
Family Buccinidae Rafinesque, 1815[1]
Genus *Americominella* Klappenbach & Ureta, 1972

Americominella duartei Klappenbach & Ureta, 1972

Americominella duartei Klappenbach & Ureta, 1972: 2, figs. 1-2; pl. 1, figs. 1-2, Castellanos & Fernández 1972b: 111, Testud 1973: 222, Figueiras & Sicardi 1973: 178, pl. 12, fig. 175; 1980: 214, Bouchet & Warén 1986, Dell 1990: 199, Scarabino 2004: 318.

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[1] We follow Bouchet & Rocroi (2005); Harasewych & Kantor (2004) placed most Subantarctic buccinodeans in Buccinulidae Finlay, 1926.

Bathydomus longisetosus Castellanos & Fernández 1972a, b: 111, figs. 1-3, Figueiras & Sicardi 1973: 178, 1980: 214, Dell 1990: 199, Scarabino 2004: 318.

Echinosipho aculeatum Kaiser 1977: 28, figs. 1-2, pl. 4, Figueiras & Sicardi 1980: 214, Bouchet & Warén 1986; 481-482, pl. 2, fig. 10; pl. 5, fig. 27; pl. 15, fig. 97-99, Dell 1990: 199, Scarabino 2004: 318.

Distribution

The holotype (live collected) and one paratype (pagurized shell) were referred as collected off Río de la Plata, SE of Isla de Lobos. The geographic distribution of the specimens collected by the R/V "Walther Herwig" and "Waser" ranged from 36°51'00"S, 54°01'00"W to 54°51'00"S, 56°40'00"W. One additional reference (Testud 1973: 222) reported the species for the "Calypso" station 171: 37º36'S-54º46'W in 740 m.

Concerning the bathymetric distribution, it ranged from 100 to 1250 m depth. The modal depth was detected in the 300-400 m depth interval (Figure 3). Maximum depth of occurrence was not correlated with latitude ($R^2 = 0.01$; $p > 0.05$), but a latitudinal effect on minimum depth was detected ($R^2 = 0.35$; $p < 0.05$). Shallower occurrences of this species are noticed as latitude increased (Figure 3).

Discussion

Americominella duartei is widely distributed along the Southern Atlantic shelf and slope, from 36°51'00" to 54°51'00"S. It is a bathyal species, commonly found at depths between 300 and 400m, although it can be found in depths ranging from 100 to 1250m. We considered the location reported for the holotype an imprecise geographic reference. The shallower record of the species mentioned in the original description (100m) seems to be assumed by the authors, since this datum is absent from the list of examined material. Considering that this material was collected by fishermen and that all the information compiled from literature and collections indicates that *A. duartei* occupies only the bathyal zone in its northern limit, we consider this depth as incorrect. This is at least the case for the living specimen (holotype). One additional pagurized shell measuring 64 mm shell length and collected at 36º 56'S, 54º 03'W in 610 m deep (MNHNM 15542), during a trap survey onboard a fishing vessel, Fig. 1A targeting the deep-sea red crab *Chaceon notialis* during 2006 conserved portions of its periostracum, providing some confidence about the presence of the species at the zone.

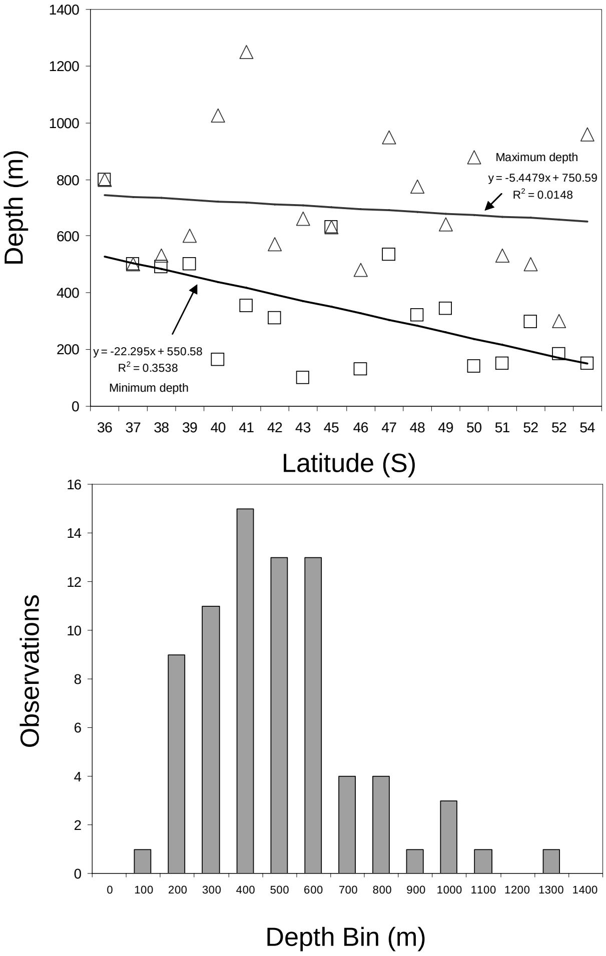

Figure 3. Relationships between minimum (open squares) and maximum (open triangles) observed depth in relation with latitude one-degree bins (a regression for each line is shown) and number of observations within 100m depth bins all along the latitudinal gradient.

However, two pagurized shells were collected in November 2004, during an onboard research in a 70 m length commercial fishing vessel targeting hake (*Merluccius hubbsi)* at 37º09'S, 54º09'W, in a depth between 145 and 148 m (MNHNM 15543). This indicates that some shells may be present at or transported to shallower waters. In conclusion, and based in data from Kaiser (1977), the northern limit of its distribution should correspond to 36°51'00"S (paratypes for *E. aculeatum*, ZMUH 1051).

The bathymetric range of the species increased with latitude, due to a positive correlation between minimum depth of occurrence and latitude. The prevalence of SAW over the shelf south of 37ºS at depths greater than 200 m, supports the idea that *A. duartei* may be considered a typical member of the SAW fauna. In addition, the progressively narrowing of it occurrence northward along the outer margin of the shelf reinforces that hypothesis. Since the Subantarctic benthic fauna is strongly associated with SAW, there is a negative correlation between the minimum depth of occurrence and latitude, with the shallower records of this species (i. e < 200 m) occurring below 39ºS. Thus, the bathymetric range of the species increased with latitude, due to a positive correlation between minimum depth of occurrence and latitude. Most likely, this may be due to a distributional response to water temperature (i.e. submergence, see Weinberg 2005), as already reported by Carcelles (1944) and discussed by Olivier & Scarabino (1972) and Schrödl (1999) for inner shelf benthic invertebrates of Patagonia that occupies much deeper zones off the Río de la Plata.

The extension and placement of the bathymetric range of *A. duartei* is similar to related species such as *Chlanidota, Pfefferia, Parabuccinum* and *Neobuccinum* (Harasewych & Kantor 2004). This generic diversity is closely related to species richness, since the monotypic condition of *Americominella* seems to be common in Antarctic and Magellanic buccinoidean gastropods, for which a high proportion (48.3%) of monotypic genera was reported (Harasewych & Kantor 2004). These findings remark the need for the performance of exploratory studies with adequate sampling methods in the continental slope and abyssal plain off South America, to increase the knowledge on deep sea biodiversity at the region.

In summary, we showed that the bathymetric and latitudinal range of a bathyal, previously poorly known, and taxonomically complex species can be reconstructed with certain accuracy using data stored in museum specimens. Further, our results suggest that the bathymetric ranges of benthic animals should be used with caution in macroecological studies, because they may lead to a blurred picture of bathymetric patterns in species richness.

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Chthonerpeton viviparum Parker & Wettstein, 1929 (Amphibia, Gymnophiona, Typhlonectinae) in Paraná state, Brazil and the first record of predation of this species by *Hoplias malabaricus* (Bloch, 1794) (Actinopterygii, Erythrinidae)

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Abstract. The present paper reports the first occurrence of *Chthonerpeton viviparum* in Paraná State (Brazil) and its predation by *Hoplias malabaricus.*

Key words: Fish, amphibian, diet, river, Atlantic rain forest.

Resumo. *Chthonerpeton viviparum* Parker & Wettstein, 1929 (Amphibia, Gymnophiona, Typhlonectinae) no estado do Paraná, Brasil e o primeiro registro de predação desta espécie por *Hoplias malabaricus* (Bloch, 1794) (Actinopterygii, Erythrinidae). O presente artigo reporta a primeira ocorrência de *Chthonerpeton viviparum* no Estado do Paraná (Brasil) e a predação desta espécie por *Hoplias malabaricus.*

Palavras-chave: Peixe, anfíbio, dieta, rio, floresta Atlântica.

Caecilians are cryptic vertebrates whose biology is poorly known. It is alarming considering that the group occurs mostly in tropical regions where the deforestation advances at fast rates, including the Atlantic Rain Forest that is one of the richest and most threatened ecosystems of the planet (Myers *et al.* 2000). The majority of species of this group has been considered as data deficient (*sensu* IUCN 2006) despite some progress toward conservation strategies (Gower & Wilkinson 2005). The subfamily Typhlonectinae is aquatic and some species of *Chthonerpeton* have been found buried in the mud (Gudynas *et al.* 1988). Fishes are considered major components of tropical rivers food webs, and tropical fishes demonstrated great trophic variation at all levels (Winemiller & Jepsen 1998). On 30 March 2006, during a study on the feeding ecology of *Hoplias malabaricus* (Bloch, 1794) we retrieved a well-preserved *Chthonerpeton viviparum* Parker & Wettstein, 1929 (Amphibia, Gymnophiona, Typhlonectinae) specimen from the stomach of an adult specimen of *H. malabaricus*, captured at Guaraguaçu river basin (25°42'08,4"S; 48°31'58"W), Atlantic Rain Forest, sub-basin of Paranaguá bay, Paranaguá city, Paraná state, southern Brazil. This species of fish is known to be a top predator that feeds mainly on fishes that become the principal prey for *H. malabaricus* when its predator ranges 200 mm standard length (Bistoni *et al.* 1995). The consumed caecilian was deposited in the Zoology Museum of São Paulo's University (MZUSP, A-138293) and measured approximately 500 mm in total length and had a mass of approximately 30 g, whereas the predator measured 365.0 mm TL and had a total mass of 600 g. *Chthonerpeton viviparum* occurs in the vicinity of Joinville in eastern Santa Catarina state (Frost 2007) and our record represents the first occurrence of this species for Paraná state.

Figure 1. Specimen of *Chthonerpeton viviparum* found in a stomach content of *Hoplias malabaricus* at Guaraguaçu river basin, Paraná state, Brazil.

Figure 2. Specimen of *Hoplias malabaricus* that predated *Chthonerpeton viviparum*.

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Variações entre contagens de *Arapaima gigas* (Schinz) (Osteoglossomorpha, Osteoglossidae) feitas por pescadores individualmente em Mamirauá, Brasil

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Abstract. Variation among counts of *Arapaima gigas* (Schinz) (Osteoglossomorpha, Osteoglossidae) made by fishers individually in Mamirauá, Brazil. Censusing of pirarucu (*Arapaima gigas*) is being increasingly used in conservation initiatives throughout the Amazon, and is done essentially by counting the individuals at the moment they come out of the water to breathe air. This 'counting method' was developed recently based on analyses of counts of pirarucu made by groups of knowledgeable and skillful fishers. But fishers vary with respect to their knowledge and skills, and the accuracy of their counts of pirarucu. In this study, we evaluated the accuracy of the counts of pirarucu made by 34 individual fishers; we compared their censuses of pirarucu in four lakes with captures of all pirarucu in the same lakes. We found that not all fishers censused the pirarucu populations accurately. Seventy-five percent of the fishers under- or over-estimated the abundance of pirarucu in the lakes up to thirty percent. The individual tendencies of the fishers were minimized when their counts were considered in groups, which is the main way fishers census pirarucu populations. The groups of fishers under- or overestimated the abundance of pirarucu in the lakes by about ten percent. These results highlight the need to pay attention to the individual ability of fishers to census pirarucu populations in the many management and conservation schemes that currently are censusing pirarucu populations.

Key words: Community-Based management, censusing of pirarucu, validation.

Resumo. Os censos das populações de pirarucu (*Arapaima gigas*) estão sendo utilizados em diversas iniciativas de conservação da espécie na Amazônia. Tais censos populacionais são feitos mediante as contagens dos indivíduos no momento em que eles vêm à superfície da água para respirar. Este 'método de contagem' foi desenvolvido com base nas análises das contagens de pirarucus feitas em grupos de pescadores habilidosos. No entanto tal habilidade e a acurácia das contagens de pirarucu podem variar entre pescadores. Assim, este estudo avalia a acurácia das contagens de pirarucu feitas por 34 pescadores de forma individual. Para isso, comparamos as contagens realizadas pelos pescadores em quatro lagos fechados na região de Mamirauá com as capturas de todos os pirarucus nos mesmos lagos. Nem todos os pescadores realizam censos acuradamente. Setenta e cinco por cento dos pescadores sub ou sobrestimaram a abundância de pirarucus nos lagos em até trinta por cento. As tendências individuais dos pescadores minimizaram-se quando suas contagens foram consideradas em grupos. Essa é a principal forma de realizar os censos de pirarucu. Os grupos de pescadores sub ou sobrestimaram a abundância de pirarucus nos lagos em média de dez por cento. Esses resultados demonstram a importância de avaliar a habilidade individual nos diversos sistemas de manejo e conservação que atualmente fazem censos das populações de pirarucu.

Palavras-clave: Manejo comunitário, censos de pirarucu, validação.

Introdução

O pirarucu (*Arapaima gigas* (Schinz, 1822)) é um peixe de grande importância econômica e social na Amazônia brasileira. Apesar dos esforços das instituições regulamentadoras, seus estoques continuam sendo explorados de forma desordenada. Em 1989, o órgão ambiental brasileiro responsável, qual seja o Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA), determinou o tamanho mínimo de captura (1,5 metro de comprimento total) e, em 1990, implementou o período de "defeso" reprodutivo (de 1º de dezembro a 31 de maio). Mas a fiscalização feita pelo mesmo órgão tem sido insuficiente para garantir o cumprimento das regras adotadas.

Mais recentemente, em 1996, o IBAMA do Estado do Amazonas proibiu a pesca do pirarucu, com exceção das áreas de pesca manejada e produção em cativeiro. Apesar dessas medidas, a pesca continua sendo feita predominantemente de forma ilegal.

Consequentemente, atualmente os estoques do pirarucu são considerados sobrexplorados na maior parte da bacia Amazônica e, economicamente, extintos em algumas de suas regiões (Isaac *et al.* 1993, 1998, Goulding *et al.* 1996, Queiroz & Sardinha 1999).

Em 1999, uma pesquisa desenvolvida na Reserva de Desenvolvimento Sustentável Mamirauá (RDSM) mostrou que pescadores experientes são capazes de estimar a abundância de pirarucus pelas contagens que são feitas no momento da respiração aérea da espécie (Castello 2004). A conclusão de que os pescadores são capazes de contar pirarucus de modo eficaz baseou-se na habilidade de 20 pescadores, a partir da avaliação das contagens feitas em grupo. Essa pesquisa também mostrou que o método utilizado para contar o pirarucu pode ser ensinado por um pescador treinado para outros, desde que todos os envolvidos sejam experientes na pescaria desse peixe.

Essa aptidão dos pescadores foi incorporada em um modelo experimental de manejo comunitário do pirarucu em comunidades da RDSM. Tal modelo baseia-se em contagens anuais dos pirarucus realizadas pelos próprios pescadores e no estabelecimento de cotas de pesca. Esse processo de manejo comunitário envolve o IBAMA, o Instituto Mamirauá e os pescadores. Estes últimos se comprometem a respeitar as normas de tamanho mínimo de captura, o "defeso" reprodutivo e as cotas de pesca. Em oito anos de experimentação, esse modelo mostrou-se efetivo na conservação do pirarucu, pois sua população vem se recuperando. Por exemplo, na área onde o manejo foi implementado, em 1999, a população de pirarucu foi estimada em cerca de 2.500 indivíduos e em 2006, nesta mesma área, em cerca de 21.000 (Arantes *et al.* 2007, Viana *et al.* 2007).

Atualmente, o número de comunidades utilizando esse modelo de manejo expandiu de 4, em 1999, para mais de 100 comunidades em 2006, envolvendo mais de 500 pescadores. Além disso, o Governo do Estado do Amazonas incorporou as contagens de pirarucu como requerimento obrigatório para o manejo legal deste recurso.

Dada a importância das contagens para o sistema de manejo do pirarucu apresentado acima, e dado o grande aumento de comunidades manejando o pirarucu dessa forma, este estudo pretende contribuir para o entendimento das contagens de pirarucu feitas por pescadores. Castello (2004) investigou as contagens de pirarucu feitas por grupos de pescadores e teve apenas duas oportunidades para avaliar a acurácia das contagens feitas por pescadores individualmente. Em tais situações, Castello (2004) encontrou pequena variação entre as contagens de vários pescadores (18%). Mas nem todos os pescadores mostram habilidades semelhantes, especialmente quando eles possuem diferentes níveis de experiência com a pesca do pirarucu. Isso pode afetar a acurácia das contagens de pirarucu e, conseqüentemente, a efetividade do manejo da espécie. Assim, o presente estudo avalia a acurácia das contagens de pirarucus feitas por pescadores individualmente.

Material e Métodos

A base deste estudo é a comparação das contagens de pirarucu feitas por pescadores individualmente com a abundância determinada a partir da captura de todos os pirarucus nos mesmos lagos contados. As atividades de campo foram realizadas entre 26 de setembro e 2 de outubro de 2005 na Reserva Mamirauá, localizada na confluência dos rios Solimões e Japurá, na Amazônia brasileira (3.83491° S e 66.06713° W). As contagens de pirarucu foram feitas por 34 pescadores, dos quais 30 são provenientes de áreas que já realizavam seu manejo nas Reservas Mamirauá e Amanã (8 do Jarauá, 7 do Tijuaca, 7 do Coraci e 8 do município de Maraã) e outros 4 provenientes de áreas que pretendem implementar o manejo da espécie (2 da região do lago Amanã e 2 do município de Silves, no Estado do Amazonas).

Os lagos foram selecionados com base nos seguintes critérios: ausência de galhos, pouca vegetação, isolamento físico, área reduzida (estas variaram de 0,64 a 4,65 ha) e distintas densidades populacionais de pirarucus. Esses critérios possibilitaram que os pescadores contassem individualmente os pirarucu que neles habitavam e também que todos os pirarucus dos lagos fossem capturados com redes de arrasto. Lagos grandes ou com galhos dificultam ou impedem o arrasto dos pirarucus.

Os procedimentos seguidos para as contagens de pirarucu são aqueles descritos por Castello (2004). Os pescadores dividiram cada lago a critério individual em áreas de distintos tamanhos (porém atingindo no máximo 2 ha.) com base no grau de dificuldade percebido para observar e escutar a "boiada" do pirarucu (i.e., quando aparecem na superfície para respirar). Cada pescador contou o número de pirarucus em uma unidade de área durante o intervalo de 20 minutos. Finalizada a contagem em uma área, o mesmo pescador deslocou-se para outra unidade, onde também contou os pirarucus, e assim por diante até completar toda a área do lago. Dessa forma, as contagens de pirarucu somadas por lago produziram censos populacionais. Ressaltamos aqui que o termo 'contagem' refere-se à contagem de pirarucu realizada pelo pescador em apenas uma unidade (de no máximo 2 ha), e que o termo 'censo' refere-se às contagens de pirarucu nas quais o pescador cobriu toda a área do lago. Foram contados somente os pirarucus maiores de 1 metro e, em seguida, fez-se a classificação em categorias juvenis (1–1,5 metro de comprimento total) e adultos (>1,5 metro de comprimento total) proposta por Castello (2004). Para assegurar a acurácia das contagens, e evitar que o comportamento do pirarucu fosse afetado, os pescadores fizeram as contagens da forma mais silenciosa possível. As contagens não foram realizadas sob condições de ventos e de chuvas, as quais reduzem a visibilidade e a audição dos pescadores.

Foi inicialmente planejado que cada pescador faria 5 censos de cada lago. No entanto, o grande número de pescadores (34) implicaria em um alto número de censos por lago aumentando assim a possibilidade de os pirarucus ficarem "espantados" ou "ariscos" conforme os pescadores afirmam. Isso, então, poderia afetar os resultados comprometendo os censos acurados do pirarucu. Castello (2004) relata ter enfrentado tal problema amostral. Assim, decidiu-se que cada pescador faria apenas um censo em cada lago.

Após todos os pescadores terem realizado os censos foram feitos arrastos em toda a área dos lagos de forma a capturar todos os pirarucus maiores de 1 metro de comprimento. Para isso, duas redes foram utilizadas: uma medindo 140m x 14m, 19 cm entre nós opostos esticados**,** e a outra, 140m x 6m, 16cm entre nós opostos. Os pirarucus foram medidos desde a extremidade do lábio inferior até a parte terminal da nadadeira caudal, e imediatamente liberados. Assegurou-se que todos os pirarucus dos lagos fossem capturados. Isso foi possível porque além de estes lagos estarem dentro dos critérios já citados, após a realização dos arrastos, os pescadores fizeram uma inspeção minuciosa desses ambientes. Para isso, os pescadores observavam e escutavam atentamente se ainda havia pirarucus "boiando" no lago durante cerca de 20 minutos. Usaremos o termo captura para nos referir ao total de pirarucus capturados em cada lago.

Análise de dados

Para avaliar a acurácia dos censos populacionais de pirarucus, consideraram-se os dados de três formas distintas: (1) os 34 pescadores em conjunto; (2) cada pescador individualmente; e (3) grupo de pescadores por regiões de manejo – Jarauá, Tijuaca, Coraci e Maraã. Para comparar os censos com as densidades de pirarucus, determinaram-se medidas de dispersão e centralidade dos censos nos casos (1) e (3). Antes de definir estas medidas verificou-se se os censos apresentam normalidade na sua distribuição por meio do teste Lilliefors (Ayres 2003). A acurácia dos censos populacionais (casos 1, 2 e 3) foi avaliada em análises de regressão simples (Vieira 1994). Para isso, consideraram-se as densidades populacionais, já que elas interferem no grau de dificuldade para as contagens serem feitas em situações de alta densidade populacional. A acurácia dos censos foi avaliada conforme os coeficientes de correlação (r) e de regressão (b).

Resultados

Os resultados mais importantes deste estudo foram os seguintes: 1) Os censos individuais da maioria dos pescadores (75%) apresentaram erros percentuais inferiores a 30%. 2) Os censos feitos pelos grupos de pescadores apresentaram erros percentuais de 2 a 20%, dependendo da região de manejo. 3) As contagens individuais apontam tendências de sub ou sobrestimação, porém estas foram minimizadas quando avaliadas em grupo.

(1) Censos de pirarucu do grupo total de pescadores

Os censos de pirarucus feitos pelos pescadores seguiram uma distribuição normal ($p < 0,005$). Esses censos variaram bastante, com coeficientes de variação entre 35 a 58 % dependendo do lago (Tabela I). Todos esses censos foram

Tabela I. Estatística descritiva dos censos populacionais de pirarucus maiores de 1 m realizados por todos os pescadores nos lagos e respectivas densidades de pirarucus.

Lago	Média das contagens	Capturas	Coeficientes de variação dos censos (%)	Erro (%) das contagens
Tucunarezinho	18,3	14	44,2	30,4
Poço	64,2	67	35,0	4,2
Redondo	10,9	10	38,2	8,5
Urucuraninha II	9,4	14	57,7	33,2
Somatório	102,7	105		2,2

aproximados às capturas de pirarucus, apresentando diferenças menores de 10% nos lagos Poço e Redondo, e pouco maiores de 30% nos lagos Tucunarezinho e Urucurana II. No entanto, quando comparadas a soma dos censos em todos os lagos e a soma das densidades de pirarucu, apenas observou-se diferença de 2%.

Os censos de pirarucus de todos os pescadores foram fortemente relacionados com as respectivas capturas (Figura 1). O coeficiente de regressão (b) mostra que houve uma leve tendência de os pescadores subestimarem o número de juvenis e adultos (b < 1) (Figura 1).

(2) Censos individuais de pirarucus

Os censos individuais de pirarucus (i.e., realizados individualmente pelo pescador) e as capturas apresentaram-se fortemente relacionados. Os coeficientes de correlação das relações entre os censos e as capturas de pirarucus foram maiores que 0, 98 (Tabela II).

A maioria dos pescadores, cerca de 56%, tenderam a subestimar o número total de pirarucus (b <1). Os coeficientes de regressão (b) das equações apresentaram-se entre 0,70 e 1,30 para a maioria dos pescadores (74%) (Tabela II).

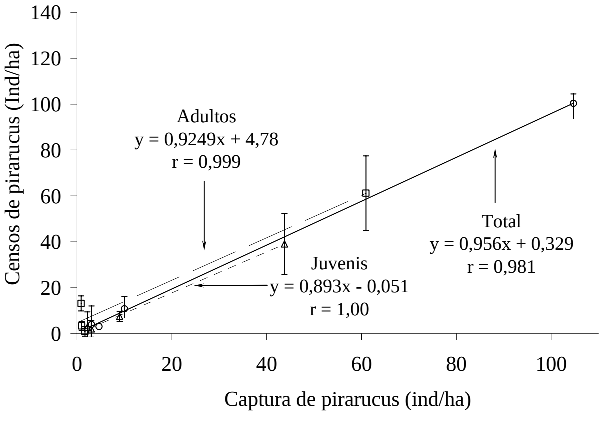

Figura 1. Regressões lineares entre a média dos censos de pirarucus realizados pelo conjunto dos pescadores e as capturas de pirarucus nos quatro lagos avaliados (ind/ha = indivíduos por hectare) (n = 4).

As avaliações destes coeficientes a partir da distinção das categorias de pirarucus (juvenis e adultos) indicaram que 71% dos pescadores subestimaram o número de juvenis e 56% subestimaram o número de adultos (Tabela II).

(3) Censos de pirarucus dos grupos de pescadores por regiões de manejo

Os censos de pirarucus dos grupos de pescadores por regiões de manejo e as capturas em cada lago foram fortemente relacionados (Figura 2 a, b, c e d).

Pescadores do Jarauá e Tijuaca tenderam a sobreestimar levemente a densidade de pirarucus e os pescadores do Coraci e do Maraã tenderam a subestimar esta densidade (Figura 2; Tabela III).

Discussão

Os resultados mostram que os pescadores possuem habilidades distintas para contar os pirarucus e a maioria (75%) conta estes peixes de maneira relativamente acurada (Tabela II). Os censos feitos individualmente apontaram tendências de sub ou sobrestimação. Porém estas tendências foram minimizadas ou parcialmente canceladas quando avaliadas em grupo. Cinqüenta e seis por cento dos pescadores tenderam a subestimar e 44% deles tenderam a sobrestimar a abundância de pirarucu. Dessa forma, as tendências se anularam, tornando os censos dos grupos do total de pescadores e das regiões de manejo acurados. Esses resultados corroboraram os encontrados por Castello (2004) quando avaliou os censos feitos em grupos.

Os censos de pirarucus nas categorias de juvenis (entre 1 e 1.5 m.) e adultos (maiores de 1.5 m.) variaram quanto à acurácia dependendo dos casos apresentados (1, 2 e 3). Para os grupos de pescadores, há evidência de que tais censos são relativamente acurados (Figuras 3; Tabela III). Porém, os censos feitos pelos pescadores individualmente indicam que a maioria (64%) realizou censos de juvenis ou adultos com percentuais de erros superiores a 30% em pelo menos uma das duas categorias. A menor acurácia

Tabela II. Coeficientes de regressão (b), de correlação (r), e (a) intercepto das relações lineares dos censos individuais de pirarucus realizados pelos pescadores nos quatro lagos avaliados e as devidas densidades de pirarucus nos mesmos (n = 4).

Pescador	**Origem**	**Juvenis**			**Adultos**			**Total**		
		b	a	r	b	a	r	b	a	r
1	Amanã	0,804	0,900	0,996	0,499	0,818	0,996	0,622	0,566	0,997
2	Amanã	0,626	0,925	0,998	0,934	0,860	0,998	0,815	0,873	0,999
3	Coraci	0,634	0,362	0,999	0,964	0,638	0,999	0,834	0,194	0,999
4	Coraci	1,176	0,045	0,997	0,827	0,387	0,999	0,966	0,459	0,999
5	Coraci	0,559	0,626	0,999	1,159	0,335	0,999	0,920	1,095	0,999
6	Coraci	0,713	0,399	0,994	1,596	0,551	0,999	1,245	2,179	0,999
7	Coraci	0,437	0,452	0,998	0,766	0,206	0,999	0,637	1,058	0,999
8	Coraci	0,331	3,123	0,952	1,031	1,219	0,999	0,750	2,809	0,998
9	Coraci	0,772	0,790	0,998	0,945	0,253	0,999	0,875	0,670	0,999
10	Jarauá	0,693	0,900	0,999	0,942	0,369	0,999	0,845	0,640	0,999
11	Jarauá	1,038	0,453	0,998	0,482	0,284	0,995	0,707	1,012	0,999
12	Jarauá	1,491	3,264	0,996	0,813	1,968	0,997	1,090	0,038	0,998
13	Jarauá	0,429	1,602	0,987	1,605	0,934	0,999	1,137	2,056	0,998
14	Jarauá	0,769	0,920	0,998	1,988	0,826	0,999	1,504	2,744	1,000
15	Jarauá	0,703	2,253	0,996	1,571	1,104	0,999	1,227	1,331	0,999
16	Jarauá	0,702	0,837	0,996	0,899	0,097	0,999	0,819	0,321	0,999
17	Jarauá	0,658	0,553	0,999	1,488	0,091	0,999	1,159	2,595	0,999
18	Maraã	0,950	0,719	0,998	1,071	0,327	0,999	1,024	0,747	0,999
19	Maraã	0,465	1,838	0,989	0,924	1,500	0,997	0,741	2,279	0,997
20	Maraã	0,781	1,513	0,997	0,709	0,530	0,999	0,741	2,129	0,999
21	Maraã	0,435	1,519	0,992	0,458	1,752	0,994	0,449	3,231	0,994
22	Maraã	0,612	1,487	0,996	0,658	3,629	0,985	0,643	4,919	0,991
23	Maraã	0,945	1,235	0,992	1,393	1,021	0,999	1,222	1,459	0,999
24	Maraã	1,241	1,316	0,999	1,277	1,826	0,997	1,268	0,285	0,999
25	Maraã	0,793	0,423	0,999	1,178	0,092	0,999	1,027	1,303	0,999
26	Silves	0,845	0,414	0,998	0,193	2,281	0,993	0,454	4,155	0,997
27	Silves	0,255	1,789	0,912	0,421	0,911	0,995	0,352	2,382	0,984
28	Tijuaca	2,108	3,839	0,997	0,406	1,813	0,998	1,089	1,719	0,999
29	Tijuaca	2,551	6,397	0,995	1,368	0,543	0,999	1,141	1,540	0,999
30	Tijuaca	1,140	2,111	0,986	0,561	0,137	0,999	0,797	0,751	0,998
31	Tijuaca	1,108	0,877	0,982	0,575	0,905	0,998	0,793	1,071	0,997
32	Tijuaca	1,719	0,527	0,999	1,269	2,353	0,998	1,453	2,731	0,999
33	Tijuaca	1,473	1,024	0,995	1,317	0,959	0,999	1,386	0,080	0,999
34	Tijuaca	0,369	2,996	0,949	1,468	0,397	0,999	1,029	0,094	0,999

dos censos quando se consideram as classes de tamanho pode se dever ao fato de que cerca de 50% dos pirarucus dos lagos mediam entre 1.30 a 1.60 m. de comprimento total (como foi evidenciado pelas capturas). Tal fato pode ter aumentado a dificuldade para os pescadores determinarem se os indivíduos eram maiores ou menores que 1.50 m. Os resultados encontrados por Castello (2004) também indicaram que as contagens distinguindo-se entre as classes de tamanho pareciam menos acuradas. Concluímos, assim, que as contagens dos pirarucus maiores de 1 m de comprimento (ou seja, sem distinção das categorias) são mais acuradas que as contagens de juvenis e adultos, provavelmente devido à dificuldade de se distinguir entre as classes de tamanho. Isso tem importantes implicações para o sistema de manejo do pirarucu realizado na Reserva Mamirauá, onde as cotas de pesca são determinadas conforme as contagens dos adultos. Nesse sistema torna-se necessário avaliar a acurácia das contagens de pirarucu (juvenil e adulto) feitas pelos pescadores e considerar com cautela os possíveis erros nessas contagens para a determinação das cotas de pesca.

Este estudo mostrou que nem todos os pescadores realizam censos acuradamente. Por isso, os sistemas de manejo que utilizam as contagens devem necessariamente considerar as tendências

Tabela III. Médias e erros percentuais dos censos populacionais de pirarucus maiores de 1 m realizados pelos pescadores das regiões de manejo nos lagos.

Lago	Jarauá			Tijuaca		
	Média dos censos	Capturas	Erro (%)	Média dos censos	Capturas	Erros (%)
Tucunarezinho	17,3	14	23,2	26,6	14	89,8
Poço	70,8	67	5,6	80,4	67	20,0
Redondo	10,9	10	8,8	11,3	10	12,9
Urucurana II	9,5	14	32,1	8,1	14	41,8
Somatório	108,0	105	2,9	126,4	105	20,4

Lago	Coraci			Maraã		
	Média dos censos	Capturas	Erro (%)	Média dos censos	Capturas	Erros (%)
Tucunarezinho	11,1	14	20,4	20,4	14	45,5
Poço	59,6	67	11,1	60,4	67	9,9
Redondo	9,4	10	5,7	12,1	10	21,3
Urucurana II	11,6	14	17,3	10,0	14	28,6
Somatório	91,7	105	12,7	102,9	105	2,0

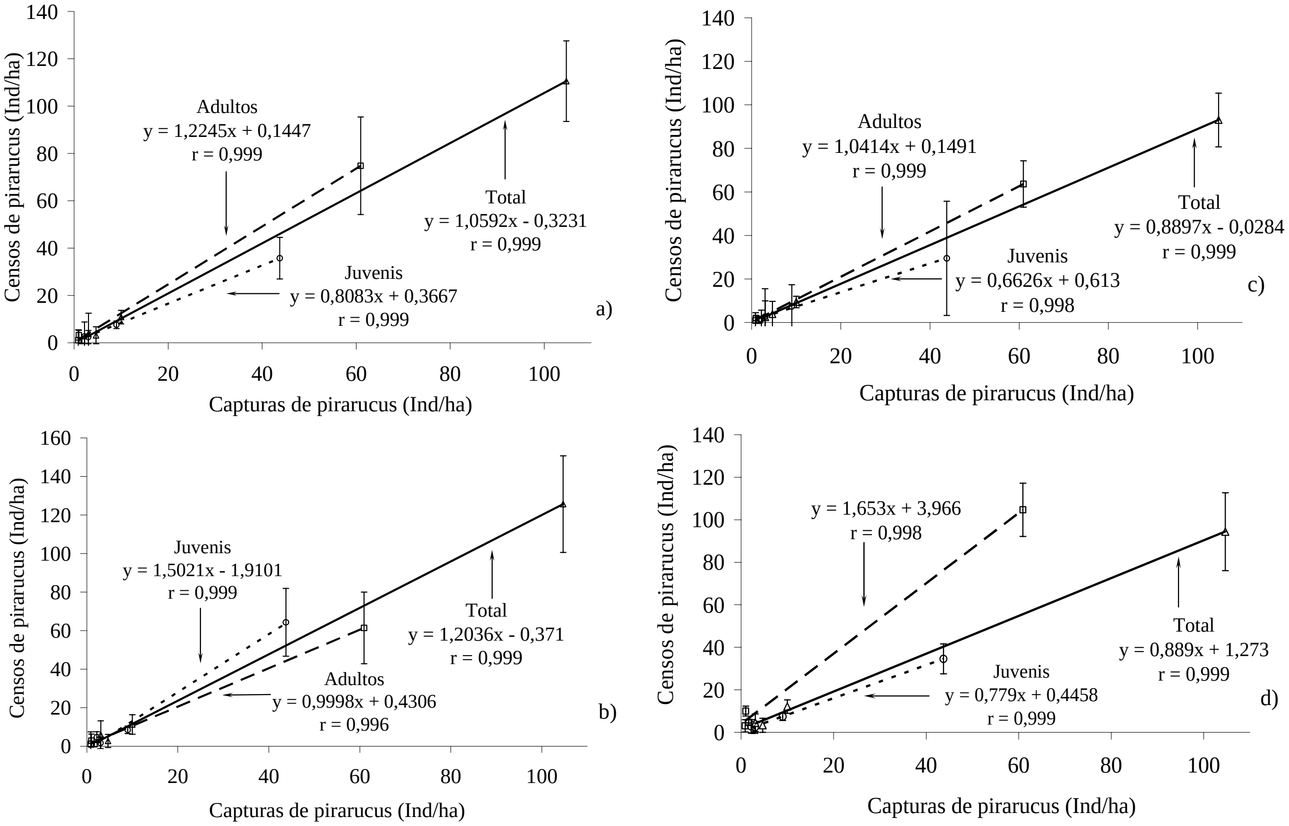

Figura 2. Regressões lineares entre as médias (com Coeficientes de Variação) dos censos de pirarucus realizados pelos pescadores das regiões de manejo das Reservas de Desenvolvimento Sustentável Mamirauá e Amanã (Jarauá, Tijuaca, Coraci, Maraã) e a densidade de pirarucus nos quatro lagos avaliados (ind/ha = indivíduos por hectare). (a) Jarauá, b) Tijuaca, c) Coraci, d) Maraã) (n = 4).

individuais das contagens de pirarucu dos pescadores que as fazem. Sugerimos que essas contagens realizadas pelos pescadores das regiões de manejo das Reservas Mamirauá e Amanã sejam consideradas como censos populacionais desde que sejam feitas pelos mesmos pescadores em grupos. Isso porque as contagens desses grupos foram fortemente correlacionadas com a abundância de pirarucu nos mesmos lagos (Figura 2), embora houvesse variações da acurácia quando analisamos as contagens realizadas pelos pescadores individualmente (Tabela II). Por isso, também é importante que as contagens sejam feitas em grupos e não individualmente.

Em diversas regiões da Amazônia, existem muitos outros pescadores que atualmente estão contando pirarucu para explorá-lo. No entanto, muitas vezes os métodos utilizados são uma adaptação do método descrito e ainda não foram validados. Além disso, não há informação sobre a capacidade de tais pescadores produzirem contagens acuradas das populações de pirarucu. Isso representa um perigo para a espécie. O método de validação apresentado aqui, em que se usam redes de arrasto para capturar todos os pirarucus de lagos pequenos, representa um modo simples para avaliar as contagens de pirarucu de outros pescadores da Amazônia.

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Study of Monstrilloida distribution (Crustacea, Copepoda) in the Southwest Atlantic

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Abstract. The Monstrilloida is one of the least known orders of planktonic Copepoda. Taxonomic and ecological work on the group has been limited by the rarity of specimens, which occur in plankton only as adults. The material examined was collected during zooplankton surveys in neritic and oceanic areas off the coast of Brazil. Sampling was carried out between April 1984 and October 1999. Data from collections made off the coast of Argentina were also analysed. Fifteen monstrilloid species: *Monstrilla brasiliensis*, *M. grandis*, *M. helgolandica*, *M. rugosa*, *M. careli*, *M. pustulata*, *M. satchmoi*, *M. bahiana*, *Cymbasoma* cf. *longispinosum*, *C. quadridens*, *C.* cf. *rigidum*, *C. rochai*, *C. gracilis*, *Monstrillopsis dubia* and *M. fosshageni* are reported herein for the Southwest Atlantic (5-50° S). The species groups were associated with three areas, each with different conditions of temperature and salinity. The tropical species association occurred off the northeast Brazilian coast with temperatures ranging from 20.5 to 29.1 ºC and salinities from 35.6 to 37.5, indicating the presence of the Shelf and Tropical Waters in the region. The subtropical species association occurred off the central coast with temperatures between 21.0 and 29.6 ºC and a salinity range of 27.5-35.8, and is related to the coastal and shelf waters. A subantarctic species association occurred off the coast of Argentina, with temperatures between 12.3 and 19 ºC and a salinity range of 33.0-34.0.

Key words: Zooplankton, Species associations, Watermasses, Brazil.

Resumo. Estudo da distribuição de Monstrilloida (Crustacea, Copepoda) do Atlântico Sudoeste. Monstrilloida é uma das ordens menos conhecidas dos Copepoda planctônicos. Estudos taxonômicos e ecológicos são limitados pela escassez dos espécimes, que ocorrem no plâncton somente como adultos. O material foi coletado durante amostragens de zooplâncton em áreas neríticas e oceânicas na costa de Brasil. As coletas foram realizadas entre abril de 1984 e outubro de 1999. Dados de materiais coletados na costa de Argentina também foram analisados. Quinze espécies de Monstrilloida: *Monstrilla brasiliensis*, *M. grandis*, *M. helgolandica*, *M. rugosa*, *M. careli*, *M. pustulata*, *M. satchmoi*, *M. bahiana*, *Cymbasoma* cf. *longispinosum*, *C. quadridens*, *C.* cf. *rigidum*, *C. rochai*, *C. gracilis*, *Monstrillopsis dubia* e *M. fosshageni* foram registradas para o Atlântico Sudoeste (5-50° S). As espécies estiveram associadas em três áreas, cada uma com condições diferentes da temperatura e salinidade. A associação de espécies tropicais ocorreu na costa nordeste brasileira, com temperaturas variando de 20,5 a 29,1ºC e salinidades entre 35,6 e 37,5, o que indica a presença das águas de plataforma e tropical na região. A associação de espécies subtropicais ocorreu na costa central, com temperaturas entre 21,0 e 29,6ºC e uma variação de salinidade entre 27,5-35,8, e foi relacionada à presença de águas costeira e de plataforma. A associação de espécies subantárticas ocorreu na costa da Argentina, com temperaturas entre 12,3 e 19,0ºC e uma variação de salinidade entre 33,0-34,0.

Palavras-chave: Zooplâncton, Associação de espécies, Massas d'água, Brasil.

Introduction

The Monstrilloida are parasitic copepods associated with benthic polychaetes and molluscs during most of their lives. Only the reproductive adults and early larval stages are free-living, planktonic, and non-feeding (Huys & Boxshall 1991).

Taxonomic and ecological work on the group has been limited by the rarity of specimens, which are captured by plankton nets only as adults (Suárez-Morales & Dias 2000). Their zoogeographical distribution remains poorly understood, mainly because records have been reported from widely differing localities (Suárez-Morales & Gasca 1990) and their taxonomy is still in development. Monstrilloids occur in oceanic samples, mostly in tropical and temperate coastal waters (Suárez-Morales & Islas-Landeros 1993). Despite the rarity of monstrilloid species, the Southwest Atlantic is a region with a high number of monstrilloid taxa (Dias 2005). To date, 15 taxa of Monstrilloida have been reported from neritic and oceanic areas off the coast of Brazil and Argentina (Giesbrecht 1891, Ramírez 1971, Hoffmeyer 1983, Esteves *et al*. 1997, Johnsson 1998, Suárez-Morales & Dias 2000, Suárez-Morales & Dias 2001a, b).

In this contribution, the patterns of geographical distribution of the monstrilloid species recorded along the coasts of Brazil and Argentina in the southwestern Atlantic (5 to 50º S) are described.

Material and Methods

The specimens examined were obtained at several localities in neritic and oceanic areas off the coast of Brazil (Figure 1). The material included specimens captured during cruises carried out between April 1984 and October 1999. A variety of gear and collecting methods were used in order to sample monstrilloids, because of their rarity. Sub-superficial horizontal, vertical and oblique (until 200 m) hauls were made using zooplankton nets with 63, 150, 200, 250, 300, 330, 500 and 1000 μm mesh size. Suction pumps with a 63 μm mesh size were also used (Table I). Samples were preserved in 4% buffered formalin. When monstrilloid copepods were found, they were sorted from the whole samples, processed for identification, and counted.

We used information from different bibliographic sources from collections off the coast of Argentina (Giesbrecht 1891; Hoffmeyer 1983; Ramírez 1971; Esteves *et al*. 1997). Several colleagues kindly provided information and unpublished data from cruises carried out in the study area (Figure 1). Temperature and salinity were measured at most stations, thus allowing a general overview of the hydrological context and oceanographic subregions (Table I).

The specimens of monstrilloids were deposited in the copepod collection of the Integrated Zooplankton and Ichthyoplankton Laboratory (LIZI) of the Federal University of Rio de Janeiro (DZUFRJ-001 to DZUFRJ-174); in the Museu Nacional/UFRJ (MNRJ-14158, MNRJ-14338, MNRJ-13646, MN-13647, MNRJ-14100, MNRJ-14157, MNRJ-14437, MNRJ-14438, MNRJ-14439, MNRJ-14440, MNRJ-14441, MNRJ-14505); and at El Colegio de la Frontera Sur (ECOSUR), Chetumal, Mexico (ECO-CHZ-00518, ECO-CHZ-00519, ECO-CHZ,-00520, ECO-CHZ-00521, ECO-CHZ-01127, ECO-CHZ-01166, ECO-CHZ-01167).

Figure 1. Map of the study area indicating the monstrilloid sampling stations, and additional localities cited in the literature (*).

Results

Four water masses were recognised: in the shelf and slope areas, the surface layer between 5 and 20ºS was occupied by the Tropical Water (TW – temperatures > 18.5 °C and salinities > 36.0), which weakens between 20.01 and 30ºS where the Coastal Water (CW – temperatures > 18.5 °C and salinities < 34.5) and the Shelf Water (SW – temperatures > 18.5 °C and salinities from 34.5 to 36.0) occur. Between 5 and 10.01º S the Tropical and Shelf Water is present with relatively high temperatures, always above 27 ºC and with peaks of 37 ºC. The Subantarctic Water (SAW) is distinguished by temperatures below 18 ºC and occupied the southern border of the study area between 30.01 and 50 ºS (Figure 2).

The total of 566 monstrilloid specimens studied included 15 species. Eight belonged to the genus *Monstrilla*, five belonged to the genus *Cymbasoma* and two belonged to the genus *Monstrillopsis* (Table II).

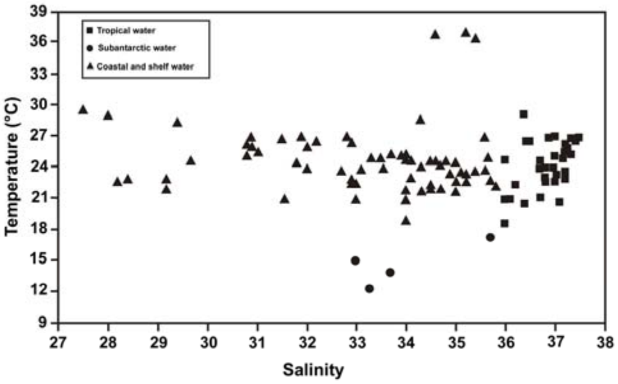

Figure 2. Temperature-salinity diagram of the watermasses found in the Southwest Atlantic.

Three monstrilloid species-groups were delimited according to the occurrence of the 15 species found and their relationship to different conditions of temperature and salinity in the region (5 to 50º S), as follows:

(A) Tropical species association. This association included *Monstrilla bahiana*, *M. brasiliensis*, *M. careli*, *M. grandis*, *M. rugosa*, *M. satchmoi*, *Cymbasoma gracilis*, *C.* cf. *longispinosum* and *C.* cf. *rigidum* (Table II). Their range off the Brazilian coast extended from Natal to Maceió, with temperatures ranging between 27.0 and 29.1 °C and salinity between 35.6 and 36.4; and the coastal zone of Bahia (Salvador), with temperatures between 20.5 and 26.9 °C and a salinity range of 36.4–37.5 (Figure 3). These values are characteristic of the SW and TW in the region (Figure 6).

(B) Subtropical species association. This association included *Monstrilla brasiliensis*, *Monstrilla grandis*, *M. pustulata*, *M. rugosa*, *Cymbasoma gracilis*, *C.* cf. *longispinosum*, *C. quadridens*, *C.* cf. *rigidum*, *C. rochai*, *Monstrillopsis dubia*, and *M. fosshageni*, which occurred in the coastal zone from Espírito Santo (Vitória) to Santa Catarina (Penha), in temperatures ranging from 21.0 to 29.6 °C and salinities from 27.5 to 35.8, mainly (Figure 4). These conditions are characteristic of the SW and CW (Figure 6). *M. bahiana* and *M. careli* were also recorded in this region (Table II).

(C) Subantarctic species association. This category included *Monstrilla helgolandica* and *M. grandis* which occurred off the coast of Argentina (Table II). Both species were associated with temperatures between 12.3 and 19 °C and a salinity range of 33.0–34.0 (Figure 5). These values are characteristic of SAW in the region (Figure 6).

Discussion

The present study recorded the occurrence of monstrilloids in the Southwest Atlantic (5 to 50 ºS) in neritic areas off Brazil and Argentina, and in Brazilian oceanic zones near reef-related environments. With a total of 15 species of monstrilloids, the Southwest Atlantic is a relatively rich region. Fourteen of these species were found off Brazil. Norway, with 12 species (Sars 1921), Mexico, with 17 species (Suárez-Morales unpublished), and the Pacific Ocean near the Philippines, with 17 species (Suárez-Morales 2000) were the areas with the highest numbers of monstrilloids up to now. The high number of taxa found in the present study is probably a function of sampling effort.

Most species have been recorded in different regions of both the northern and southern hemispheres. Suárez-Morales and Gasca (1990) and Suárez-Morales (2001) reported monstrilloids in reef-associated environments of the Caribbean Sea. Neritic species usually occurred in shallow surface waters, although their distribution was not determined by depth, but by the variation of the physical and chemical proprieties of the environment (Van der Spoel & Heyman 1983).

In the tropical species association, certain widely distributed species such as *Cymbasoma* cf. *longispinosum*, *C.* cf. *rigidum*, *C. gracilis*, and *Monstrilla grandis* occurred. These species were recorded in all the areas of the study. The largest number of individuals of *C. gracilis* occurred in the coastal zone off Maceió. The presence of *Monstrilla brasiliensis*, found previously in the coastal zone of Rio de Janeiro and Espírito Santo states (Dias 1996), and of *M. satchmoi* was observed for the first time in this region. This occurrence may represent the northern limit of their distribution. *Monstrilla bahiana* was found in this species association. This species has been collected in the oceanic region, where monstrilloids are rarely found. The species *Monstrilla bahiana* and *M. satchmoi* were found in samples collected near a reef-related environment, in the Abrolhos coral reefs (17º25'–18º10' S and 38º33'–39º37' W). The reef lagoon is the most favourable environment for monstrilloid copepod reproduction (Sale *et al*. 1976).

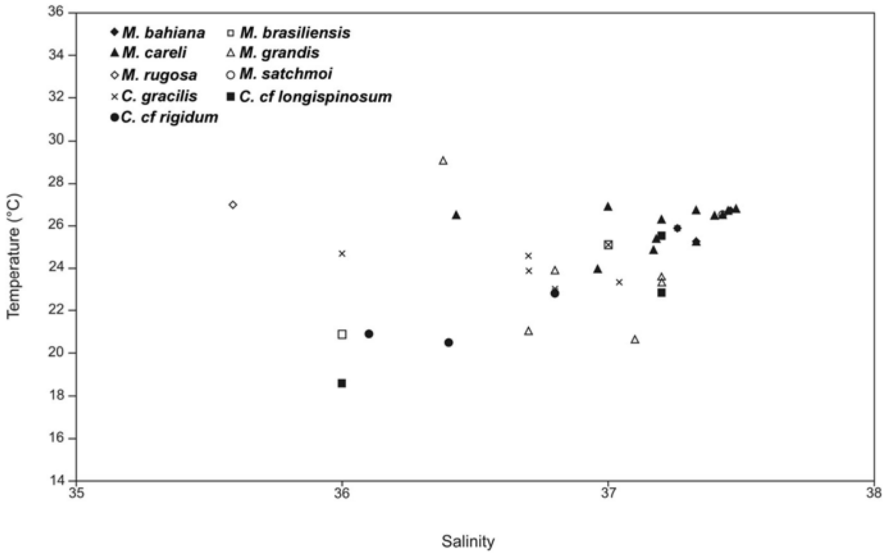

Figure 3. Temperature-salinity-species diagram of the Tropical species association found in the Southwest Atlantic.

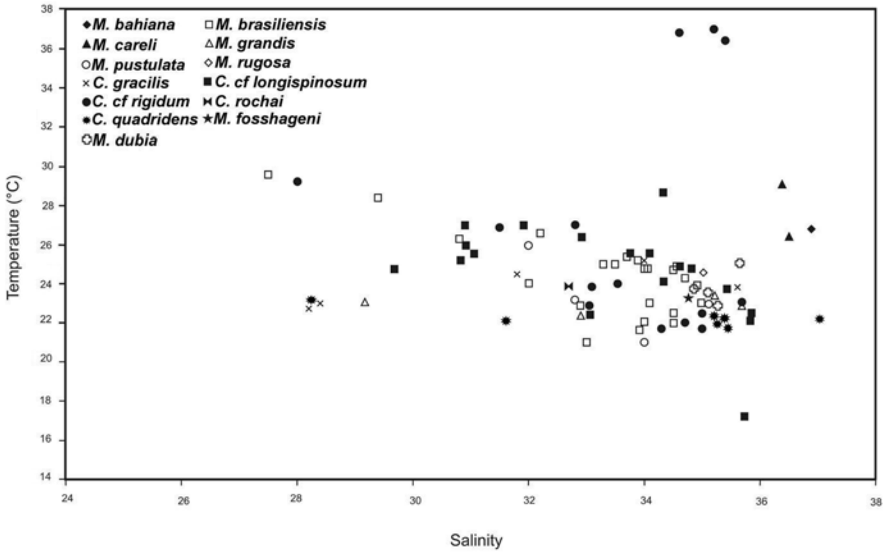

Figure 4. Temperature-salinity-species diagram of the Subtropical species association found in the Southwest Atlantic.

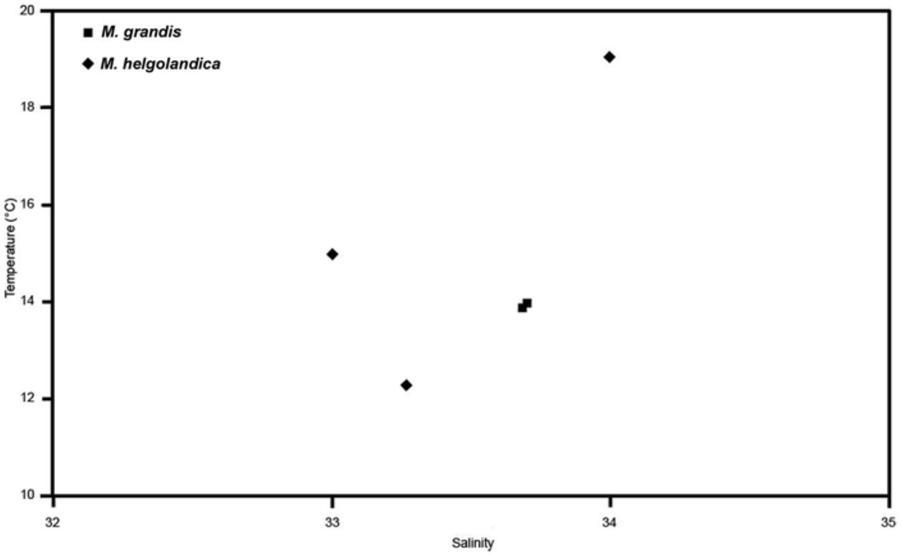

Figure 5. Temperature-salinity-species diagram of the Subantarctic species association found in the Southwest Atlantic.

Table I. Localities of sampling in the Southwest Atlantic, total samples, samples containing monstrilloids, sampling gear, type of hauls (sub-superficial horizontal, oblique, vertical), presence (X) or absence (-) of data for temperature and salinity.

Localities	Total Samples	Samples with Monstrilloida	Sampling gear	Hauls	Temperature and Salinity
BRAZIL					
Natal (6º04’00” – 6º10’60”S and 35°04’60” – 35°06’00” W)	20	4	Net (250 µm)	Hor	X
Recife (8°15’ – 8°30’S and 34°55’ – 35°05’W)	96	2	Net (300 µm)	Hor	X
Maceió (9°42’38”S and 35°41’89”W)	6	1	Net (200 µm)	Hor	X
Salvador (12°46’62” – 18°07’70”S and 35°52’93” – 38°54’99”W)	128	16	Net (200, 330, 500 and 1000 µm)	Obl - Hor	X
Vitória (19°52’50” – 20°35’89”S and 35°44’99” – 40°18'28"W)	639	65	Net (200, 300, 330, 500 and 1000 µm)	Obl - Hor	X
Rio de Janeiro (22°19’ – 2344’S and 41°35’ – 44°22’W)	567	51	Net (200 and 500 µm) and in aquarium water with *Perna perna*	Obl - Hor - Vert	X/ -
São Sebastião (23º48’07” – 23º 49'86"S and 45º25'28" – 46º24’W)	17	5	Net (150 and 300 µm)	Hor	X
Pontal do Sul (25º33´41”S and 48º21´25”W)	12	5	Suction pumps and Net (63 µm)	Hor	-
Penha* (26°47’S and 48°37’W)	1	1	Net (300 µm)	Hor	X
ARGENTINA					
Coastal region *[1] (38º43’31” – 42º46’37”S and 62º16’27” – 65º02’13”W)	179	5	Net (100 and 200 µm)	Hor	X/ -
Oceanic region *[2] (38º30’ – 49ºS and 57º – 63ºW)	10	3	Net ("Palumbo"/ ?)	Hor - Vert	X/ -

Literature: (*) Data for Penha (Brazil) were taken from Johnsson (1998); (*[1]) for the coastal region off Argentina from Esteves *et al.* (1996) and Hoffmeyer (1983); and (*[2]) for the oceanic region off Argentina from Giesbrecht (1891) and Ramirez (1971).

Table II. Numbers of specimens of each species of monstrilloid (M = male, F = female), at the sampling localities and as cited in the literature.

Species/Locality	Natal (#1)	Recife (#2)	Maceió (#3)	Salvador (#4)	Vitória (#5)	Rio de Janeiro (#6)	São Sebastião (#7)	Pontal do Sul (#8)	Penha* (#9)	Coastal Region *^{1} (# 11/ 12)	Oceanic region *^{2} (#10/ 13/ 14)
Monstrilla brasiliensis Suárez-Morales and Dias 2000				1 F	8 F	66 F					
Monstrilla grandis Giesbrecht 1891		1 M			250 (6F/242M)	1 F					2 (1F/1M); + (#10/14)
Monstrilla helgolandica Claus 1893										+	1 F (#13)
Monstrilla rugosa Davis 1947			1 M						2 M		
Monstrilla careli Suárez-Morales and Dias 2000		1 F		17 F	10 F	2 F					
Monstrilla pustulata Suárez-Morales and Dias 2001a						3 F					
Monstrilla satchmoi Suárez-Morales and Dias 2001b				1 F							
Monstrilla bahiana Suárez-Morales and Dias 2001b				4 M	2 M						
Cymbasoma cf. *longispinosum* Bourne 1890	5 (3F/2M)				12 (8F/4M)	18 (12F/6M)	28 (8F/27M)		46 (7F/39M)		
Cymbasoma quadridens Davis 1947					13 M						
Cymbasoma cf. *rigidum* Thompson 1888	18 M				29 (18F/11M)	1 M		3 M			
Cymbasoma rochai Suárez-Morales and Dias 2001b					2 M	2 M					
Cymbasoma gracilis Gurney 1927	26 F			2 F	26 F	3 F		5 F			
Monstrillopsis dubia T. Scott 1904					2 F	1 F		1 F			
Monstrillopsis fosshageni Suárez-Morales and Dias 2001b					1 M						

Literature: (*) Data for Penha (Brazil) were taken from Johnsson (1998); (*^{1}) for the coastal region off Argentina from Esteves *et al.* (1996) and Hoffmeyer (1983); and (*^{2}) for the oceanic region off Argentina from Giesbrecht (1891) and Ramirez (1971).

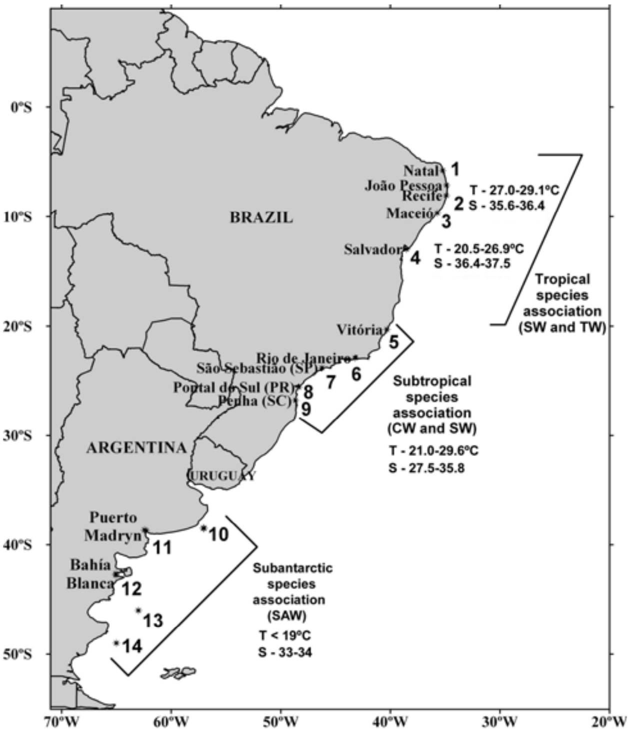

Figure 6. The three monstrilloid species associations determined by cluster analysis. The watermasses and temperature and salinity ranges within each area are indicated.

In the Subtropical species association, the highest numbers of taxa and individuals were found in the neritic zone of the central coast of Brazil, *Monstrilla grandis* and *Cymbasoma* cf. *longispinosum*, mainly. The coastal region offers a substratum for the development of potential hosts. Although the highest number of samples containingmonstrilloids was related to different neritic, shallow environments, the high number of taxa and individuals of monstrilloids in a region can be attributed to other factors. According to Suárez-Morales (2001), the reasons for local aggregation in adult monstrilloid copepods (remaining near hosts or mating, but not feeding) seem to be quite different from those of other planktonic copepods (avoidance of predators, feeding, mating). Monstrilloid copepods respond to light stimuli and are lured by flashlights (Grygier 1994). They probably remain near the bottom (and near their potential hosts) during the day and swim toward the surface at dusk (Suárez-Morales 2001). Swarming enhances copepod mating encounters and success, bringing together adult males and females in high concentrations, too. This is crucial for the supposedly short-term (one day/night) reproductive life of monstrilloids.

In the Subantartic species association (between 30-43ºS) *Monstrilla grandis* and *M. helgolandica*, occurred in the coastal region of Argentina. The presence of *M. grandis* was also recorded in the Tropical and Subtropical species associations. The occurrence of this species in the Subantartic species association is probably a result of the intrusion of the Brazil Current waters, which flow between the main axis of the Malvinas Current and the coast and move southward along the shelf (Boltovskoy 1981, Boltovskoy *et al.* 1999, Berasategui *et al.* 2006). *Monstrilla helgolandica* was recorded only in this species association. This species was associated with low temperatures over the entire study area (Ramírez 1971, Hoffmeyer 1983, Esteves *et al*. 1997).

In the Southwest Atlantic, the number of species of Monstrilloida decreased from north to south. This latitudinal pattern differs according to each zooplankton group. Boltovskoy *et al.* (1999) made a very rough estimate of the latitudinal span of certain zooplanktonic groups, and found that few taxa are restricted to ranges below 10-20º S, or occupy areas below 50º S; instead, most zooplankters occur over moderately wide areas between 20-40º S. The same pattern was found for the Monstrilloida in this study: most species occurred in the Subtropical Zone between 20-30º S.

Very little is known about the behaviour (migrations, day-night distribution) of monstrilloids, and almost nothing is known about the seasonality of the adults emerging from their hosts. In general, not more than a few specimens of monstrilloids are caught in plankton samples. Isaac (1974) collected 40 individuals of *Monstrilla grandis*, and attributed this to a local mass liberation of adults from aggregated benthic hosts. Suárez-Morales (2001) collected a total of 2,067 individuals of different species in a reef area in the western Caribbean, which can be attributed to the aggregation and abundance of their potential hosts (polychaetes and molluscs) in reef-related environments.

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Descrição da pesca e perfil sócio-econômico do pescador da garoupa-verdadeira *Epinephelus marginatus* (Lowe) (Serranidae: Epinephelinae) no Molhe Oeste da Barra de Rio Grande, Rio Grande do Sul, Brasil

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Abstract. Fishery's description and socioeconomic profile of the fishermen of the dusky grouper *Epinephelus marginatus* (Lowe) (Serranidae: Epinephelinae) in the west jetty of the Rio Grande, Rio Grande do Sul state, Brazil. The dusky grouper *Epinephelus marginatus* (Lowe, 1834) is a marine fish commonly found in rocky bottoms at shallow waters, particularly rocky coastal and reefs. This species play an important role in fisheries of southern Brazil, and the conservation status of dusky grouper's populations is seriously endangered in Brazil and elsewhere (code as ENA2d at IUCN). The 4.5 km long jetties at Rio Grande city (32°09'38"S e 52°05'54"W) connecting the Patos Lagoon with the sea, seem to be an adequate hábitat for the dusky grouper due to its rocky structure and great extension. Our study employed semi-structured interviews and observation *in situ* to describe the fishing method and the socio-economical profile of fishers of the dusky grouper at the Rio Grande's jetties. The study was conducted between January and February of 2006, when the fish activity is concentrated. The results obtained by the interviews showed that the dusky grouper fishery occurs mainly between late spring and throughout the summer, and is conducted mainly by man with an average age of 45 years old. The grouper's fishery in this location is made only by one type of fish gear; hook and line. A total of 84 groupers were observed and measured during the 11 field trips, with size ranging from 31 to 61 cm, and average of 44.5 cm. According to reproductive studies of this species elsewhere, these individuals could be considered as young, sexually immature individuals, which did not reproduced yet. We strongly recommend further analysis of the fishing effort, altogether with investigations of biological aspects, in order to achieve a proper diagnostic and to guide future management of this poorly known grouper population.

Key words: Threatment species, conservation, artisanal fisherman, amateur fishing.

Resumo. A garoupa-verdadeira *Epinephelus marginatus* (Lowe, 1834) é um peixe marinho associado a fundos rochosos que habita águas costeiras, particularmente em costões rochosos e recifes de corais. Essa espécie possui um papel importante na pesca costeira no sul do Brasil, porém, esta espécie compõe a atual lista de espécies ameaçadas de extinção da IUCN (código EN A2d) devido ao precário estado de conservação das suas populações. Os molhes da barra de Rio Grande, localizados na desembocadura da Lagoa dos Patos (32°09'38"S e 52°05'54"W), devido à sua formação rochosa e sua longa extensão (4,5 Km), constitui um hábitat adequado para a garoupa-verdadeira. O presente estudo utiliza entrevistas semi-estruturadas e observações *in situ* para descrever a pesca e o perfil sócio-econômico dos pescadores que capturam a garoupa-verdadeira no molhe oeste da barra de Rio Grande. O estudo foi realizado entre janeiro e fevereiro de 2006, quando há maior concentração da pesca da garoupa. A análise das entrevistas mostra que o pescador atua predominantemente no final da primavera e durante o verão, sendo, na grande maioria, do sexo masculino e com média de 45 anos de idade. A pesca é realizada unicamente com "linha de mão" e um único anzol grande. Oitenta e quatro garoupas foram medidas em 11 visitas de campo, com comprimentos totais entre 31 e 61 cm e tamanho médio de 44,5 cm. Baseado em estudos de reprodução da espécie em outras regiões, foi possível estimar que 73% dos indivíduos capturados eram fêmeas jovens sexualmente imaturas. Recomendamos um maior acompanhamento do esforço de pesca, assim como a obtenção de informações sobre a sua biologia, para que se possa estabelecer um correto diagnóstico e futuro gerenciamento dessa população tão pouco investigada.

Palavras-chave: Espécie ameaçada, conservação, pesca artesanal, pesca recreativa.

Introdução

A garoupa-verdadeira *Epinephelus marginatus* (Lowe, 1834) (Serranidae: Epinephelinae), é uma espécie que está associada a fundos rochosos, sendo comum em águas costeiras, especialmente em costões rochosos e recifes de coral, podendo habitar locais com profundidade de até 80m. Sua distribuição estende-se por toda costa do Mediterrâneo, e em ambos os lados da costa do Oceano Atlântico (Fiqueiredo & Menezes 1980; Heemstra & Randall 1993; Barreiros 1998). A distribuição mais meridional da espécie nas Américas parece ser o Golfo da Patagônia, Argentina (42ºS) (Irigoyen *et al.* 2005), enquanto no Brasil, a população de garoupa que habita os molhes da barra de Rio Grande, possivelmente represente a distribuição mais austral dessa espécie ao longo da faixa litorânea brasileira.

No Rio Grande do Sul as garoupas são pescadas na região superior do talude, em extensas áreas de fundos irregulares (Haimovici *et al.* 1994). Em contrapartida, são incomuns em zonas rasas ao longo da costa gaúcha, provavelmente porque os fundos arenosos que predominam nessa região não são hábitats propícios para os adultos da espécie. Os molhes da barra de Rio Grande, localizado na desem-ocadura da Lagoa dos Patos, constituem uma importante exceção. Seu substrato rochoso parece constituir um hábitat adequado para a garoupa-verdadeira que ocorre em abundância suficiente a ponto de permitir sua pesca regular.

Devido à pesca discriminada e à destruição de seu hábitat natural, a garoupa-verdadeira é atualmente classificada como ameaçada de extinção (código EN A2d) (Cornish & Harmelin-Vivien 2004; Froese & Pauly 2006). Um entrave importante na conservação das populações de garoupas no Brasil é a carência de estudos científicos sobre sua biologia e pesca (Hostim-Silva *et al.* 2006). Até o momento, não há informações disponíveis sobre a biologia e a pesca da garoupa-verdadeira que habita os molhes da barra de Rio Grande.

Segundo Gerhardinger *et al.* (2006), os pescadores podem representar uma fonte importante de conhecimento sobre a biologia e a pesca de populações de garoupas. De fato, o uso de entrevistas semi-estruturadas (*sensu* Richardson 1989) com pescadores recreativos na Praia do Cassino (Rio Grande, RS) já se mostrou um método efetivo no levantamento de informações e descrição da atividade pesqueira (Basaglia & Vieira 2005). Nesse contexto, o presente estudo utiliza entrevistas semi-estruturadas e observações *in situ* para descrever o perfil sócio-econômico dos pescadores que capturam a garoupa-verdadeira no molhe oeste da barra de Rio Grande, bem como para fornecer uma descrição do método de pesca empregado. O trabalho também apresenta dados preliminares sobre a freqüência de tamanho dos peixes capturados e o número de pescadores atuando no local.

Material and Métodos

A área de estudo foi o molhe oeste da barra de Rio Grande (32°09'38"S e 52°05'54"W), situado na boca do estuário da Lagoa dos Patos (Fig. 1). Os molhes foram construídos com blocos de pedra de até dez toneladas (Fig 2a), totalizando 4,5 milhões de toneladas de pedra, e se estendem cerca de 4,5 km mar adentro (Motta 1969).

As entrevistas e as coletas de dados foram realizadas durante os meses de janeiro e fevereiro de 2006, totalizando 11 saídas de campo, das quais seis foram realizadas em janeiro nos dias 14, 15, 21, 23, 25 e 30; e cinco em fevereiro nos dias 06, 13, 16, 18 e 21. No total foram realizadas 61 entrevistas semi-estruturadas com 27 pescadores diferentes. Em cada uma das saídas de campo todos os pescadores atuando ao longo da extensão dos molhes foram abordados e entrevistados, independentemente de serem identificados como pescador recreativo ou profissional. As entrevistas semi-estruturadas constituem num roteiro simples de perguntas e questões que são apresentadas e posteriormente complementadas pelo entrevistado, de modo que haja certa flexibilidade ao entrevistador e entrevistado na coleta de informações, incluindo,

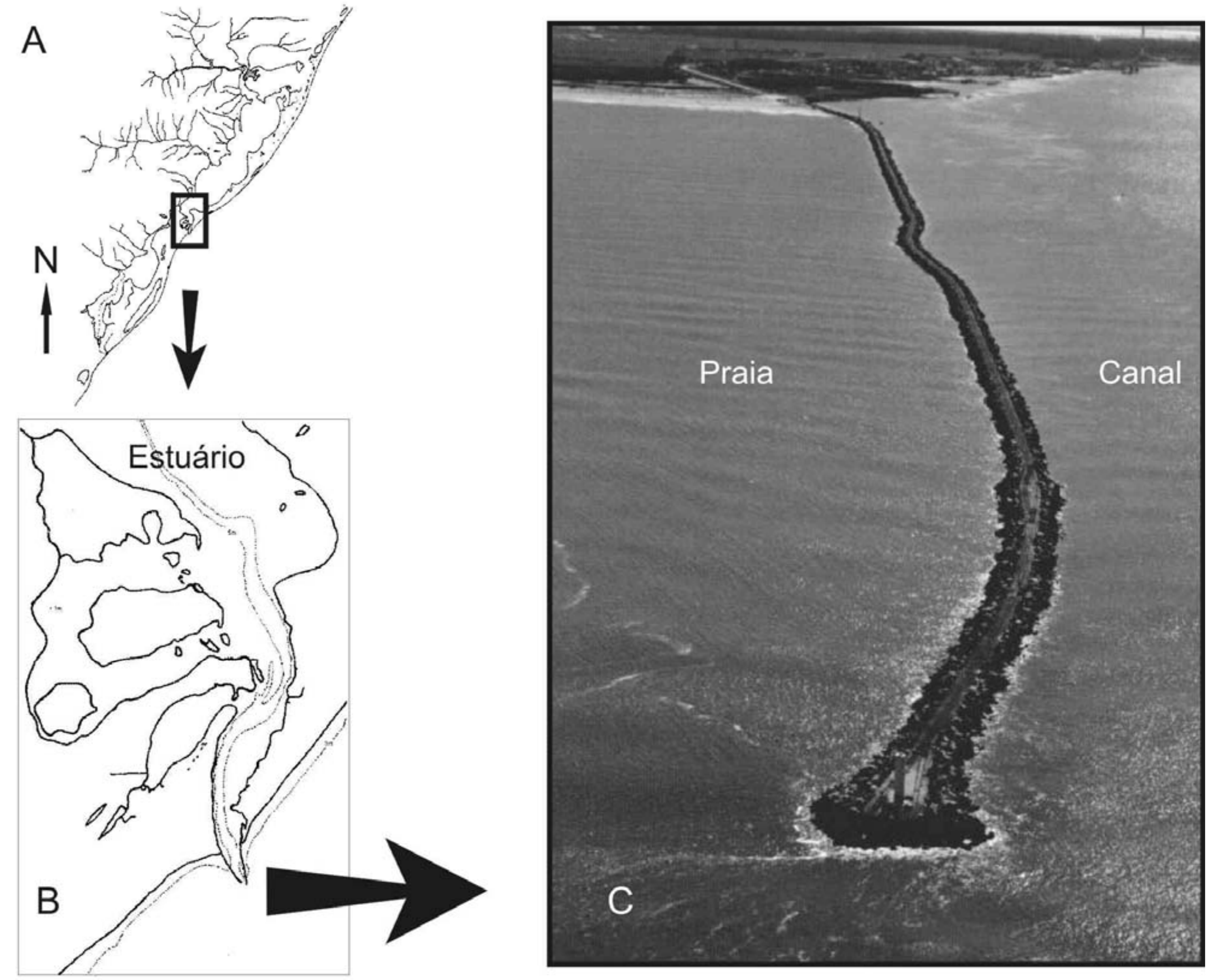

Figura 1. (A) Bacia de drenagem da Lagoa dos Patos, Rio Grande do Sul, Brasil e (B) sua região estuarina mostrando sua conexão com o mar. (C) molhe oeste da barra de Rio Grande com cerca de 4,5 Km de comprimento mostrando a localização do canal de acesso a Lagoa dos Patos (direita) e a Praia do Cassino (esquerda) aonde são realizadas a pesca com linha e anzol da garoupa-verdadeira.

por exemplo, perguntas não inicialmente previstas no roteiro e possíveis opiniões do entrevistado (Richardson 1989). A entrevista foi organizada em duas seções gerais: a) relativa ao perfil do pescador, questões enumeradas de 1 a 10 e b) relativa a atividade da pesca, questões 11 a 19 (Tabela 1). O número amostral para as perguntas (1) à (16) foi de 27, correspondendo ao número de pescadores entrevistados. Já o número amostral para as perguntas (17) à (19) foi de 61, pois essas perguntas relativas ao número de linhas, número de peixes capturados e tipo de isca empregada, foram efetuadas mais de uma vez para o mesmo pescador, quando este estava pescando em dias diferentes.

Adicionalmente, no intuito de complementar as entrevistas com os pescadores nos molhes, foram realizadas duas entrevistas, com cerca de 30’ de duração cada e sem a utilização de questionários, com dois proprietários de lojas de artefatos de pesca que estão estabelecidos a mais de 10 anos na cidade de Rio Grande.

Durante cada saída de campo foi estimado o número de pessoas envolvidas na pesca da garoupa no molhe oeste da barra e o número de exemplares capturados por cada pescador ou grupo de pescadores. Quando obtido consentimento, foi registrado o comprimento (em centímetros) dos exemplares de garoupa capturados pelos pescadores. Os indivíduos foram identificados a partir de Figueiredo & Menezes (1980) e Hostim-Silva *et al.* (2006).

RESULTADOS E DISCUSSÃO

O perfil sócio-econômico do pescador

A pescaria nos molhes da barra é praticada quase que exclusivamente por homens (apenas uma mulher foi registrada), onde a amplitude de idade dos pescadores varia entre 17 e 65 anos, com média de 43 anos (erro padrão, EP = 2,6). Esses resultados coincidem com os valores observados para os pescadores artesanais do estado do Rio Grande do Sul (RS) como um todo. No estado, a idade média dos pescadores é de 42,9 anos (entre 18 e 66 anos), onde 8 a 10% destes pescadores são mulheres (Garcez & Sanchez-Botero 2005). Um perfil semelhante em relação ao gênero sexual (94% homens) e a idade (a maioria entre 40 e 50 anos) também foram descritos para os pescadores recreativos de caniço que atuam na Praia do Cassino (RS) (Basaglia & Vieira 2005).

Os dados obtidos (Tabela 1) permitem caracterizar os pescadores em duas categorias (*sensu* Diegues 1983): a) pescador recreativo (19 % dos casos): que não tem na pesca da garoupa nenhum interesse comercial, pescando apenas por lazer e b) o pescador profissional ou artesanal (81%): que tem na pesca da garoupa um importante complemento de renda. Esses pescadores profissionais vendem a garoupa primeiramente para as peixarias próximas ao molhe oeste, na localidade da 5º Secção da Barra e, em menor escala, para peixarias no balneário do

Figura 2. A) Disposição das linhas de pesca (setas) no molhe; B) detalhe da linha enrolada no suporte de madeira e iscada com tainha; C) exemplar de garoupa-verdadeira capturado pelo pescador (comprimento total: 35 cm).

Tabela 1. Tópicos das 61 entrevistas semi-estruturadas realizadas com 27 pescadores entre janeiro e fevereiro de 2006, que forneceram dados para traçar o perfil do pescador e descrever a pesca da garoupa-verdadeira no molhe oeste da barra de Rio Grande (RS). O número amostral (n) para as perguntas (1) à (16) foi de 27, correspondendo ao número de pescadores entrevistados. Já o número amostral para as perguntas (17) à (19) foi de 61, pois essas perguntas foram efetuadas mais de uma vez para o mesmo pescador, quando este estava pescando em dias diferentes. EP: Erro padrão.

Perguntas feitas ao pescador	Respostas
EM RELAÇÃO AO PERFIL DO PESCADOR	
(1) Sexo	Homem (96,3%), Mulher (3,7%)
(2) Idade	15-30 anos (11,1%), 31-45 (51,8%), 45-65 (37,0%)
(3) Nível de instrução	1° Grau (85%), 2° Grau (11%), Superior (4%)
(4) Renda mensal (R$)	0-400 reais (33,3%), 400-800 (33,3%), >1000 (14,8%), NI (18,5%)
(5) Quantas pessoas família	1-2 pessoas (11,1%), 3-4 (59,2%), 5-7 (22,2%), 8-10 (7,7%)
(6) Residência	Rio Grande, Barra (88,8%), Pelotas (3,7%), Outras (7,5%)
(7) Horário da pesca	Manha (9%), Tarde (0), Entardecer (22%), Noite (0), Entardecer-Noite (57%), Todo dia (13%)
(8) Em que época pesca	Veraneio (100%), Ano todo (0)
(9) Pesca quantas vezes semana	1-2 dias (11,1%), 3-5 dias (29,6%), 6-7 (44,4%), NI (14,8%)
(10) Tipo de apetrecho usa	Linha de mão (100%), Vara de pesca (0)
EM RELAÇÃO A ATIVIDADE DA PESCA	
(11) Quantas horas pesca em média	Média= 8,6, EP= 0,4, Min= 2, Max= 15
(12) Quantos peixes pesca em média	Média= 3,3, EP= 0,5, Min= 0, Max= 10
(13) Qual destino do pescado	Consumo (7,5%), Venda direta (3,7%), V. peixaria (74,0%), NI (14,8)
(14) Tamanho do anzol	Número 13 (100%)
(15) Espessura da linha	100mm (3,7 %), 140 (11,1%), 160 (33,3%), 180 (37%), NI (14,8%)
(16) Comprimento da linha	Média= 8,3, EP= 0,7, Min= 4, Max= 20
(17) Número de linhas empregado	Média= 13.9, EP= 0,9, Max= 32, Min= 1
(18) Quantos peixes pescou hoje	Média= 1.3, EP= 0,2 , Max= 8, Min= 0
(19) Tipo de isca	Tainha (38%), Savelha (30%), Ta+Sa (20%), Outras spp (13%)

Cassino. A garoupa é comumente vendida com vísceras para os intermediários (donos de peixarias na região) ao preço de R$ 6,00 por quilograma. Em alguns casos (n=3), a pesca da garoupa representa a única fonte de renda familiar para o pescador no período de dezembro a março. Os pescadores artesanais entrevistados relatam que, eventualmente, os donos das peixarias selecionam as garoupas de maior porte e as revendem para outras localidades no sudeste do Brasil como São Paulo e Rio de Janeiro.

O nível de escolaridade dos pescadores entrevistados, incluindo recreativos e profissionais, mostrou-se bastante heterogêneo, variando de 1° grau incompleto a curso superior, ainda que 85% deles possuíssem apenas o 1° grau incompleto, ou seja, inferior a oito anos de ensino formal (Tabela 1). Contudo, 100% dos pescadores profissionais possuem apenas o 1° grau incompleto. Esse grupo possui menor renda familiar (média mensal R$ 452,80), e quando comparado ao pescador recreativo que possui renda média mensal de R$ 1.160,00. Estes resultados são corroborados pela correlação positiva entre escolaridade e renda ($r = 0,70$, $p = 0,0003$). O baixo nível de escolaridade e de renda observados para os pescadores artesanais atuando na pesca da garoupa do molhe oeste segue o padrão típico encontrado para os pescadores do RS, visto que 93,3% não possuem o 1º grau completo e cerca de 52 % recebem de 1 a 3 salários mínimos (Garcez & Sanchez-Botero 2005).

Variação temporal da atividade de pesca

Dada à importância da atividade como fonte de renda, os pescadores profissionais que atuam na pesca da garoupa nos molhes pescam pelo menos cinco vezes por semana, durante o período do final da primavera e verão, enquanto o pescador recreativo realiza essa atividade de forma mais esporádica. Em geral, o horário preferencial da pesca para a maioria (57%) dos pescadores engloba o entardecer (18:00-24:00) e a noite (24:00-06:00) (Tabela 1). As observações *in situ* mostram que o número médio de pescadores observados no local foi de 5,5 (+EP = 0,8) variando de 1 a 11 indivíduos, independentemente da categoria.

Em relação a sazonalidade, a análise das entrevistas (Tabela 1) mostra que o pescador de garoupa do molhe oeste atua predominantemente no final da primavera e durante o verão (inicio de dezembro a final de março). Segundo relato da maioria dos pescadores profissionais, a pesca não ocorre nos meses frios devido às baixas capturas ou baixa densidade da espécie e também devido à piora das condições climáticas na região. Estudos em outras regiões também apontam marcada variação sazonal na abundância da garoupa-verdadeira. Por exemplo, Zabala *et al.* (1997a) observaram em populações do noroeste do Mediterrâneo maiores densidades de *E. marginatus* no verão do que no inverno. Um padrão semelhante também foi encontrado para os juvenis da garoupa no litoral de Santa Catarina (Machado *et al.* 2003). Segundo Zabala *et al.* (1997a), existem duas hipóteses na literatura para explicar a diminuição da garoupa no inverno, uma relacionada ao metabolismo e outra a migração. A primeira hipótese considera que com a menor temperatura no inverno a garoupa-verdadeira apresentaria um menor metabolismo, um comportamento mais sedentário e maior permanência nos abrigos (tocas), o que resultaria em menores capturas pelos pescadores (Chauvet & Francour 1991). A segunda hipótese sugere que os indivíduos realizariam uma migração sazonal de pequena escala relacionada com comportamentos de dispersão e agregação dos indivíduos. No momento, existem poucas evidências na literatura que permitam testar essas duas hipóteses.

Descrição da pesca da garoupa-verdadeira no molhe oeste

O apetrecho de pesca usado é a ‘linha de mão’, que é composta por aproximadamente 10 m de linha de nylon com espessura variando de 160 a 180 mm, um único anzol grande (N° 13) e um pequeno pedaço de madeira que serve para enrolar a linha (Fig 2b). Cada pescador utiliza em média 14 unidades de pesca (‘linha de mão’: linha + anzol + madeira) em cada pescaria, podendo variar de 1 a 35 unidades, as quais são distribuídas ao longo dos molhes com distâncias que variam de 2 a 5 metros entre cada unidade. Essa distância depende da quantidade de linhas que o pescador estiver utilizando no dia: em geral, quanto maior o número de unidades de pesca menor à distância. Os pescadores profissionais geralmente possuem pontos preferenciais de pesca, variando pouco os locais durante a estação. Os recreativos, por outro lado, não possuem muito conhecimento dos locais de pesca nos molhes e não apresentam essa preferência.

A pesca ocorre em ambos os lados do canal de navegação que dá acesso ao estuário, sendo que o esforço é maior no lado voltado para a praia do Cassino (Fig. 1c). Segundo os pescadores, esta preferência de local ocorre devido à predominância de ventos de quadrante nordeste, os quais ocorrem com maior freqüência na região durante os meses de verão (Braga & Krusche, 2000). Estes ventos ajudam a afastar as linhas de pesca das pedras que constituem os molhes e as mantêm mais esticadas, minimizando a perda de material por enrosco nas pedras.

Essa pesca com linha de mão com um único anzol parece ser uma adaptação específica para as condições de pesca que é propiciada pela estrutura de pedra dos molhes, não estando descrita para outras regiões. Em outros locais do Brasil, como Santa Catarina a garoupa é capturada pelos pescadores industriais e artesanais através de vários métodos: arrasto de fundo industrial e artesanal, rede de espera, vara de pesca, espinhel (uma linha longa com vários anzóis utilizada a partir de uma embarcação) e pela pesca submarina com arpão (Gerhardinger *et al.* 2006). A maioria desses modos de pesca não pode ser utilizada nos molhes, já que,

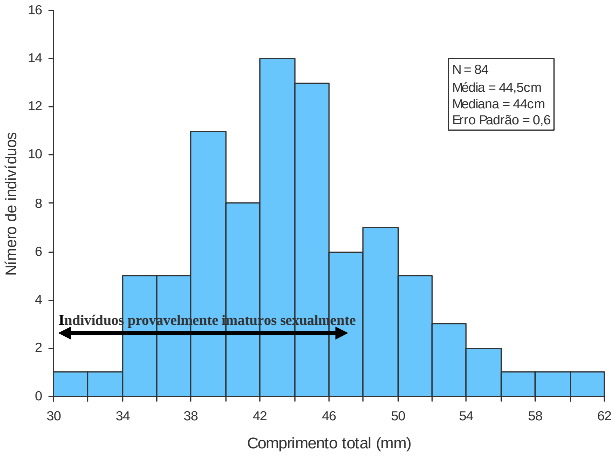

Figura 3. Histograma dos comprimentos totais dos exemplares de garoupa-verdadeira medidos *in situ* durante as 11 saídas de campo realizadas entre janeiro e fevereiro de 2006 no molhe oeste da barra de Rio Grande, RS. A seta (comprimento total: < 47 cm) demarca os indivíduos que poderiam estar imaturos sexualmente tendo como base o trabalho de Andrade et al. (2003).

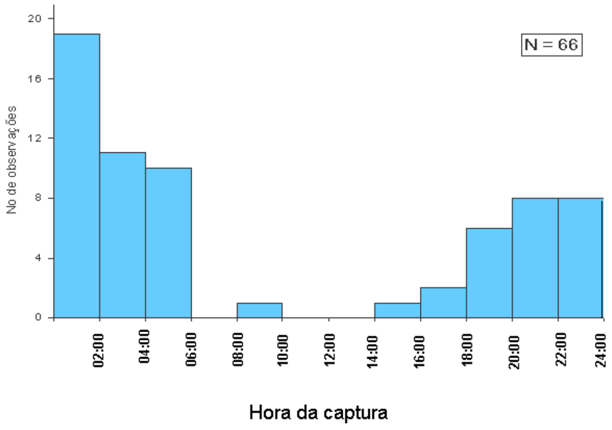

Figura 4. Histograma de freqüência dos horários das capturas da garoupa-verdadeira observadas *in situ* durante as 11 saídas de campo realizadas entre janeiro e fevereiro de 2006 no molhe oeste da barra de Rio Grande, RS.

por exemplo, a operação de um espinhel a partir das pedras ser inviável e devido a falta de visibilidade para pesca submarina. Os pescadores locais usualmente empregam a rede de espera e a pesca com vara e anzol nos molhes, porém não são observados capturas de garoupas com tais apetrechos.

As iscas preferenciais utilizadas por ambos os grupos de pescadores foram duas espécies de peixes facilmente encontradas na região, a tainha (*Mugi sp*) e a savelha (*Brevoortia pectinata*). Essas iscas são usadas exclusivamente (em 38% dos casos para tainha e 30% para savelha), ou em combinações com outros peixes, como anchova (*Pomatomus saltatrix*), corvina (*Micropogonias furnieri*), espada (*Trichiurus lepturus*), maria luiza (*Paralonchurus brasiliensis*), pampo (*Trachinotus marginatus*) e o papa-terra (do gênero *Menticirrhus*). Estes peixes ocorrem em abundância na região, especialmente na primavera e verão (Chao *et al.* 1985) e são capturados para isca pelos próprios pescadores profissionais através do uso de rede de espera no molhe ou em praias próximas.

Um total de 84 indivíduos foram medidos durante as observações *in situ* com comprimentos totais variando entre 31 e 61 cm e tamanho médio de 44,5 cm (mediana: 44 cm) (Fig. 3). Segundo Andrade *et al.* (2003), que estudaram a reprodução da garoupa-verdadeira na Reserva Marinha do Arvoredo, SC (entre 27º 10’ S e 27º 20’ S), a maior parte das fêmeas da espécie (L50) atinge a maturação com 47 cm e com aproximadamente 2 kg. Estimativas de maturação sexual para as fêmeas em outras regiões de ocorrência da espécie variam de 43,8 cm no Mediterrâneo (Marino *et al.* 2001) a 62,8 cm na África do Sul (Fennessy 2006). Estudos de determinação da idade através da leitura de otólitos indicam que a garoupa leva cerca de quatro anos para atingir tamanhos entre 47 e 49 cm (Fennessy 2006). Dessa forma, tendo como base os estudos de Andrade *et al.* (2003) e Fennessy (2006), podemos supor que a grande maioria dos indivíduos (78%) capturados pelos pescadores no molhe oeste, os quais foram medidos durante as onze visitas de campo realizadas em janeiro e fevereiro de 2006, eram jovens imaturos com idade inferior a quatro anos que ainda não tiveram oportunidade de reproduzir.

Comparado às fêmeas, a maturidade sexual do macho geralmente ocorre em tamanhos muito maiores (Marino *et al.* 2001). Isso ocorre porque *E. marginatus* é uma espécie hermafrodita protogínico, ou seja, o mesmo indivíduo se desenvolve primeiramente como fêmea e depois se transforma em macho. Essa reversão sexual geralmente ocorre nos indivíduos entre 80 e 90 cm de comprimento e com 14 a 17 anos de idade (Zabala *et al.* 1997a,b).

O número médio de garoupas registradas em cada saída de campo foi 7,6 (EP=1,3), enquanto que o máximo registrado foi de 14 indivíduos numa única saída. Essa estimativa provavelmente está subestimada já que em alguns casos os pescadores mantinham os peixes guardados em sacos e não davam consentimento para realizar a contagem e a mensuração de tamanho. Com uma única exceção, em todas as saídas de campo foi observada a captura de garoupas no local (Tabela 2), sendo que 61% dos 84 indivíduos foram capturados principalmente no período das 18:00 às 06:00, com pico entre as 00:00 e 06:00 da manhã (Fig. 4). Uma possível explicação para esses picos de captura preferencial poderia estar relacionada com picos de atividade alimentar da espécie. Porém, embora existam várias informações sobre o hábito alimentar da espécie (Harmelin &

Tabela 2. Número de pescadores e de exemplares de garoupa-verdadeira capturadas no molhe oeste da barra de Rio Grande, RS, durante as saídas de campo realizadas em 2006. Os dados de direção do vento foram obtidos da estação meteorológica da FURG, localizada a 13 km de distância (linear) do molhe oeste.

Saída	Data	Hora da entrevista	Nº Pescadores	Nº Garoupas	Vento
1	14/01	09:30	1	0	NE
2	15/01	07:00	7	13	NE
3	21/01	07:00	5	7	NE
4	23/01	19:25	11	8	NE
5	25/01	06:45	5	14	SW
6	30/01	07:10	5	7	E
7	06/02	07:00	5	8	S
8	13/02	07:30	3	5	NE
9	16/02	07:00	4	7	NE
10	18/02	07:00	8	12	NE
11	21/02	19:30	7	3	NE
Média por saída			5,5	7,6	
Erro padrão			0,8	1,3	

Harmelin-Vivien, 1999), não há informações disponíveis na literatura sobre os picos diários de atividade alimentar da espécie que permitam uma melhor avaliação dessa hipótese.

Considerações finais

As características peculiares da reprodução da garoupa-verdadeira *E. marginatus*, como a reversão sexual de fêmea para macho, assimetria na proporção sexual (relativamente poucos machos em relação ao número de fêmeas) e a complexidade do seu comportamento reprodutivo (Zabala *et al.* 1997a,b) torna essa espécie bastante vulnerável a pressão pesqueira (Heemstra & Randall, 1993; Hostim-Silva *et al.* 2006). Uma avaliação mais detalhada do atual esforço de pesca sobre a população de garoupa do molhe oeste é, portanto, de vital importância e demanda novos estudos. Embora não existem dados históricos sobre o número de pescadores (esforço de pesca) profissionais atuando na pesca da garoupa nos molhes. Dois proprietários de estabelecimentos de pesca na cidade de Rio Grande relataram haver ocorrido, na última década, um aumento no número de pescadores profissionais na pesca da garoupa. O acompanhamento do esforço de pesca no local aliado a realização de estudos sobre a biologia reprodutiva, estrutura de idade e crescimento e alimentação da população de *E. marginatus*, são informações imprescindíveis que devem ser geradas para que seja possível avaliar e diagnosticar possíveis impactos que a mortalidade pela pesca possa estar ocasionando a população da garoupa-verdade que habita os molhes da barra de Rio Grande. A premência desses estudos é evidente quando consideramos o estado precário de conservação dessa espécie no Brasil (Brasil 2004) e no exterior (Cornish & Harmelin-Vivien 2004).

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Effects of recreational activities on the fish assemblage structure in a northeastern Brazilian reef

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Abstract. Uncontrolled recreational activities are known to cause severe damage to reef dwelling organisms and to the reef overall structure. In order to investigate the effects of human recreational activities on the reef fish assemblage, surveys were undertaken in two shallow coastal reefs (Picãozinho and Quebra Quilhas) with similar physiographic features. However, recreational activities only take place at the former, and the latter was investigated as a control reef. The most speciose and abundant families on both reefs were Pomacentridae, Scaridae, Haemulidae, Acanthuridae and Labridae, but species evenness was fairly different between the reefs due in particular to the extremely high abundance of the sergeant major *Abudefduf saxatilis* at Picãozinho. This species represented almost ⅔ of all individuals recorded at Picãozinho and was the underlying feature responsible for the assemblage structure pattern observed on this reef. The present study showed that one single species was of major influence on species evenness and trophic structure, and that unregulated recreational activities have the potential to severely alter reef fish assemblage structure.

Key words: Tourism, assemblage, reef fishes, Brazil, *Abudefduf saxatilis*.

Resumo. Efeitos de atividades recreativas sobre a estrutura da assembléia de peixes em um recife Brasileiro Atividades recreativas não controladas são conhecidas por causarem danos a organismos associados a recifes, bem como em sua estrutura geral. Para investigar os efeitos das atividades recreativas na assembléia de peixes recifais, amostragens foram realizadas em dois recifes costeiros (Picãozinho e Quebra Quilhas) com características fisiográficas semelhantes. No entanto, as atividades recreativas ocorrem somente no primeiro e este último foi investigado como um recife controle. Em ambos os recifes, as famílias com o maior número de espécies e abundância foram Pomacentridae, Scaridae, Haemulidae, Acanthuridae e Labridae, mas a uniformidade foi bastante diferente entre os recifes, principalmente devido à abundância extrema do sargentinho *Abudefduf saxatilis* em Picãozinho. Esta espécie representou aproximadamente ⅔ de todos os indivíduos registrados em Picãozinho, e foi a principal responsável pelo padrão observado na estrutura da assembléia neste recife. O presente estudo mostrou que uma única espécie exerceu uma forte influência na uniformidade e na estrutura trófica, e que atividades recreativas não controladas têm o potencial de alterar severamente a assembléia de peixes recifais.

Palavras-chave: Turismo, assembléia, peixes recifais, Brasil, *Abudefduf saxatilis*.

Introduction

Fishing and tourism, when mismanaged, are potentially threatening activities to reefs (Milazzo *et al.* 2002). Fishing is clearly one of the most harmful sources of human impact on coral reefs (Bell 1983, Garcia-Rubies & Zabala 1990, Polunin & Roberts 1993, Garcia-Rubies 1999, Jackson *et al.* 2001, Myers & Worm 2003). One of the harshest effects of fishing is that, when certain species are caught, reef fish structure may be altered due to a cascade of interactions (McClanahan & Kaunda Arara 1996, Sala *et al.* 1998, Pinnegar *et al.* 2000). As a consequence, while the abundance of some species drastically collapses, particularly those targeted by fisheries, other species are benefited and rapidly increase their population size. As a result of this discrepancy, the whole community structure is modified (Sala *et al.* 1998, Pinnegar *et al.* 2000).

When compared to fisheries, recreational activities seem like a minor component with the potential to alter reef fish assemblage structure (see Milazzo *et al.* 2002). However, uncontrolled recreational activities are also potentially threatening. Many investigations have demonstrated the effects of trampling (Beauchamp & Gowing 1982, Liddle & Kay 1987, Liddle 1991, Brosnan & Crumrine 1994, Chandrasekara & Frid 1996, Brown & Taylor 1999, Eckrich & Holmquist 2000), boat anchoring (Walker *et al.* 1989, Hastings *et al.* 1995, Creed & Amado Filho 1999, Backhurst & Cole 2000), SCUBA-diving and snorkeling (Hunnam 1987, Hawkins & Roberts 1992, Davis & Tisdell 1996, Sala *et al.* 1996, Harriot *et al.* 1997, Medio *et al.* 1997, Rouphael & Inglis 1997) and artificial feeding (Perrine 1989, Cole 1994, Sweatman 1996, Hawkins *et al.* 1999, Milazzo *et al.* 2005, M. I. Ilarri *et al.* in prep.) on marine environments. Therefore, just as fisheries, recreational activities have the potential to strongly affect the overall community structure of marine environments, whether directly (e.g. boat anchoring) or indirectly (e.g. artificial feeding) (Brosnam & Crumrine 1994, Eckrich & Holmquist 2000, Milazzo *et al.* 2002).

The number of recreational activities has strongly increased worldwide in the past decades (Milazzo *et al.* 2002) and a corresponding increase in the number of studies investigating the effects of these activities on marine ecosystems can also be recognized (see Milazzo *et al.* 2002 for a review). However, only a few studies that investigated these effects on assemblage structure have been accomplished in Brazil (e.g. Creed & Amado Filho 1999, Vuelta, 2000, Costa *et al.* 2007), despite its almost 8000 km of coastline and the fact that the Brazilian coast has unique features (Maida & Ferreira 1997, Leão & Dominguez 2000) and holds a rich endemic fauna (Floeter & Gasparini 2000, Rocha 2003).

The present study was carried out in the northeastern coast of Brazil, an area which has received very little scientific attention in synecology and overall conservation ecology. Although attempts have been made in order to describe the effects of tourism on the studied reef, no quantitative data on these effects has been published up to date, and these few available attempts (Vuelta, 2000, Costa *et al.* 2007) are somewhat descriptive, thus providing limited information. The aim of this study was to verify the long-term effects of recreational activities on fish assemblage in a tropical shallow reef of the northeastern coast of Brazil, by comparing its fish assemblage structure to a nearby similar control reef, where tourism does not occur.

Material and Methods

Study area

Reef fish assemblage structure was evaluated at Picãozinho (W 34º 48’45”, S 7º 06’ 45”), a coastal tropical reef with a maximum depth of 6 m, located 1.5 km off the coast of João Pessoa, Paraíba, Brazil. The control reef, Quebra Quilhas (W 34º 48’ 45”, S 7º 06’ 9”) is also a shallow reef with a maximum depth of 5 m located 0.3 km to the north of Picãozinho (Figure 1).

Both reefs have similar physiographic characteristics being formed by large patches separated by internal pools and small water channels. The benthic community is dominated by algae and corals, with the most common algae being *Caulerpa racemosa* (Forsskal) J. Agardh, *Halimeda opuntia* (Linnaeus) and *Dictyopteris delicatula* J.V. Lamouroux, and the most common corals being *Palythoa caribaeorum* (Duchassaing & Michelotti), *Zoanthus sociatus* (Ellis)*, Siderastrea stellata* Verril and *Mussismilia hartii* Verril. Other components of the benthic communities, such as the sea urchin *Echinometra lucunter* (Linnaeus), the hydrocoral *Millepora alcicornis* Linnaeus, and other invertebrates including mussels, barnacles, sponges and ascidians, are also present, albeit much less abundant than the algae and corals. Large boulders, sand and limestone predominate in the adjacent areas of the patches.

Despite their similarities and the fact that neither Picãozinho nor Quebra Quilhas are under any kind of legal protection, tourist visitation is a common activity throughout the year at Picãozinho, being an important source of income to the local tourism industry since the mid 80’s. Nowadays, during low tides, between 90 and 200 tourists, in up to nine boats, visit the reef without any type of legal supervision. However, Quebra Quilhas is not visited by tourists mainly because of its small surface area, low water visibility and lack of anchoring places for boats close to the reef. Further, Picãozinho is traditionally regarded as one of the main tourist attractions of the city.

Sampling design

Fish assemblages were evaluated using a stationary visual census technique adapted from Bohnsack & Bannerot (1986). A diver remained in the centre of an imaginary cylinder with a 2.5 m radius and listed all species observed from the surface to the bottom during the first five minutes.

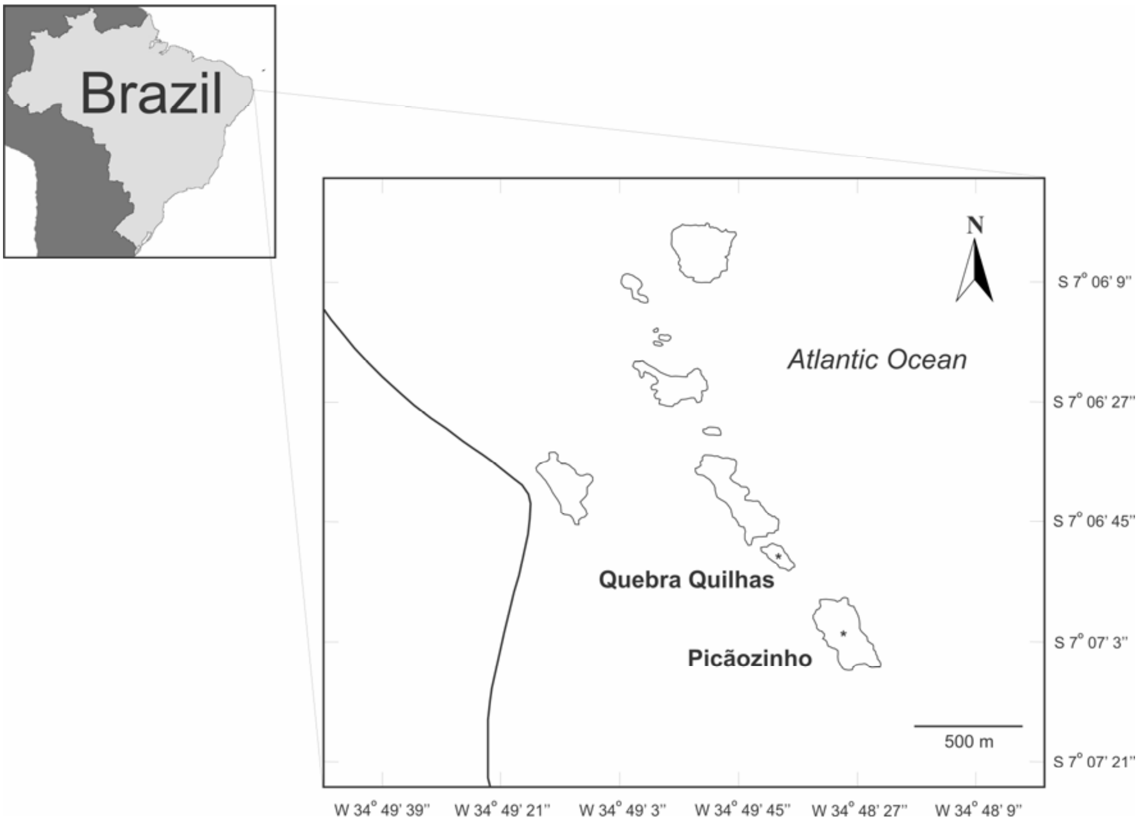

Figure 1. Location of the studied reefs in the northeastern coast of Brazil

In the subsequent five minutes, the number of individuals observed and their estimated size classes were listed. Size classes used were: 1-5 cm, 6-10 cm, 11-15 cm, 16-20 cm, 21-25 cm, 26-30 cm and 31-35 cm. Prior to the beginning of the study, the method described above was tested and researchers were familiarized with the areas by snorkelling along all extensions of the reefs.

A total of 60 censuses were done in haphazardly chosen areas within each reef between 8:00 and 14:00, from April through October of 2006, during low tides at depths between 0.4 and 2.5 m. All censuses totalled 1,200 minutes of underwater observation. Since the aim of the present study was to compare the long-term effects of tourism on fish assemblage, and not *in situ* influence of their visitation, censuses at Picãozinho were always done during the times with no tourist visitation to avoid bias caused by the human presence and their activities. Also, within-habitat, all sites sampled on both reefs presented similar physical characteristics being located near the reef border and composed of at least 75% consolidated substrata.

Species were grouped into one of nine trophic categories: carnivores, cleaners, mobile invertivores, omnivores, piscivores, planktivores, roving herbivores, sessile invertivores and territorial-herbivores (see Ferreira *et al.* 2004 for description of the categories). Trophic categories were presumed based on the available literature (Randall 1967, Hobson 1975) and from direct observations of the species behaving in their natural areas within each reef.

Data analysis

Species richness was the number of each species at each area and is always shown as an integer value. Frequency was the proportion of censuses that contained the species and was calculated by dividing the number of occurrences for a single species by the total number of occurrences for all species. Relative abundance was the number of individuals of a given species relative to overall abundance and was calculated by dividing the abundance of a species by the total abundance of all species combined.

Shannon Wiener's diversity (H') and equitability (E) indexes were estimated using Bio DAP (Biodiversity Data Analysis Package). Student's *t* tests were performed to compare the values obtained in each census between the reefs and was calculated with the program Statistica version 5.1 (Statsoft Corp., United States).

Results

A total of 4659 fishes belonging to 33 species and 19 families were recorded at Picãozinho (Table I). The most speciose families were Haemulidae (6 species), Acanthuridae (3), Pomacentridae (3) and Scaridae (3) and the five most frequent species, in decreasing order, were *Abudefduf saxatilis* (Linnaeus), *Sparisoma* sp., *Stegastes fuscus* (Cuvier), *Halichoeres brasiliensis* (Bloch) and *Haemulon parra* (Desmarest). Occasional and rare species (< 10% of occurrence) represented 49% of all fishes recorded. The pomacentrids *A. saxatilis* (n = 2869) and *S. fuscus* (n = 577) were the most abundant species accounting together for 73.98% of all individuals recorded, while the other 31 species represented 26.02%. Of the 19 families recorded, Pomacentridae (75.16%), Haemulidae (9.05%), Scaridae (7.27%), Labridae (2.6%) and Acanthuridae (2.47%) grouped 96.55% of all fishes observed in this reef.

At Quebra Quilhas, 1793 fishes belonging to 34 species and 19 families were recorded (Table I). The most speciose families were Haemulidae (5 species), Pomacentridae (3), Scaridae (3) and Serranidae (3) and the five most frequent species, in decreasing order, were *S. fuscus*, *A. saxatilis*, *Sparisoma* sp., *H. brasiliensis* and *Stegastes variabilis* (Castelnau). Occasional and rare species (< 10% of occurrence) represented 46% of all fishes recorded. The most abundant species were *S. fuscus* (n = 636) and *A. saxatilis* (n = 461), which accounted together for 61.16% of all individuals recorded, while the other 32 species represented 38.84%. Of the 19 families recorded, Pomacentridae (64%), Scaridae (8.53%), Haemulidae (8.03%), Acanthuridae (6.42%) and Labridae (5.3%) grouped 92.28% of all fishes observed in this reef.

Of the 41 species recorded, 26 were found on both reefs, seven were found exclusively at Picãozinho (*Acanthurus bahianus* Castelnau, *Entomacrodus vomerinus* (Valenciennes), *Eucinostomus argenteus* Baird & Girard, *Haemulon squamipinna* Rocha & Rosa, *Mugil curema* Velenciennes, *Ocyurus chrysurus* (Bloch) and *Sphoeroides testudineus* (Linnaeus)) and eight were found exclusively at Quebra Quilhas (*Ablennes hians* (Valenciennes), *Apogon americanus* Castelnau, *Cephalopholis fulva* (Linnaeus), *Elacatinus figaro* Sazima, Moura & Rosa, *Lutjanus analis* (Cuvier), *Pareques acuminatus* (Bloch & Schneider), *Rypticus saponaceus* (Bloch & Schneider) and *Scorpaena plumieri* Bloch) (Table I).

The overall diversity at Picãozinho (H' = 1.52) was considerably lower than at Quebra Quilhas (H' = 2.11). However, when considering fish diversity per area, values at both reefs were not significantly different (Table II). The overall equitability at Picãozinho (E = 0.43) was lower than at Quebra Quilhas (E = 0.6) and also, when considering equitability per area, Quebra Quilhas had significantly higher values. Number of species per area and total number of fishes per area were significantly higher at Picãozinho (Table II).

Of the species observed on both reefs, eight showed significant differences in abundance (Figure 2). Of these, six species were significantly more abundant at Picãozinho (*A. saxatilis*, *Acanthurus coeruleus* Bloch & Schneider, *Caranx latus* Agassiz, *Haemulon aurolineatum* Cuvier, *H. parra* and *Sparisoma* sp.) and two were more abundant at Quebra Quilhas (*Anisotremus moricandi* (Ranzani) and *Coryphopterus glaucofraenum* Gill).

At Picãozinho, the most speciose trophic category was mobile invertivores (n = 12 species), comprised mostly of haemulids and labrids, followed by roving herbivores (n = 8), mostly acanthurids and scarids, and carnivores (n = 4) (Table I). The other categories were omnivores (n = 3), planktivores (n = 2), territorial herbivores (n = 2), piscivores (n = 1) and sessile invertivores (n = 1). The most abundant trophic categories were omnivores (62.85%), territorial herbivores (13.57%), mobile invertivores (11.87%) and roving herbivores (9.83%), grouping 98.12% of all fishes recorded.

At Quebra Quilhas, the most speciose trophic category was also mobile invertivores (n = 11), comprising mostly haemulids and labrids, followed by carnivores (n = 7) mostly serranids, and roving herbivores (n = 5) mostly acanthurids and scarids. Other categories were planktivores (n = 3), omnivores (n = 2), territorial herbivores (n = 2), cleaners (n = 1), piscivores (n = 1) and sessile invertivores (n = 1). The most abundant trophic categories were territorial herbivores (38.32%), omnivores (26.1%), roving herbivores (14.95%) and mobile invertivores (13.78%), grouping 93.15% of all fishes recorded (Table I).

With regards to the abundance of trophic groups, a comparison between the reefs is shown in Figure 3. The trophic structure at Picãozinho was highly influenced by the high abundance of omnivores and that of Quebra Quilhas was much more homogeneous. Additionally, of the nine trophic categories recorded on both reefs, five were significantly different (i.e. mobile invertivores, omnivores, piscivores, planktivores and roving herbivores) (Table III).

Table I. Trophic categories, number of individuals, density per 20 m² (mean ± SE), frequency (%) and relative abundance (%) of reef fishes at Picãozinho and Quebra Quilhas.

		Picãozinho				**Quebra Quilhas**			
Family/Species	Trophic category	n	Density	Frequency (%)	Abundance (%)	n	Density	Frequency (%)	Abundance (%)
Acanthuridae									
Acanthurus bahianus Castelnau, 1855	Rov. Herbiv.	4	0.07 ± 0.04	5	0.09	—	—	—	—
Acanthurus chirurgus (Bloch, 1787)	Rov. Herbiv.	28	0.47 ± 0.11	30	0.6	79	1.32 ± 0.62	35	4.41
Acanthurus coeruleus Bloch & Schneider, 1801	Rov. Herbiv.	83	1.38 ± 0.16	71.66	1.78	36	0.6 ± 0.26	30	2.01
Apogonidae									
Apogon americanus Castelnau, 1855	Planktivore	—	—	—	—	2	0.03 ± 0.03	1.66	0.11
Belonidae									
Ablennes hians (Valenciennes, 1846)	Piscivore	—	—	—	—	1	0.02 ± 0.02	1.66	0.06
Blenniidae									
Entomacrodus vomerinus (Valenciennes, 1836)	Rov. Herbiv.	4	0.07 ± 0.03	6.66	0.09	—	—	—	—
Ophioblennius trinitatis Miranda Ribeiro, 1919	Omnivore	44	0.73 ± 0.11	51.66	0.94	7	0.12 ± 0.05	10	0.39
Carangidae									
Caranx latus Agassiz, 1831	Piscivore	17	0.28 ± 0.07	25	0.36	5	0.08 ± 0.04	8.33	0.28
Chaetodontidae									
Chaetodon striatus Linnaeus, 1758	Sessile Invertiv.	5	0.08 ± 0.04	8.33	0.11	1	0.02 ± 0.02	1.66	0.06
Gerreidae									
Eucinostomus argenteus Baird & Girard, 1855	Omnivore	15	0.25 ± 0.06	23.33	0.32	—	—	—	—
Gobiidae									
Coryphopterus glaucofraenum Gill, 1863	Planktivore	31	0.52 ± 0.12	31.66	0.67	67	1.12 ± 0.21	36.66	3.74
Elacatinus figaro Sazima, Moura & Rosa, 1997	Cleaner	—	—	—	—	1	0.02 ± 0.02	1.66	0.06

continue

Table I. continuation

		Picãozinho				Quebra Quilhas			
Family/Species	Trophic category	n	Density	Frequency (%)	Abundance (%)	n	Density	Frequency (%)	Abundance (%)
Haemulidae									
Anisotremus moricandi (Ranzani, 1842)	Mob. Invertiv.	3	0.05 ± 0.03	5	0.06	24	0.4 ± 0.13	18.33	1.34
Anisotremus virginicus (Linnaeus, 1758)	Mob. Invertiv.	19	0.32 ± 0.11	20	0.41	31	0.52 ± 0.12	35	1.73
Haemulon aurolineatum Cuvier, 1830	Mob. Invertiv.	154	2.57 ± 0.54	58.33	3.31	6	0.1 ± 0.07	5	0.33
Haemulon parra (Desmarest, 1823)	Mob. Invertiv.	233	3.88 ± 0.95	80	5	50	0.83 ± 0.26	45	2.79
Haemulon plumieri (Lacepède, 1801)	Mob. Invertiv.	3	0.05 ± 0.04	3.33	0.06	33	0.55 ± 0.26	11.66	1.84
Haemulon squamipinna Rocha & Rosa, 1999	Mob. Invertiv.	10	0.17 ± 0.08	8.33	0.21	—	—	—	—
Holocentridae									
Holocentrus adscensionis (Osbeck, 1765)	Mob. Invertiv.	3	0.05 ± 0.03	5	0.06	3	0.05 ± 0.03	5	0.17
Myripristis jacobus Cuvier, 1829	Planktivore	1	0.02 ± 0.02	1.66	0.02	1	0.02 ± 0.02	1.66	0.06
Labridae									
Halichoeres brasiliensis (Bloch, 1791)	Mob. Invertiv.	102	1.7 ± 0.17	85	2.19	82	1.37 ± 0.18	71.66	4.57
Halichoeres poeyi (Steindachner, 1867)	Mob. Invertiv.	19	0.32 ± 0.07	28.33	0.41	13	0.22 ± 0.07	16.66	0.73
Labrisomidae									
Labrisomus nuchipinnis (Quoy & Gaimard, 1824)	Carnivore	21	0.35 ± 0.08	30	0.45	28	0.47 ± 0.12	33.33	1.56
Lutjanidae									
Lutjanus analis (Cuvier, 1828)	Carnivore	—	—	—	—	2	0.03 ± 0.02	3.33	0.11
Ocyurus chrysurus (Bloch, 1791)	Carnivore	4	0.07 ± 0.03	6.66	0.09	—	—	—	—
Mugilidae									
Mugil curema (Valenciennes, 1836)	Rov. Herbiv.	4	0.07 ± 0.07	1.66	0.09	—	—	—	—
Mullidae									
Pseudupeneus maculatus (Bloch, 1793)	Mob. Invertiv.	1	0.02 ± 0.02	1.66	0.02	2	0.03 ± 0.02	3.33	0.11

continue

Table I. continuation

		Picãozinho				Quebra Quilhas			
Family/Species	Trophic category	n	Density	Frequency (%)	Abundance (%)	n	Density	Frequency (%)	Abundance (%)
Ophichthidae									
Myrichthys ocellatus (Lesueur, 1825)	Mob. Invertiv.	1	0.02 ± 0.02	1.66	0.02	2	0.03 ± 0.02	3.33	0.11
Pomacentridae									
Abudefduf saxatilis (Linnaeus, 1758)	Omnivore	2869	47.82 ± 6.92	98.33	61.6	461	7.68 ± 1.02	88.33	25.71
Stegastes fuscus (Cuvier, 1830)	Ter. Herbiv.	577	9.62 ± 0.78	96.66	12.38	636	10.6 ± 0.91	96.66	35.45
Stegastes variabilis (Castelnau, 1855)	Ter. Herbiv.	55	0.92 ± 0.15	51.66	1.18	51	0.85 ± 0.15	50	2.84
Scaridae									
Scarus trispinosus Valenciennes, 1840	Rov. Herbiv.	2	0.03 ± 0.03	1.66	0.04	10	0.17 ± 0.05	15	0.56
Scarus zelindae Moura, Figueiredo & Sazima, 2001	Rov. Herbiv.	3	0.05 ± 0.04	3.33	0.06	6	0.1 ± 0.04	10	0.33
Sparisoma sp. Swainson, 1839	Rov. Herbiv.	334	5.57 ± 0.42	98.33	7.17	137	2.28 ± 0.39	80	7.64
Scianidae									
Odontoscion dentex (Cuvier, 1830)	Carnivore	1	0.02 ± 0.02	1.66	0.02	2	0.03 ± 0.03	1.66	0.11
Pareques acuminatus (Bloch & Schneider, 1801)	Mob. Invertiv.	—	—	—	—	1	0.02 ± 0.02	1.66	0.06
Scorpaenidae									
Scorpaena plumieri Bloch, 1789	Carnivore	—	—	—	—	1	0.02 ± 0.02	1.66	0.06
Serranidae									
Cephalopholis fulva (Linnaeus, 1758)	Carnivore	—	—	—	—	1	0.02 ± 0.02	1.66	0.06
Epinephelus adscensionis (Osbeck, 1765)	Carnivore	8	0.13 ± 0.04	13.33	0.17	9	0.15 ± 0.05	15	0.5
Rypticus saponaceus (Bloch & Schneider, 1801)	Carnivore	—	—	—	—	2	0.03 ± 0.02	3.33	0.11
Tetraodontidae									
Sphoeroides testudineus (Linnaeus, 1758)	Mob. Invertiv.	1	0.02 ± 0.02	1.66	0.02	—	—	—	—

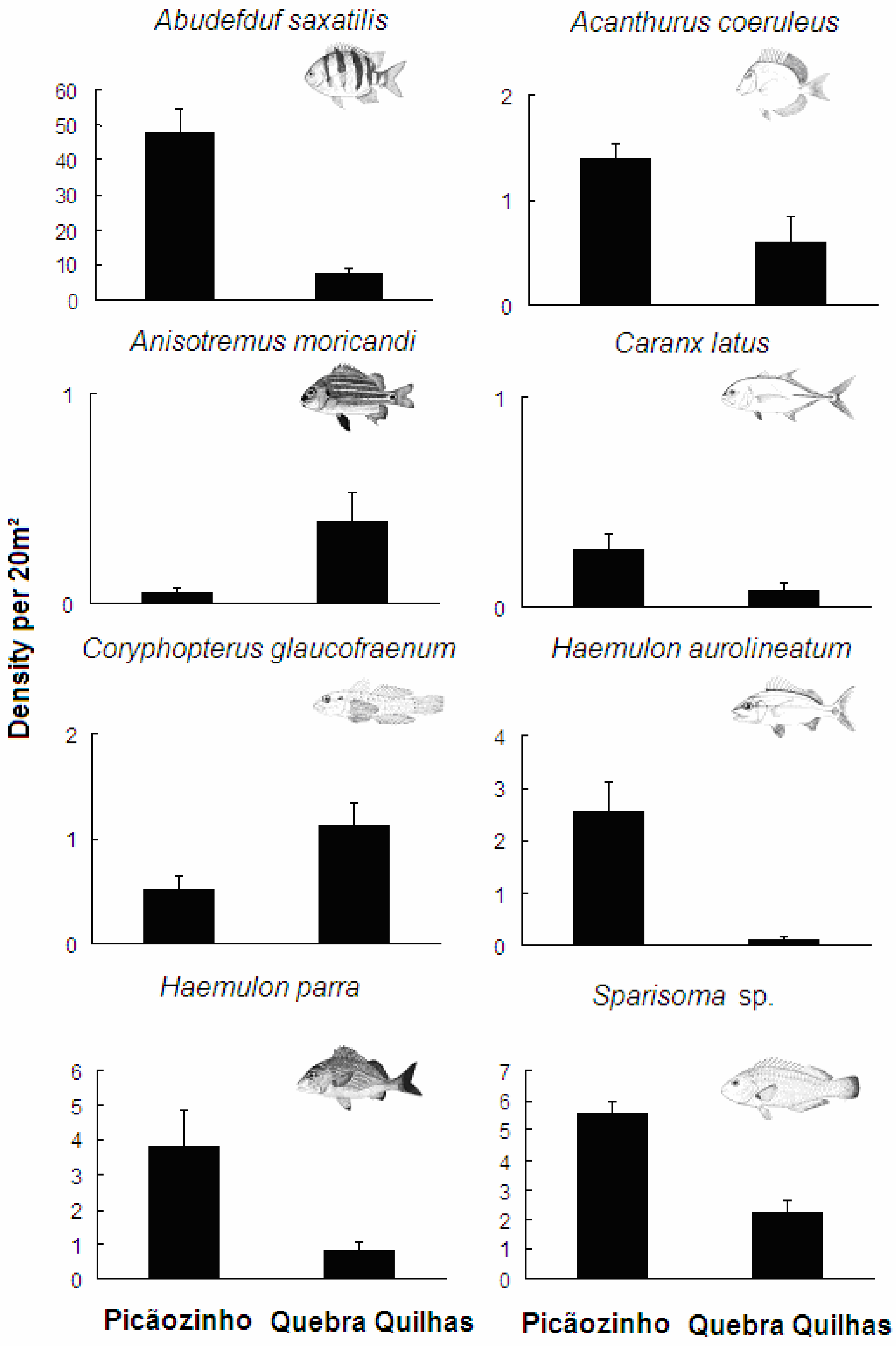

Figure 2. Density of fishes (per 20 m²) (mean ± SE) at Picãozinho and Quebra Quilhas. Student's *t* test showed significant differences in fish abundance between reefs ($P < 0.05$). Note that different scales were used.

Table II. Summary of reef fish variables (mean ± SD) plus the Student's *t* test results of comparisons between study sites. * Indicates significant difference.

	Picãozinho	Quebra Quilhas	Student's *t* test results
Fish diversity (H') per 20m^2	1.45 ± 0.51	1.51 ± 0.37	t = -0.74; P = 0.46
Fish equitability (E) per 20m^2	0.65 ± 0.2	0.75 ± 0.11	t = -3.67; P < 0.001*
Number of species per 20m^2	9.57 ± 2.17	7.62 ± 2.10	t = 5.01; P <0.001*
Number of fishes per 20m^2	77.65 ± 55.40	29.88 ±14.63	t = 6.46; P < 0.001*

Table III. Reef fish trophic categories (density per 20m^2) (mean ± SD) plus the Student's *t* test results of comparisons between study sites. * Indicates significant difference.

Trophic Categories	Picãozinho	Quebra Quilhas	Student's *t* test results
Carnivores	0.14 ± 0.39	0.11 ± 0.43	t = 1.08 ; P = 0.28
Cleaners	-	0.02 ± 0.13	t = -1.00 ; P = 0.32
Mobile invertivores	0.71 ± 2.67	0.37 ± 1.44	t = 3.90; P < 0.001*
Omnivores	16.36 ± 38.13	3.9 ± 6.74	t = 5.87; P < 0.001*
Piscivores	0.28 ± 0.52	0.05 ± 0.22	t = 2.35; P < 0.05*
Planktivores	0.27 ± 0.73	0.39 ± 1.09	t = -2.45; P < 0.05*
Roving herbivores	1.09 ± 2.34	0.89 ± 2.8	t = 3.02; P < 0.01*
Sessile invertivores	0.08 ± 0.28	0.02 ± 0.13	t = 1.68; P = 0.1
Territorial herbivores	5.27 ± 6.15	5.73 ± 7.02	t = -0.75; P = 0.46

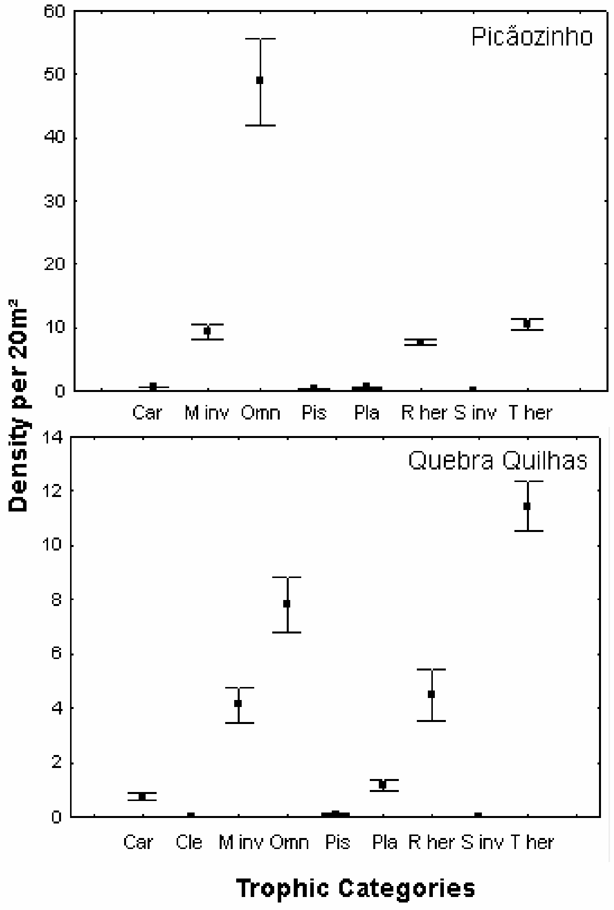

Figure 3. Density of fish trophic categories (mean ± SE) at Picãozinho and Quebra Quilhas. Note that different scales were used. Car: carnivores, Cle: cleaners, M inv: mobile invertivores, Omn: omnivores, Pis: piscivores, Pla: planktivores, R her: roving herbivores, S inv: sessile invertivores and T her: territorial herbivores.

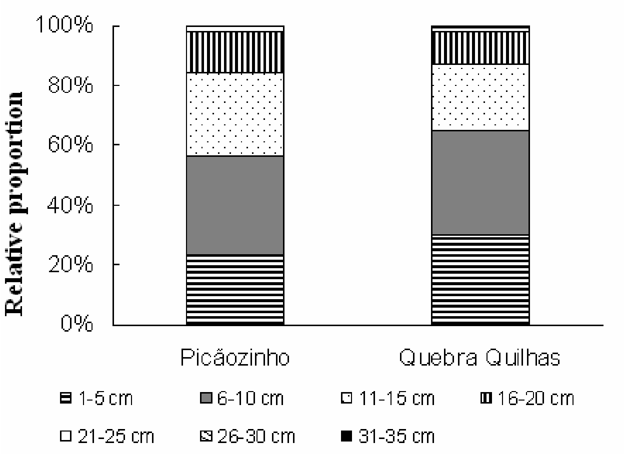

Figure 4. Relative abundance of the size classes of the fishes at Picãozinho and Quebra Quilhas.

At Picãozinho, 33% of the fishes measured between 6 and 10cm, 28% between 11 and 15cm and 23% measured between 1 and 5cm, whereas at Quebra Quilhas, 35% of the fishes measured between 6 and 10 cm, 30% between 1 and 5 cm and 22% measured between 11 and 15 cm (Figure 4). No significant differences related to size classes between the two reefs were detected (Student's *t* test, $P > 0.05$).

Discussion

The two studied reefs sustained similar fish assemblages with the most speciose and abundant families being Pomacentridae, Scaridae, Haemulidae, Acanthuridae and Labridae. These families group the typical reef dwelling fishes, which are very common in the northeastern coast of

Brazil (Ferreira *et al.* 1995, Rocha *et al.* 1998, Rocha & Rosa 2001, Dias *et al.* 2001, Feitosa *et al.* 2002).

Despite these similarities, remarkable differences were detected between the reefs. The most striking disparity concerns the extremely high abundance of the sergeant major *Abudefduf saxatilis* at Picãozinho, which accounted for almost ⅔ of all individuals recorded on this reef and was over six times more abundant than at Quebra Quilhas. During tourist presence at Picãozinho, this species is conspicuously the most affected fish, becoming effortlessly attracted by the external sources of food provided by tourists. In fact, a remarkable change in the behavior of this species can be observed ever since tourist arrival at the reef and changes in their overall abundance may also be observed when comparing between human-frequented and unfrequented periods (M.I. Ilarri *et al.* in prep.). Feeding by tourists has the potential to directly alter the behavior of many fish species, which are attracted by this external source of food (Cole 1994, Sweatman 1996) and eventually may display aggressive behaviors (Perrine 1989, Quinn & Kojis 1990). It is very likely that over the past decades, uncontrolled tourism may have strongly benefited the individuals of *A. saxatilis* and, as a consequence, the overall abundance of this species was dramatically increased. Human trampling is another activity that may supply the fishes with other sources of food in the studied reef (M.I. Ilarri *et al.* in prep.). When humans trample the substrate, especially in algal dominated areas, burrowing invertebrates become exposed and attract potential invertivores and carnivores which are nearby. Consequently, this activity also has the potential to alter fish behaviour considerably.

Furthermore, the higher abundances of juveniles of *Acanthurus coeruleus* and *Sparisoma* sp. at Picãozinho suggest that this reef is under a higher level of human interference, since high abundance of herbivores in marine ecosystems may indicate a sign of degradation due to the higher biomass of algae (e.g. Rogers & Beets, 2001). Although the above-mentioned species were benefited by these activities, a discrepancy on the population levels within a fish assemblage is considered a sign of historical environmental change, which is caused or, at least, enhanced by human activities. These discrepancies were also noticed elsewhere (see Milazzo *et al.* 2002) and have been related to recreational activities benefiting one or few species, with harsh consequences on others. Although in reefs worldwide, protected or non-protected, it is common to observe a pattern shifting from common abundant species and a progressive decline to rarer species (Magurran 1996), in no undisturbed natural system investigated up to date in Brazil, one single species prevail all other by 75% (e.g. Ferreira *et al.* 1995, Floeter *et al.* 2000, Feitosa *et al.* 2002, Rocha *et al.* 2001, Ferreira *et al.* 2004). Nonetheless, although only two species were less abundant at Picãozinho (see Figure 2), most other species did not seem to be negatively affected by the recreational activities and their abundances did not differ from those of the control reef. However, the increased population size of only a few species indicates a significant shift in fish assemblage structure at Picãozinho.

Nowadays, unregulated recreational activities are one the underlying anthropogenic factors responsible for causing several types of impacts on marine ecosystems and their living organisms (Sala *et al.* 1996, Harriot *et al.* 1997, Millazzo *et al.* 2002).

As a consequence of the uneven fish composition, due especially to the extremely high abundance of *A. saxatilis*, trophic structure was more homogenous in the control reef. Undisturbed tropical fish assemblages usually display a large trophic spectrum with many categories in the community (Hobson 1974). In a study conducted in another shallow reef of northeastern Brazil by Feitosa *et al.* (2002), fish trophic categories even showed a more homogenous distribution than the reefs evaluated in the present study (Figure 5).

Furthermore, highly diversified and undisturbed communities are usually characterized by the presence of few common species and a progressive decline to many occasional or rare species (Magurran 1996). Therefore, the great abundance of few species in such a diverse ecosystem is atypical and this progressive decline

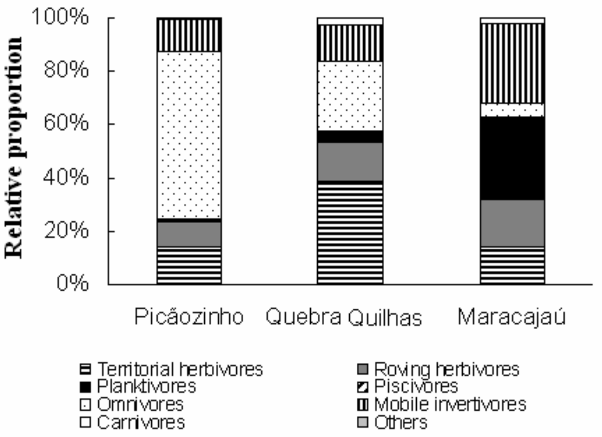

Figure 5 Relative abundance of trophic categories of the fishes at Picãozinho, Quebra Quilhas and Maracajaú. Data from Maracajaú was obtained from Feitosa *et al.*, 2002.

was observed on neither reef, but to a much less extent at Picãozinho. Thus, the observed structure of both reefs suggests that, besides tourism at Picãozinho, other external factors may have contributed to the current patterns observed. Nowadays, large predators in northeastern Brazil are restricted to deeper reefs as a consequence of a long history of overfishing that took place in the shallow reefs of this area (Feitoza *et al.* 2005). Thus, it is reasonable to consider that fishing has also played a major role in shaping the assemblage structure on these shallow reefs by altering the reef trophic dynamics over the decades. The removal of large predators is considered to have a major influence on the trophic structure of a reef, often leading to an increase in the population of their prey, which in turn, influences the whole base of the food web (Steneck 1998, Pace *et al.* 1999, Shears & Babcock 2002, Duffy 2003). For example, Ceccarelli *et al.* (2006) experimentally removed medium and large fishes, as a simulation of over-fishing, and found changes in the relative abundances of two species of damselfishes and on their overall dynamics.

The present study showed how one single species, *A. saxatilis*, was of major influence on species evenness and trophic structure on a reef with common tourist visitation. Therefore, the extremely high abundance of this species was the underlying feature responsible for the assemblage structure pattern observed on the reef. Due to uncontrolled recreational activities that take place in this reef since the mid 80's without regulation or authority supervision whatsoever, fish assemblage structure has been intensively modified. Whether by artificially feeding the fishes or by trampling over the substrate, humans represent potential threats to the reef. Nonetheless, the patterns observed on both reefs suggest that other external factors, such as the historical over-harvesting of large predators, may have also contributed to the current pattern observed nowadays.

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Lytechinus variegatus (Lamarck) (Echinodermata, Toxopneustidae), covering behavior

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The green sea urchin *Lytechinus variegatus* (Lamarck, 1816) is commonly found in inshore shallow-water areas where it usually occurs alone on sandy bottoms (Hill & Lawrence 2003). Frequently, this species can adorn itself with debris in a so-called ‘covering behavior’ (Millott 1955, Verling *et al.* 2004). Much controversy surrounds the significance of this behavior, but it may provide protection against predators or against physical factors such as light and temperature, thus avoiding body desiccation (see Verling *et al.* 2004). On December 08th 2006 at 11:20, a 12 cm total length specimen of *L variegatus* was observed covered by the brown seaweed *Dictyota* sp. and a terrestrial angiosperm on a rocky shore of Ilha Grande, Angra dos Reis-RJ, Brazil at a depth of 1.5 m. This behavior has great ecological importance, since it may help in the dispersal of marine, estuarine and even terrestrial plants attached to its back. Since the wave action is considerably strong on rocky shores (Nybakken & Bertness 2004), these plants may leave the sea urchin spines and occasionally establish themselves on a favorable sheltered place. Picture Characteristics: Sony® DSC-N1; Resolution of 8.1 megapixels (300 dpi); diaphragm aperture F/4; time of exposition 1/640; Speed ISO-64.

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Predation of the sea anemone *Bunodosoma cangicum* Corrêa, 1964 (Cnidaria, Anthozoa, Actiniidae) on a swimming crab *Callinectes* sp. Stimpson, 1860 (Decapoda, Brachyura, Portunidae)

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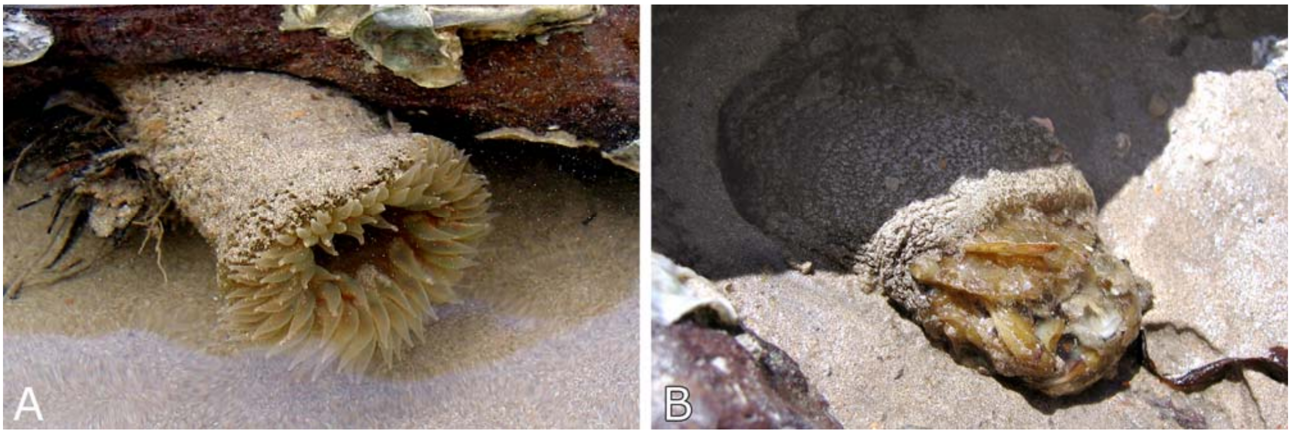

Sea anemones are solitary polyps that belong to the Phylum Cnidaria and the Class Anthozoa (Order Actiniaria or Corallimorpharia) (Fautin & Allen 1994). These animals inhabit shallow or deep coastal waters throughout the world, but are particularly diverse in tropical oceans (Ruppert *et al*. 2005). Although they are not considered especially voracious predators, sea anemones feed on a variety of prey that includes small fish, sea cucumbers, mollusks and crustaceans, especially crabs (Fautin & Allen 1994). Sea anemones of the species *Bunodosoma cangicum* Corrêa, 1964 are frequently seen in the inter-tidal zone during low tides on the coastal reefs of Cabo Branco beach (João Pessoa, Paraíba State, Brazil) (Fig. A). On April 1, 2007, during field work on these reefs (7º08’50” S, 34º47’51” W) a predation event was witnessed involving *Bunodosoma cangicum* attacking a swimming crab, *Callinectes* sp. Stimpson, 1860 (Fig. B). At the moment of the sighting, the inter-tidal region was totally exposed due to the low tide. The anemone was approximately 5 cm tall and the swimming crab occupied the entire gastro vascular cavity. The crab appeared to be larger than the anemone could hold, and the crab was in fact partially visible, which allowed its identification to the genus level. The crab was covered by a transparent gelatinous material, presumably secreted by the anemone to facilitate the digestive processes. In light of the sessile habit of the anemones and the large size of the crab, this animal was probably captured during high tide, and the ingestion and digestion processes continued even as the tide ebbed. Although the remains of swimming crabs have been reported among the stomach contents of sea anemones (Fautin & Allen 1994, Ruppert *et al*. 2005), this is the first photographic documentation of the predation of *Callinectes* sp. by *Bunodossoma cangicum* under natural conditions. Picture’s characteristics: Digital Machine model Canon PowerShot S50, 5 megapixels resolution (180 dpi), diaphragm aperture 2.8 (Fig. A) and 3.5 (Fig. B), time of exposition 1/200 (Fig. A) and 1/1000 (Fig. B).

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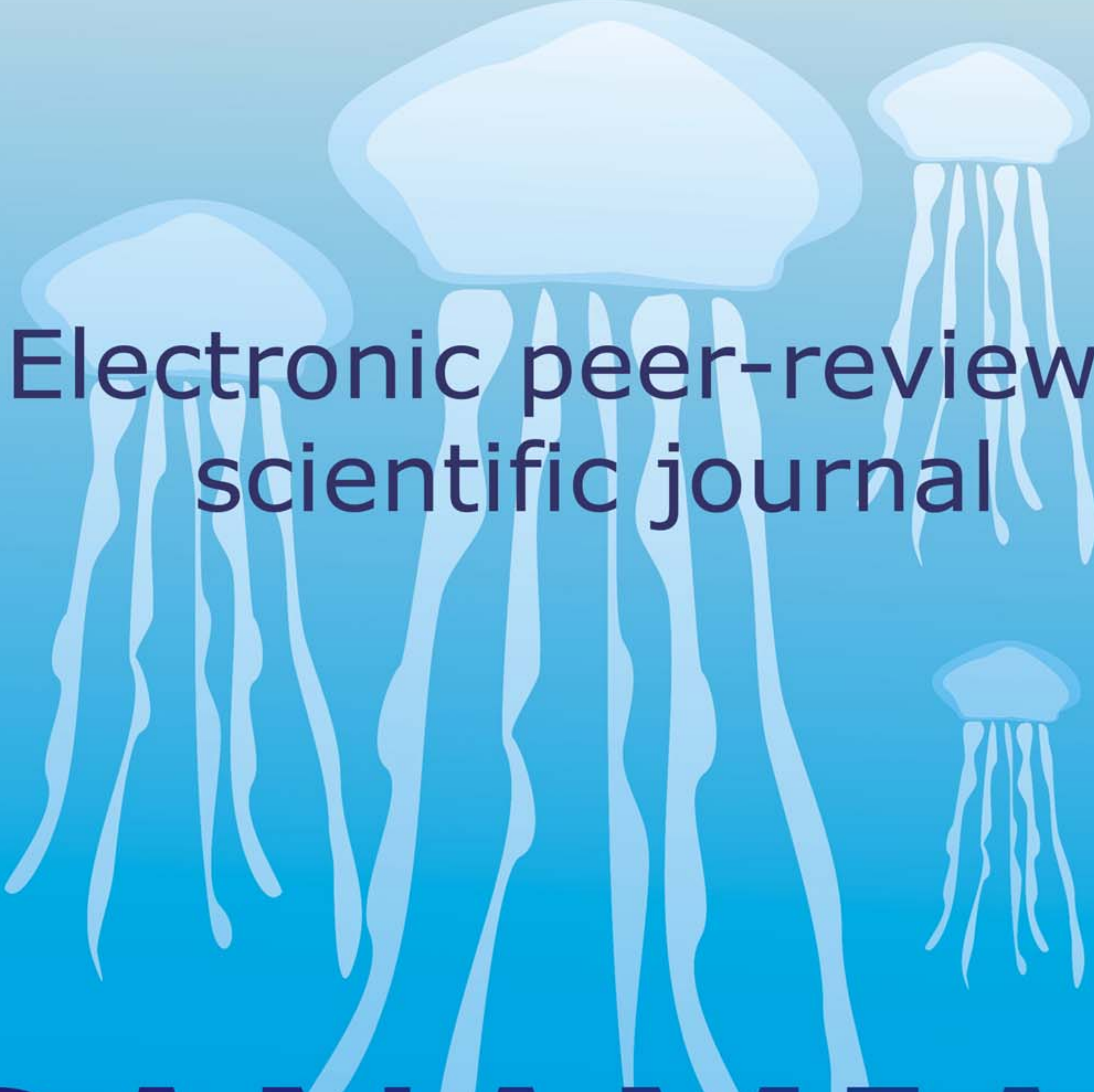

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