UNIVERSIDADE FEDERAL DO PARÁ
MUSEU PARAENSE EMÍLIO GOELDI
PROGRAMA DE PÓS-GRADUAÇÃO EM ZOOLOGIA
CURSO DE DOUTORADO EM ZOOLOGIA

ECOLOGIA POPULACIONAL DO CARANGUEJO *Dissodactylus crinitichelis* Moreira, 1901 (CRUSTACEA: DECAPODA) E SEU HOSPEDEIRO *Encope emarginata* Leske, 1778 (ECHINODERMATA: CLYPEASTEROIDEA) NO LITORAL NORDESTINO BRASILEIRO

M. Sc. Aislan Galdino da Cunha

Tese apresentada ao Programa de Pós-graduação em Zoologia, Curso de Doutorado, do convênio Museu Paraense Emílio Goeldi e Universidade Federal do Pará como requisito parcial para obtenção do grau de Doutor em Zoologia.

Orientador: Dr. **Luciano Fogaça de A. Montag**
Lab. de Ecologia e Conservação, ICB/UFPA

Co-orientadora: Dra. **Sigrid Neumann-Leitão**
Dep. de Oceanografia, UFPE

Belém - Pará
2015

ECOLOGIA POPULACIONAL DO CARANGUEJO *Dissodactylus crinitichelis* Moreira, 1901 (CRUSTACEA: DECAPODA) E SEU HOSPEDEIRO *Encope emarginata* Leske, 1778 (ECHINODERMATA: CLYPEASTEROIDEA) NO LITORAL NORDESTINO BRASILEIRO

M. Sc. Aislan Galdino da Cunha

Banca examinadora:
Dr. **Luciano Fogaça de Assis Montag** (ICB/UFPA) – Orientador/Presidente
Dra. **Sigrid Neumann-Leitão** (DOCEAN/UFPE), Co-orientadora

Dra. **Jussara Moretto Martinelli-Lemos** (ICB/UFPA)
http://lattes.cnpq.br/5264841936875017

Dra. **Valéria de Albuquerque Oliveira** (UNAMA)
http://lattes.cnpq.br/0793726662640165

Dr. **José Eduardo Martinelli Filho** (IGEOG/UFPA)
http://lattes.cnpq.br/2080628833884538

Dr. **Felipe Andrés León Contrera** (ICB/UFPA)
http://lattes.cnpq.br/3815182976544230

Suplentes:
Dr. **Jesser Fidelis de Souza Filho** (UFPE)
http://lattes.cnpq.br/1937412883296517

Dr. **Cleverson Rannieri Meira dos Santos** (CZO/MPEG)
http://lattes.cnpq.br/8626400902445523

DEDICATÓRIA

“Dedico aos meus pais Severino Galdino da Cunha, que pode não ter sido o melhor pai do mundo, mas, não mediu esforços para se torna-lo, a minha mãe que é a melhor mãe do universo, e minha filha Sophia Mendes da Cunha, com sorrisos energéticos e revigorantes em todos os momentos”

AGRADECIMENTOS

Um trabalho dessa grandeza não poderia ser desenvolvido sem a colaboração de outras pessoas. Agradeço a Deus, por me manter com força e saúde, ao longo desse estágio da minha vida pessoal e profissional.

Ao meu orientador Luciano Montag por aceitar e contribuir com meu projeto de vida. Além de ser um orientador sempre presente, professor exigente e compreensivo, e amigo, que sempre estava ao meu lado em todos os momentos. Mostrando o caminho certo e "puxando" minhas orelhas quando necessário. "Levarei todos os seus ensinamentos ao longo de minha vida".

A minha co-orientadora Sigrid Neumann-Leitão, que não mediu esforços para realização deste trabalho. Em todos os momentos foi otimista, alegre e com palavras certas, nas horas certas, ao longo de todo o nosso convívio. Além de contribuir com ensinamentos profissionais e pessoais, sempre visando aprimorar seus alunos e amigos.

Aos meus amigos em Belém, Guilherme uma das pessoas mais humildes e inteligente, que encontrei na minha vida. Ao Bruno Prudente, Tiago, Cleo, Valéria, pessoas altamente competentes, solícitas e inteligentíssimas.

Aos meus amigos Unilton, Cristopher, Leonardo, Milton e Priscila, que tornaram momentos longe da família em momentos únicos vividos. Principalmente ao longo das disciplinas, sempre puxaram todo o grupo para um conjunto, quando necessário.

Aos professores da pós-graduação da UFPA e Museu Emílio Goeldi, pelos ensinamentos, conselhos e ajudas, sempre que necessário.

A grande família do laboratório de zooplâncton, Tamara Almeida, Xiomara Garcia, Lucas Figueiredo, Alejandro Esteweson, Erica Côrrea, Danielle Melo e Jana Ribeiro, capitaneada pela professora Sigrid, com profissionais altamente capacitados e que não medem esforços para ajudar seus membros. Além de outras pessoas que compõem o laboratório de zooplâncton marinho, como o professor Ralf Schwamborn, Glace Santos, Cyntia Lima e Igor Ávila.

Agradeço a toda minha família que nunca deixou de me ajudar, mesmo em madrugas frias e com chuva, tornavam minhas coletas em evento familiar. A minha esposa Deise Mendes, que mesmo com barrigão de Sophia ajudou em minhas coletas e segurou todos os problemas no início da criação da segunda mulher de minha vida, sem minha presença. Só consegui alcançar este passo na minha vida, graças a ela, "a mulher de minha vida". Aos meus país Severino Galdino e Joaquina Galdino, que mesmo com

problemas de saúde estavam sempre em minhas coletas, apoiando com muita gargalhada, otimismo e muito “vamos que dá”.

ÍNDICE

LISTA DE FIGURAS

LISTA DE TABELAS

RESUMO

CUNHA, A. G. da (2015). **Ecologia populacional do caranguejo *Dissodactylus crinitichelis* Moreira, 1901 (Crustacea: Decapoda) e seu hospedeiro *Encope emarginata* Leske, 1778 (Echinodermata: Clypeasteroidea) no litoral nordestino brasileiro**. Tese de Doutorado. Universidade Federal do Pará e Museu Paraense Emílio Goeldi.

Esta tese apresenta informações a respeito dos efeitos das variáveis ambientas sobre a ecologia populacional do caranguejo *Dissodactylus crinithichelis* e seu hospedeiro *Encope emarginata* e as influências que as bolachas-da-praia exercem sobre a população do caranguejo no litoral nordestino brasileiro. Foram realizadas amostragens biótica e abiótica, ao longo de nove praias que compõem o litoral pernambucano, que faz parte do Atlântico Sul-ocidental. A granulometria foi a variável abiótica com maior influência sobre as duas espécies. As bolacha-da-praia tendem a ocupar, com maior densidade, a costa norte de Pernambuco, sendo as fêmeas adultas a maioria da população. O período de recrutamento foi descrito para agosto e maio. Os indivíduos de bolacha-da-praia apresentaram maior densidade nas classes de comprimento intermediária, com destaque para os comprimentos de 10 à 12 cm. As bolachas-da-praia não apresentaram crescimento polifásico, com alometria negativa. Em relação aos parâmetros populacionais de *D. crinitichelis*, residindo nas bolachas-da-praia, não foi observado variação ao longo dos meses do ano. Os caranguejos também apresentaram maior densidade nas praias do litoral norte. Houve um domínio de machos nos meses do período de estiagem, enquanto que de fêmeas no período chuvoso. Foi observado recrutamento de indivíduos juvenis ao longo de todo ano, com um pico no mês de maio. A espécie apresentou elevada correlação entre os indivíduos juvenil, imaturo e macho adulto, com crescimento polifásico, com alometria positiva juvenis, imaturos e machos adultos, assim como para as fêmeas adultas, com maior evidenciamento da alometria positiva. Em relação da influência de *E. emarginata* sobre a população de *D. crinitichelis*, foi verificado que os caranguejos apresentam habitam com maior intensidade as bolachas-da-praia adultas, em suas classes intermediárias. No entanto, quando essas encontram-se ocupadas, as bolachas-da-praia imaturas podem ser ocupadas pelos caranguejos. Observou-se uma diminuição na densidade dos estágios subsequentes dos caranguejos, independente dos estágio de desenvolvimento da bolacha-da-praia. Foi observado uma maior abundância de caranguejos machos, nas classes de área da bolacha-da-praia. Desta forma, o presente trabalho contribui com informações sobre a biologia populacional de *E. emarginata* e *D. crinitichelis*, além de contribuir com papel que uma espécie exerce sobre a outra. Visto que, são espécies bioturbadoras da camada superficial do sedimento marinho, com função de manutenção da trofia nas praias arenosas, tanto para as espécies residentes como para as espécies visitantes. Sendo estas áreas como locais de manutenção das populações circunvizinhas de caranguejo *D. crinitichelis* como da bolacha-da-praia *E. emarginata*. E de relevante interesse a ecologia das populações, pesca subsistência da população ribeirinha e lazer da população humana.

INRODUÇÃO GERAL

O caranguejo *Dissodactylus crinitichelis* (Figura 1) é um crustáceo da Ordem Decapoda, Infra-Ordem Brachyura, Superfamília Pinnotheroidea e Família Pinnotheridae (SCHMITT *et al.*, 1973; MARTINS & D'INCAO, 1996). É encontrado nos hábitats marinho e costeiro, distribuído em quase todos os oceanos (SCHMITT *et al.*, 1973; MARTINS & D'INCAO, 1996). Possui uma ampla distribuição no Atlântico Ocidental, com espécimes encontrados na América do Norte, desde o Estado da Carolina do Norte, Flórida e Golfo do México (EUA); ao longo de toda América Central, e na América do Sul até a Argentina (RATHBUN, 1918; MELO, 1999).

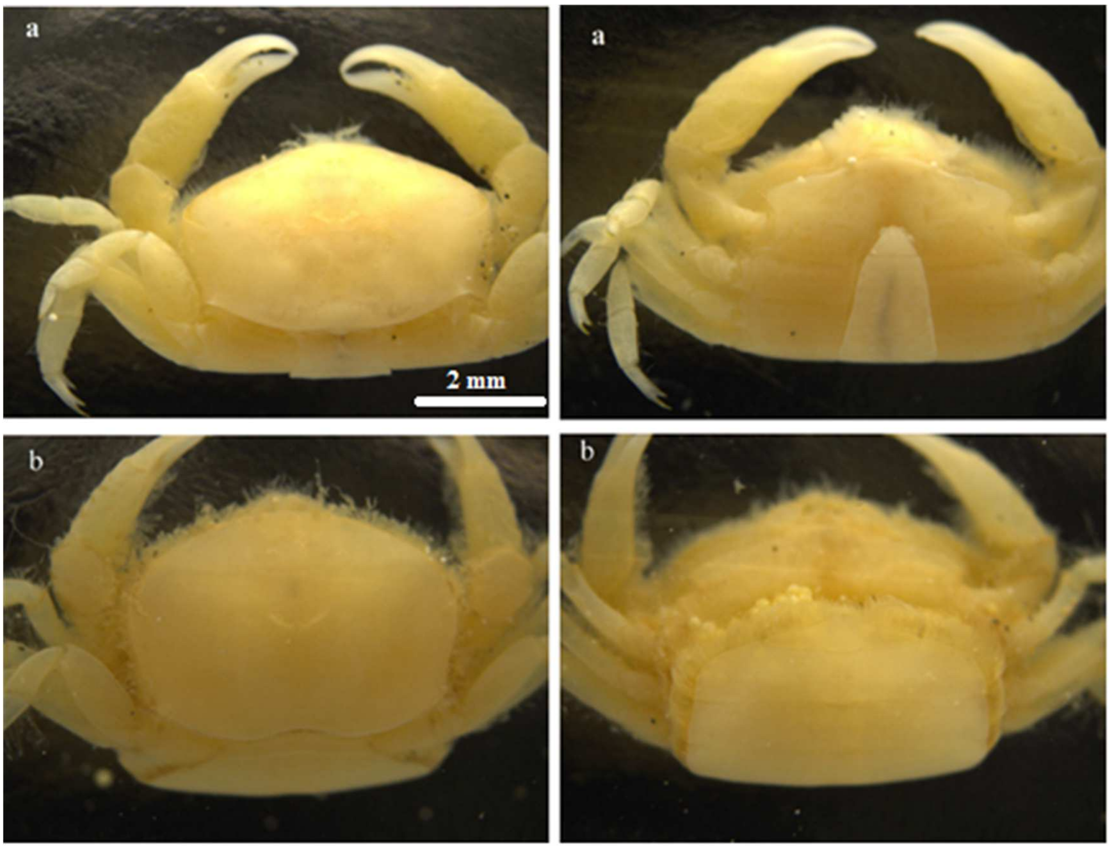

Figura 1. Foto de *Dissodactylus crinitichelis*, a - macho adulto e b - fêmea adulta capturados nas praias do litoral de Pernambuco - Brasil.

Os indivíduos dessa SuperFamília vivem associados a outras espécies. Alguns caranguejos vivem dentro do seu hospedeiro, os quais se adaptaram morfologicamente para viverem de forma solitária, como *Zaops ostreum* Say, 1817 (dentro de moluscos bivalves). Outros vivem de forma comunal (sobre a superfície do seu hospedeiro), como os *D. crinitichelis* (TELFORD, 1978b; POHLE & TELFORD, 1981; GRIFFITH, 1987).

Iniciam sua vida no plâncton (BELL, 1984), passam a viver, após o assentamento, quase que exclusivamente em seus respectivos hospedeiros. As espécies do gênero *Dissodactylus* Smith, 1870 residem sob equinóideos irregulares (bolacha–da–praia). De acordo com GEORGE & BOONE (2003), os caranguejos deste gênero residem entre uma camada densa de espinhos no lado oral de várias espécies de bolachas-da-praia.

O caranguejo *D. crinitichelis* já foi registrado nas seguintes espécies de equinóides irregulares: *Encope emarginata* Leske, 1778 (Figura 2A), *E. michelini* Agassiz, 1841, *Clypeaster subdepressus* Gray, 1825 e *Leodia sexiesperforata* Leske, 1778 (Figura 2B) (TELFORD, 1978b; POHLE & TELFORD, 1981; GRIFFITH, 1987). GRAY *et al.* (1968) registraram a presença do caranguejo na bolacha-da-praia *Mellita quinquiesperforata* Leske, 1778 (Figura 2C). No entanto, como indicado por TELFORD (1978b), não se sabe como as populações destas espécies se apresentam sobre os efeitos do ambiente ou se ocorre influência de uma espécie sobre a outra. PEARCE (1962); PEARCE (1964) e TELFORD (1978a) estudando as espécies da Família Pinnotheridae, verificaram que os caranguejos *D. crinitichelis* roubariam o alimento transportado pelos pedicelos até a abertura oral da bolacha–da–praia.

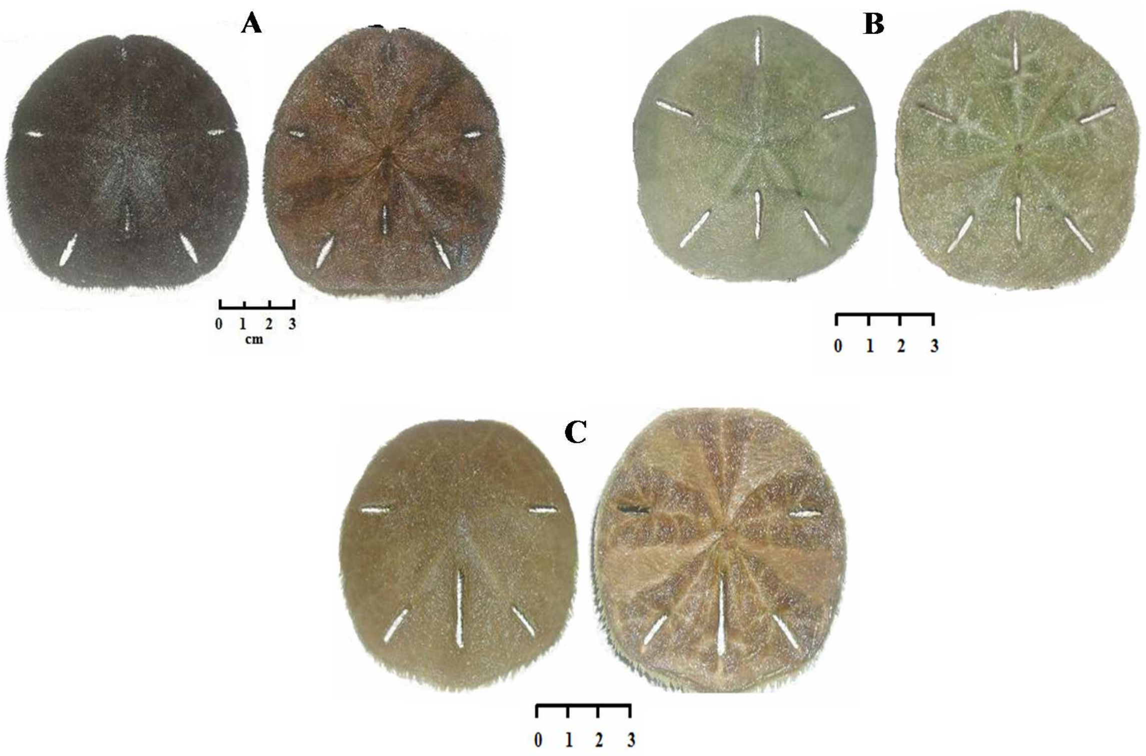

Figura 2. Foto das espécies de bolacha-da-praia encontradas no litoral de Pernambuco, Atlântico Sudoeste; visão aboral (esquerda) e visão oral (direita) *Encope emarginata* (A), *Leodia sexiesperforata* (B) e *Mellita quinquiesperforata* (C).

A bolacha-da-praia *E. emarginata* é um dos hospedeiros do gênero *Dissodactylus*, é um equinóide irregular, está inserida dentro do Filo Echinodermata, Classe Echinoidea, Ordem Clyperasteroida e Família Mellitidae (TOMMASI, 1999; FERNANDES *et al.*, 2002; MANSO *et al.*, 2008). É marinha, com corpo levemente arredondado ou elíptico e achatado dorsoventralmente. Possui elevada abundância no ambiente bentônico (HENDLER *et al.*, 1995) e é amplamente distribuída em todos os oceanos (AMARAL *et al.*, 2003). Esta espécie de bolacha-da-praia pode ser encontrada das regiões entremarés (LIMA & FERNANDES, 2009) até 50 metros de profundidade (REICHHOLF, 1981). Na costa atlântica costumam habitar a região do sublitoral, próximo à zona de arrebentação das ondas, nos ambientes não consolidados e tende a apresentar comportamento gregário (BORGES *et al*., 2002).

De modo geral, as diferentes espécies da Família Mellitidae, que ocorrem no oceano Atlântico, mostram-se bem adaptadas a ambientes costeiros, próximo à desembocadura de rios, com salinidades de até 18 e boa adaptação à variação térmica (TAVARES, 1996). A existência desses animais num determinado hábitat pode estar relacionada à granulometria, as quais evitam fundos síltico-argilosos, bancos de ostras e substratos com raízes de plantas, onde a escavação pode ser dificultada (TAVARES, 1996). Nestes ambientes, ocupam exclusivamente sedimentos arenosos onde vivem parcialmente enterradas nas camadas superficiais de areia, preferencialmente em depressões, barras ou locais onde há moderada ação de ondas, deixando a região posterior com a lúnula anal visível (WEIHE & GRAY, 1968; BELL & FREY, 1969; MERRIL & HOBSON, 1970).

A região costeira, onde estas espécies vivem (*D. crinitichelis* e *E. emarginata*) desempenha uma importante função para a biota como um todo, sendo hábitat para muitas espécies residentes (molucos, equinodermata, crustáceos e fanerógamas), e visitantes (peixes e crustáceos), os quais utilizam como locais de alimentação, proteção, dispersora e receptora de novas colonizações (WIEGERT & POMEROY, 1981; HECK *et al.*, 1995; ALLEN, 2000; WEISTEIN & KREEGER, 2000).

Entre as variáveis ambientais com maior importância para as comunidades de macroinvertebrados bentônicos destacam-se a salinidade, o oxigênio, a temperatura, e as características do sedimento (KAISER *et al.*, 2005). Deste último, a caracterização das partículas do sedimento é identificada como um importante fator, porém não é limitante para os organismos ali residentes (WEISBERG *et al.*, 1997; LLANSÓ *et al.*, 2002), sendo a salinidade apontada como o fator dominante e limitante, interagindo diretamente na distribuição dos organismos ao longo da região costeira (LITTLE, 2000; KAISER *et al.*, 2005). Apesar da temperatura ser uma variável com pouca variação na região tropical, é responsável pela alteração no metabolismo dos indivíduos, atingindo diretamente o consumo do alimento e o processo digestivo (SMITH, 1989). E com isto, influencia diretamente na duração de cada ciclo de muda e intermuda em cada indivíduo na população de caranguejo (CASTIGLIONI & NEGREIRO-FRANSOZO, 2006).

A estrutura populacional das espécies costeiras, está diretamente relacionada aos regimes hidrológicos, às variações de salinidade e temperatura ao longo do ano e em diferentes locais (ALBUQUERQUE *et al*., 2012). Inserido nesse contexto, está o padrão de distribuição das espécies, que é resultado das suas preferências e plasticidades, em adaptarem-se às diferentes características dos hábitats (NORSE, 1978; HINES *et al.*, 1990), os quais regem, muitas vezes, a flutuabilidade nos valores da densidade, através do comportamento migratório, como o assentamento de larvas, na busca por novas áreas, servindo para fins de assentamento (CAMERON & RUMRILL, 1982; EPIFANIO, 1988; DALTOV, 2000; POSEY *et al.*, 2005).

A fim de completar as informações biológicas das espécies, fazem-se necessário o conhecimento detalhado de suas características populacionais, além de descrever o efeito que a espécie hospedeira (bolacha-da-praia) exerce ao seu hóspede (caranguejo) (BUCHANAN & STONER, 1988). O conhecimento da influência dessas variáveis na comunidade permite compreender os mecanismos que podem favorecer a ocupação, recolonização e/ou expansão do número de indivíduos, as quais respondem de forma favorável às flutuações impostas pelo ambiente ao longo do ano (MAIA-BARBOSA *et al.*, 2003).

Com base nos expostos acima, a presente tese está estruturada para responder as seguintes perguntas:

(i) As variáveis abióticas nas respectivas praias do litoral nordestino influenciam positivamente a população de *E. emarginata*.

Espera-se encontrar uma correlação positiva entre a densidade de *E. emarginata* e dos seus estágios de desenvolvimento no litoral nordeste brasileiro, e as principais variáveis abiótivas, que oscilam ao longo do ano (regimes hidrológicos, salinidade, temperatura e granulometria).

Fatores exógenos (regime hidrológico, temperatura, salinidade e granulometria) regem muitas vezes a variação anual das diferentes espécies que ocorrem no ambiente; influenciam diretamente nas densidades das espécies, assim como, na densidade de cada estágio do ciclo de vida (VENTURA & PIRES, 2002). E indirentamente, condicionam outros fatores como a proporção sexual, período de recrutamento e o crescimento das espécies (LAGE *et al.*, 2011).

(ii) A espécie *D. crinitichelis*, residente nas espécies de bolacha-da-praia é afetada pelas variáveis ambientais em diferentes praias do litoral nordestino brasileiro?

Espera-se encontrar a mesma densidade de *D. crinitichelis* e de seus estágios desenvolvimento residentes nas bolachas-da-praia, encontradas nas diferentes praias do litoral nordestino sob influência do regime hidrológico e variações de temperatura e salinidade da água do mar; além de caracterizar a razão sexual, o período de recrutamento e o crescimento de *D. crinitichelis* ao longo dos meses amostrados.

De acordo com OLIVEIRA & MASUNARI (1995) e SCHWAMBORN (1997), de forma geral os caranguejos apresentam abundâncias semelhantes, em suas estruturas populacionais, ao longo dos meses do ano, não apresentando grandes flutuações anuais em um mesmo local. Porém estes mesmos autores citam uma exceção de dois picos distintos no assentamento das fases larvais e pós-larvais, ocasionados por condições propícias para uma melhor dispersão dos indivíduos, como por exemplo, à maior amplitude anual das marés (OLIVEIRA & MASUNARI, 1995; SCHWAMBORN, 1997). Estas marés são registradas em março (período chuvoso) e a segunda no mês de setembro (período de estiagem). Este comportamento é utilizado pelos crustáceos para que possam sincronizar, uma maior quantidade das suas formas larvais (zoea e megalopa), minimizando os riscos de predação, a fim de perpetuar a carga genética ao longo dos diferentes ambientes costeiros (OLIVEIRA & MASUNARI, 1995; SCHWAMBORN & BONECKER, 1996).

O conhecimento da população de *D. crinitichelis*, nos regimes hidrológico, nas variações de salinidade, temperatura da água e granulometria, pode auxiliar o entendimento da sua dinâmica populacional e indicar se alguns destes fatores ambientais regem o comportamento dispersivo da espécie (BREWER, 1994) e, a partir daí, descrever os estoques populacionais da espécie (DORNELAS *et al.*, 2011), que são afetados muitas vezes pelos impactos antrópicos (MANTELLATO & BARBOSA, 2005).

(iii) Como a bolacha-da-praia *E. emarginata* influencia o caranguejo *D. crinitichelis* residente em sua superfície?

Espera-se encontrar a mesma abundância total, assim como dos seus estágios de desenvolvimento bentônico do *D. crinitichelis*, residentes nos estágios de desenvolvimento bentônico, sexo e área corpórea da *E. emarginata*; além disso, caracterizar a razão sexual e o crescimento do caranguejo *D. crinitichelis* residentes nos diferentes estágios de desenvolvimento e sexo da bolacha-da-praia *E. emarginata*.

Outras espécies de caranguejos (*D. mellitae*) residentes em *Mellita quiquiesperforata* (bolacha-da-praia) demonstram ter preferência por bolacha-da-praia maiores. Uma vez que, o caranguejo poderia encontrar um desenvolvimento bem sucedido em indivíduos maiores (POHLE & TELFORD, 1981). Ou seja, *E. emarginata* com maior área corpórea ofereceriam melhor proteção e maior quantidade de alimento, para todos os *D. crinitichelis* residentes nesses indivíduos, proporcionando melhores condições de vida para população (GRAY *et al.*, 1968; DEXTER, 1977).

A fim de responder os questionamentos acima propostos, esta tese divide-se em três capítulos intitulados:

- Capítulo I - Influence of environmental parameters on population structure of the sand dollar Encope emarginata Leske, 1778 (Echinodermata: Clypeasteroidea: Mellitidae) in a tropical Brazilian Coast;

- Capítulo II - Estruture populational of Dissodactylus crinitichelis Moreira 1901 (Decapoda: Pinnotheridae) on the Pernambuco coast: Relationships to environmental variables;

- Capítulo III – Influence of host Encope emarginata Leske, 1778 (Echinoidea: Clypeasteroida) over the crab the crab Dissodactylus crinitichelis Moreira, 1901 (Brachyura: Pinnotheridae) in a Tropical Brazilian Coast.

Área de Estudo

O Atlântico Sudoeste tropical abrange os mares costeiros e plataformas continentais abaixo da linha do equador ao longo da costa da América do Sul até o Cabo Frio, no Rio de Janeiro, onde é inserido o Estado de Pernambuco. O litoral de Pernambuco apresenta 187 km de comprimento caracterizadas por uma faixa estreita de areia com muito pequenas manchas de floresta original Atlântico. Esta área tem um clima quente e úmido tropical e é classificada como As' (escala de Köppen). A temperatura média anual do ar é de 26ºC e de água é de cerca de 27ºC. Umidade relativa do ar está em torno de 80% ea precipitação anual varia 1000-2300 mm, estação chuvoso ocorre de março a agosto e estiagem de setembro a fevereiro. O vento predominante é sudeste e sua velocidade média é de 3 $m.s^{-1}$ (Andrade & Lins, 1965; Aragão, 2004). As características mais notáveis são os recifes de arenito que ocorrem em várias linhas paralelas à costa, representando linhas de praia rock, às vezes com um crescimento excessivo fina de algas calcárias e corais (Mabesoone & Coutinho, 1970).

Costa Pernambuco pode ser dividido nas praias do Norte e Sul (Araújo, 2003), com o rio Capibaribe (Recife Cidade) como marca divisória. As praias do litoral Norte têm pequenos bancos de angiospermas marinhas (*Halodule wrightii* Ascherson) e ricos fragmentos de algas calcárias de *Halimeda* spp. bancos (Magalhães et al., 1997); e, apresentam deposição de areia e silte sedimento fino, regado pelos rios do continente (Barros et al., 2001). As praias do litoral Sul apresenta sedimentos variando de arenosa a areia e cascalho, com a parte rasa feita de siliciclástica dominado por quartzo, ea parte mais profunda, com sedimentos bioclásticos (Hickson, 1980, Fonseca et al., 2002).

CAPÍTULO I - Influence of environmental parameters on population structure of the sand dollar *Encope emarginata* Leske, 1778 (Echinodermata: Clypeasteroidea: Mellitidae) in a tropical Brazilian Coast

Cunha, A. G.; Neumann-Leitão, S.; Montag, L. F. A.

Capítulo a ser submetido para a revista *Hydrobiologia* (ISSN: 1573-5117)

Abstract

Studies about *Encope emarginata*, were carried out in nine beaches tropical Brazilian Coast to assess the influence of abiotic variables and seasonality over its population structure. On area of 200 m² was sampled in each of the beaches. Abiotic variables were simultaneously collected. It was obtained the density, biomass, length, developmental stage and sex of individuals. 1,801 males, 2,253 females and 410 immature sand-dollars were collected, of which 98.3% were from the north coast of Pernambuco State. It was observed the following average values of total density 0.27 ind.m^{-2} and sex ratio (M: F) 1.3:1. Furthermore, occurred a peak recruitment in August and the species presented a negative allometric growth. The abiotic variables had influence in the population, with differences, between coasts. Having a granulometry as the variable that governs the entire distribution of individuals, which demonstrates an intimate relationship. Additionally, which were related to local hydrodynamics, as the beaches on the South coast have beachrocks close to the beach, forming a zone of wave energy absorption compressing and hindering the settlement and displacement of individuals. It was observed a sex ratio is around 1, which it is common for Echinoidea. The growth reflects the need of individuals to achieve larger sizes, continuously along their development stages. This article contributes to the spatial and seasonal distribution of *Encope emarginata*. Demonstrating its importance for the preservation of areas important to all marine biodiversity.

Keyword: Seasonal, Abiotic variables, Population biology, Sand beach, Tropical Atlantic.

Introduction

Benthic animals have a significant function in energy transfer since they are intensely preyed by fish, larger crustaceans and others carnivorous (Solan et al., 2004). The sand dollars recycle nutrients and pollutants, and are used as indicators of environment quality since they are closed connected with the bottom and sedentary life (Underwood & Chapman, 1996; Chapman, 2005). Among benthic organisms, echinoderms are a dominant group of macro-invertebrates living on and in many soft and hard bottom of marine assemblages; and, they play an important role in structuring these communities (Vazquez-Bader et al., 2008).

The *Encope emarginata* presented a wide distribution of on the Brazilian coast, however, there are fow studies about this species. Most researches are in the gray literature, or mention its occurrence and distribution in Santa Catarina, South of Brazil (Reichholf, 1981), morphology (Ventura et al., 2010), in associations with a crab (Guizardi & Couto, 2014; Martinelli et al., 2014), or, inserted in studies about echinoderms to Brazil (Tommasi, 1964) and to Pernambuco, Northeastern Brazil (Lima & Fernandes, 2009).

The *E. emarginata* is an irregular echinoiderms that lives in sandy substrates of protected bays and open coastal places, with a wide distribution in the Western Atlantic littoral (Lawrence et al., 2004; Guizardi & Couto, 2014). They live in partially buried in the surface stratum of sand and in areas of moderate wave action forming patches in the low intertidal and subtidal zones of sheltered bays, and in the subtidal zone just ahead of the break zone of coastal areas (Giberto et al., 2004; Guizardi & Couto, 2014). The bioturbation activity by this species is fundamental to oxygenate the sediment improving biomass, organic matter availability and nutrients regeneration, vital processes to the productivity of oceans (Solan et al., 2004).

Furthermore, little is known about the influence of environmental variables on survival these irregular echinoids, which are governed by different variables (Drouin et al., 1985; Lawrence, 1996; Tyler et al., 2000). Evem as the annual variation of rainfall, temperature, salinity and nature of sediment that can influence the spatial and temporal patterns of distribution (Barnes & Crook, 2001; Kaiser et al., 2005; Swigart & Lawrence, 2008). Furthermore, also influence the settlement and recruitment (Young & Chia, 1982; Ebert, 1983; Hereu et al., 2004), food availability (Menge, 1992), predation (Tegner & Dayton, 1981; Sala, 1997), and competition (Hagen & Mann, 1992). As described in a few decades ago, with extensive mortality of shallow water subtropical and tropical echinoiderms from exposure to high temperature (Glyn, 1968); and, experiments with sand dollars have shown a reduced fertilization success during low-salinity events (Allen & Pechenik, 2010). Besides, the substrate also influences the position of echinoiderms (Morin et al., 1985), and most species dominate in medium to fine grain sand showing substrate preference (Harold & Telford, 1982).

The abiotic variables may affect indirectly influencing the length/biomass ratio of these organisms (Schwalne & Chouinard, 1999). The study of this ratio is important, as it is possible to describe one variable when the other is absent. Thus, it can be seen how environmental conditions affect individuals, allowing growth comparisons in different populations (Schwalne & Chouinard, 1999). Length/biomass ratio can be used as a quantitative indicator of the growth and degree of healthiness, known as condition factor (Le Cren, 1951). The espécies of echinoids presented differences in the allometric growth between the parametres evaluated, this species present a high degree of variability in the growth, the male present a typical growth and the female other, feature of need that each individual presents (Hérnandez & Russel, 2010). Already the condition factor has been used to evaluate different feeding conditions in many species, interferences in population density, weather and other environmental parameter, so the condition factor can be used as a body index reflecting the interactions between the individual studied (sand dollar) and abiotic variables (Schwalne & Chouinard, 1999).

This study was carried out to assess the monthly variation of the main abiotic variables influencing the population of the sand dollar *E. emarginata* from Pernambuco coastal area, located in the tropical Western Atlantic. Our hypothesis is that the temperature, salinity, rainy and granulometria vary along the year and beaches may be preponderant in explaining the variations of density population. Other hypothesis is that abiotic variables vary along the year with sex ratio, recruitment period and allometric condition factor. The species growth is expected to be presents a polyphasic.

Material and methods

Study Area

The Coast of Pernambuco is inserted in the Southwest Atlantic Tropical (Figure 1). The Pernambuco beaches are composed of two deposits of sediment, the surface is rich in sandy sediment (fine - rough) rich in quartz and silt; this coastal, there are seagrass banks (*Halodule wrightii* Ascherson) and fragments of calcareous algae Halimeda spp. (Magalhães et al., 1997; Barros et al., 2001; Fonseca et al, 2002;. Araujo, 2003). The outstanding features of this coast is the presence of sandstone reefs that occur on multiple lines (distant - North Coast, 2,000 m and near - South Coast, 50 m) parallel to the coast; representing lines of "rock beaches", sometimes with a thin overgrowth of calcareous algae and corals (Mabesoone & Coutinho, 1970).

The collections were carried out monthly, from November 2011 to October 2012, during low tide. For the purpose of standardization, these sampling were held in the interval between two days before and after new moon. Nine beaches along the coast were selected, about 20 km from one another, with four on the north and five on the south coast (Figure 1). The beaches from the north coast: Carne de Vaca (07º 35. 352’ S; 034º 49. 216 W), Sossego (07º 42. 987’ S; 34º 49. 877’ W), Orange (07º 48. 522’ S; 34º 50. 161’ W) and Maria Farinha (07º 51. 804’ S; 34º 50. 063’ W). South coast: Suape (08º 21. 851’ S; 34º 57. 496´ W), Porto de Galinhas (08º 30. 247’ S; 35º 00. 009’ W), Barra de Sirinhaém (08º 36. 721’ S; 35º 02. 814’ W), Tamandaré (08º 44. 926’ S; 35º 05. 203’ W) and São José da Coroa Grande (08º 52. 718’ S; 35º 08. 242’ W).

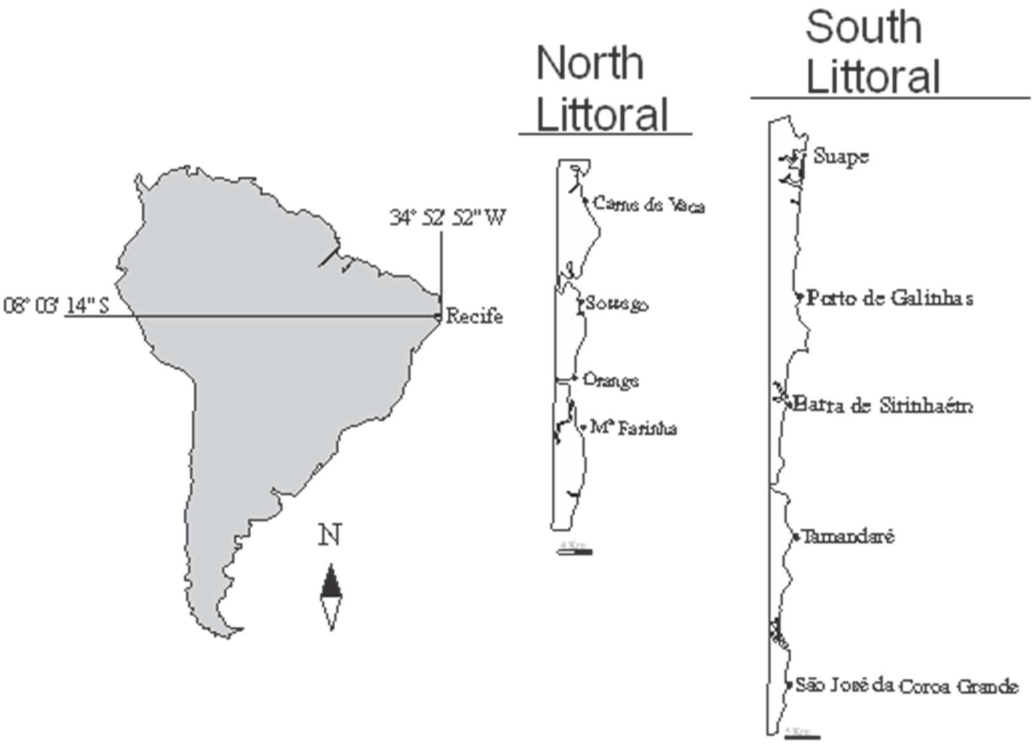

Figure 1. Studied area and sampling stations (North Littoral - Carne de Vaca, Sossego, Orange, Maria Farinha; South Littoral – Suape, Porto de Galinhas, Barra de Sirinhaém, Tamandaré e São José da Coroa Grande) of Pernambuco littoral, Sowthwestern Atlantic, from October/2011 to September/2012.

Design Experimental

All samples were obtained from a fixed quadrant of 600 m² (20 m x 30 m) positioned parallel to the beach line at diurnal low tide. This quadrant was subdivided into three areas with 200 m² (20 m x 10 m), with one selected at random to be sampled, and this area was not used in the following month, minimizing overlapping of samples.

All individuals of *E. emarginata*, inside the quadrant of 200 m², were manually collected using diving equipment (mask and breathing tube) according to Bell & Stansik (1983). Each individual was packaged inside a plastic tray and placed in a plastic bag, properly labeled, packed in coolers with ice and brought to the Zooplankton laboratory of the Federal University of Pernambuco (Brazil), and kept cooled in freezers until the analysis. Parallel collections of biological material, has measured up abiotic variables that could influence the metabolism of species (temperature) and the spatial distribution (salinity and grain size). For this, mostred a sampled of water temperature (mercury thermometer ºC) and salinity (Optical refractometer) were obtained in each sampling site. Sediment samples were taken for analysis of granulometry, according to Suguio (1973).

Laboratory proceedings

In the laboratory, the species were identified with specific literature (Fernandes et al., 2002; Manso et al., 2008). Then, for each individual it was measured the total length (TL) with a 0.05 mm precision caliper rule; and, the wet biomass in grams (HB) using an analytical electronic balance (0.001 g precision), after removing the excess of water with tissue paper.

The *E. emarginata* specimens were classified in two gonad maturity stages: immature (with undefined sexual glands) and adults (with developed sexual glands). These adults were subdivided into adult male (AM), when the gonads presented colors ranging from cream to brown; and, adult female (AF), when the gonads ranged around lilac color (Dias, 2008).

Data analysis

Initially, the density of *E. emarginata* was checked for its normality (Kolmogorov-Smirnov test) and homocedasticity (Levene test). As the data did not reach this assumption, it was transformed ($\text{Log}_{10}(x + 1)$) and reassessed for its normality and homocedasticity, and from there it was only used non-parametric tests.

To verify differences in the population structure (total, immature, male and female), over the months, the Kruskal-Wallis test was used. The influence of the abiotic variables on the density of each stage that makes up the population was calculated through multiple and single regression (Zar, 1999). The recruitment period was verified through analysis of variance (Kruskal-Wallis) and sex ratio was verified by a Chi-Square-test (X^2).

It was established the number of size classes length based in "Sturges model" (k=1+3.3*log (n)), that determines "k" in function of "n", where "*k*" is the number of classes and "*n*" is the number of individuals. It was established 12 length classes (1.5 cm interval).

For analyses growth, initially was developed a simple linear regression analysis between biomass x length to give a potency equation for male and female, from these equations proportional residuals of male and female were obtained. After, the values of proportional residuals (male and female) was verified if existence of polyphasic growth for specie. For this, it was found in the length / biomass of male and female individuals, through the distribution of its proportional residuals, compared with a *t* test (Zar, 1999). If differences were observed between the proportion residues of males and females, growth was considered whether or not polyphasic. Male individuals have a different growth of females, forcing the need to describe all developmental stages and sex of the species. Length and weight measurements were conducted to allometric equation, following the model of Huxley ($y=a.x^b$), where "y" is the individual wet biomass, "x" is the individual length, "a" is proportionality coefficient and "b" is allometric coefficient. The coefficient of allometric growth (b) can be isometric (= 3), negative (<3) or positive (> 3). For adjust the values of allometric conditions factor was plotted a potency equation. The condition factor (k) was developed by the formula "$k= B/L^b$", B = individual biomass, L = individual length and "b" = Allometric coefficient of its beach and month in which the individual was collected. From there was adjusted a polynomial equation that best represents the plotted data.

The tests described were calculated in statistical software "R", in its version 3.1.1, and it was considered a significance level of α = 0.05 "package stats".

Results

We collected 4,464 individuals of *Encope emarginata*, of these 410 (9.18%) individuals were immature, 1,801 (40.34%) individuals were adults males, and 2,253 (50.48%) individuals were adults females.

The species *E. emarginata* presented an average of 0.27 ± 0.72 Ind.m^{-2} with the largest value average (0.58 Ind.m^{-2}) obtained in the May month and lower value average (0.03 Ind.m^{-2}) obtained in the September (figure 2a). The immature showed an average of 0.02 ± 0.09 Ind.m^{-2}, with the largest average value (0.08 Ind.m^{-2}) obtained in the August, while no immature were recorded in November and February (figure 2b). The adult males showed an average of 0.08 ± 0.30 Ind.m^{-2}, the greatest average value (0.30 Ind.m^{-2}) obtained in the May and lower value average (0.01 Ind.m^{-2}) obtained in the September (figure 2c). The adult females showed an average of 0.10 ± 0.36 Ind.m^{-2}, the greatest average value (0.32 Ind.m^{-2}) obtained in the August and lower value average (0.006 Ind.m^{-2}) obtained in the September (figure 2d).

No difference was registered between total density of *E. emarginata* in the months ($H_{(12, 9)} = 2.6596$, $p = 0.9945$). As the benthic development stages of *E. emarginata*: immature ($H_{(12, 9)} = 7.2605$, $p = 0.7776$), male ($H_{(12, 9)} = 2.1808$, $p = 0.9978$), female ($H_{(12, 9)} = 6.0536$, $p = 0.8698$).

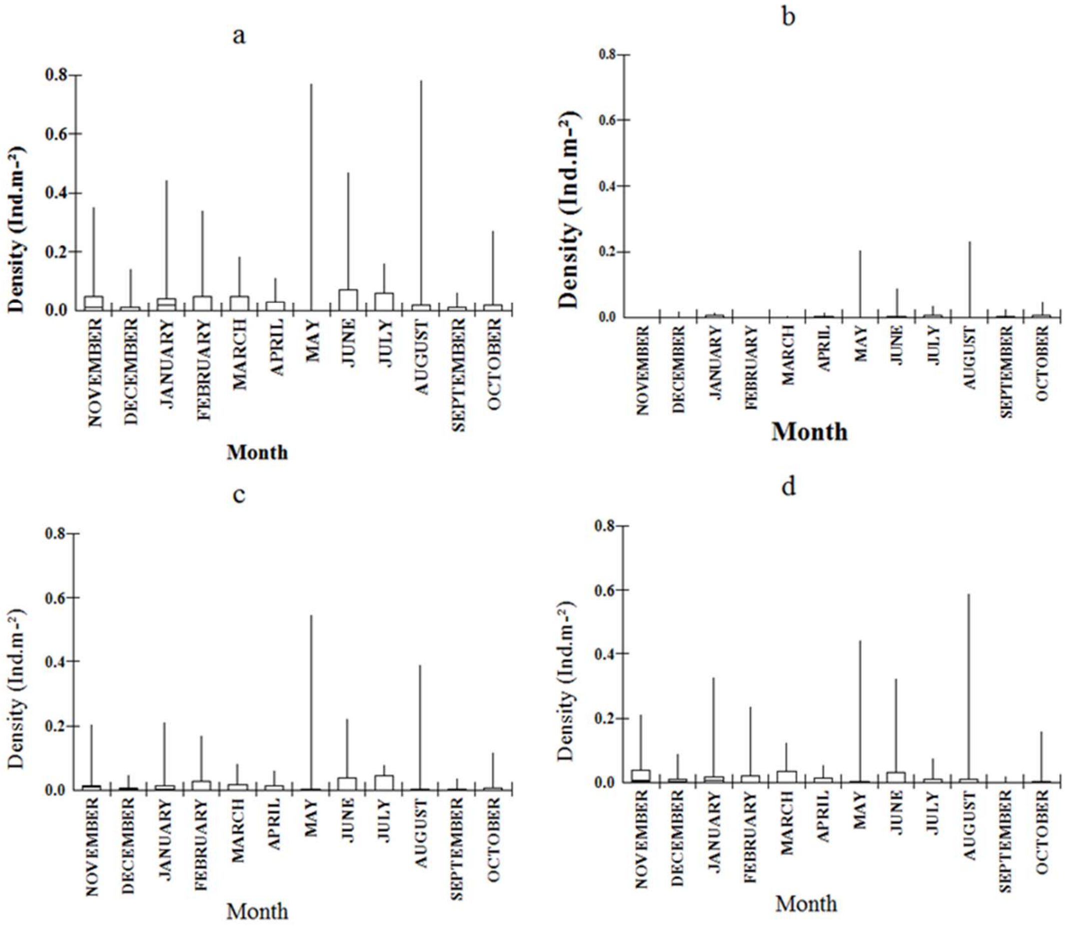

Figure 2: *Encope emarginata* population: “a” total density, “b” density of immature, “c” density of male and “d” density of female, at Pernambuco littoral, tropical Southwestern Atlantic, from November/2011 to October/2012.

In respect of populational density, of all development stage and sex, in the differents beaches, the highest average value was always registered in the Sossego beach (total – 1.52 Ind.m^{-2}, immature – 0.15 Ind.m^{-2}, male – 0.59 Ind.m^{-2} and female – 0.80 Ind.m^{-2}) (figure 3). Was not registered *E. emarginata* in the Porto de Galinhas beach, as it was not registered immature and female in the Tamandaré beach (figure 3b and 3c).

However, differences were registered between total density of *E. emarginata* in the beaches of the Pernambuco coastal ($H_{(9, 12)} = 72.9553$, $p < 0.001$), with the beaches Sossego, Orange and Mª Farinha, presenting a higher average, than other beaches (Figure 3a). As the development stages *E. emarginata*: Male ($H_{(9, 12)} = 62.6505$, $p < 0.001$) with the beaches Sossego, Orange and Mª Farinha presenting higher average, than other beaches and female ($H_{(9, 12)} = 61.7335$, $p < 0.001$) with the beaches Carne de Vaca, Sossego, Orange and Mª Farinha with higher average, than other beaches. Furthermore, no difference was registered between Immature density of *E. emarginata* in the months ($H_{(9, 12)} = 13.7675$, $p = 0.0880$).

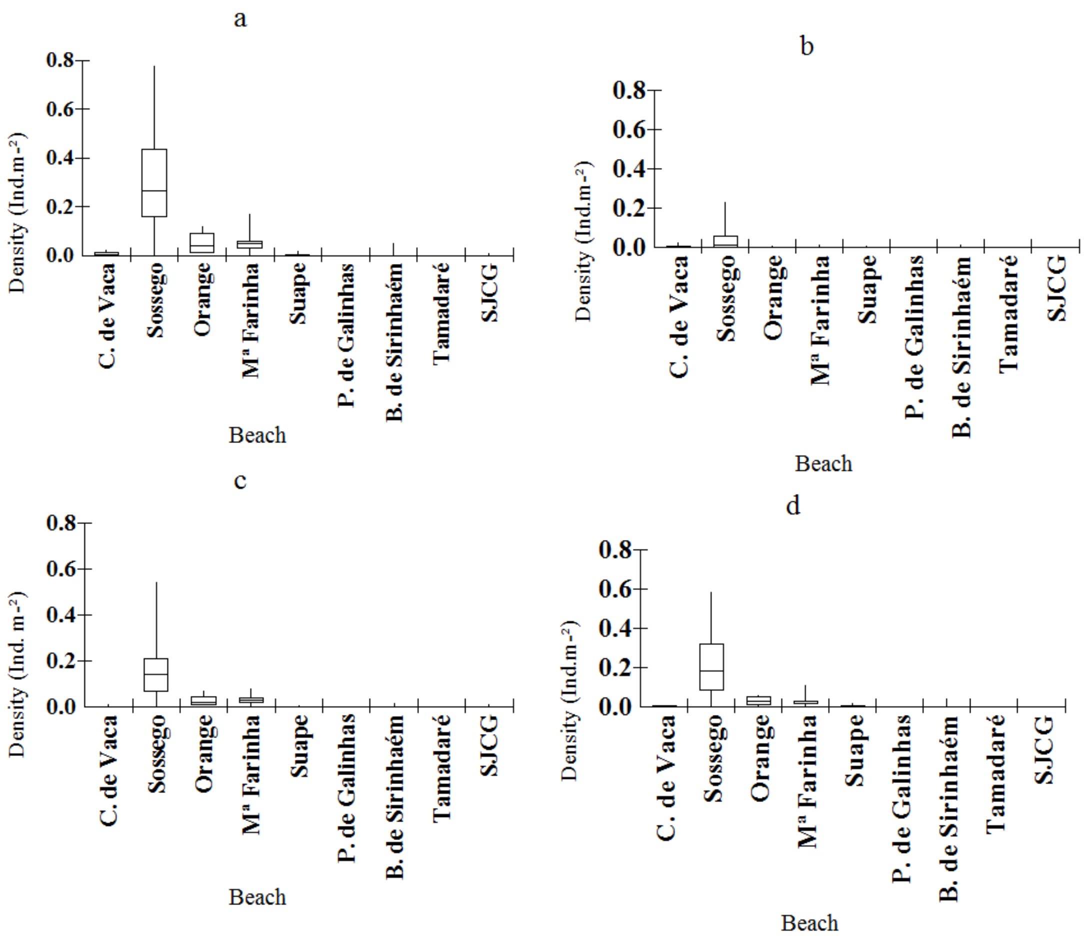

Figure 3: *Encope emarginata* population: “a” total density, “b” density of immature, “c” density of male and “d” density of female, in the beaches at Pernambuco littoral, tropical Southwestern Atlantic, from November/2011 to October/2012.

Abiotic variables x density of the stages of Encope emarginata

Multiple regression analysis showed that all the abiotic variables, influenced the adults individuals of *E. emarginata* (Table 1). Except immature, since these individuals did not show any correlation with abiotics variables in Pernambuco beaches ($p=0.08$). While noting that the abiotic variables influence the population and its adults, relationship of values (R) were between 36-38%, indicating acceptable correlation. Once, the high values observed in the regression coefficients (β) and difference (p patial < 0.05), suggests that the grain size is variable may the density variation in the population (Table 1). Influencing all individuals in the population, including immature (Table 1).

Table 1. Multiple regression "R", the regression coefficient "β", the sampling error "ε" the test value "F" and the significance of "p", temperature “T”, salinity “S”, rainfall “P” and granulometry “G”.

	R	B				ε	F	**p**
		β T	β S	β P	β G			
Total	0.37	0.04	0.05	0.05	0.35	0.68	4.23	< **0.003**
p partial		0.68	0.55	0.56	<**0.001**			
Immature	0.27	0.08	0.04	0.01	0.23	0.09	1.98	0.104
p partial		0.45	0.69	0.91	0.02			
Male	0.37	0.01	0.05	0.07	0.36	0.28	4.05	**0.004**
p partial		0.91	0.59	0.46	<**0.001**			
Female	0.38	0.05	0.06	0.05	0.36	0.34	4.45	**0.002**
p partial		0.60	0.53	0.60	<**0.001**			

Sex Ratio

The sex ratio (M:F) of *E. emarginata* presented an annual average of 1.3:1; ranging from 0.5:1 (December) to 2:1 (September) with females predominance during eight months, mainly during dry season, while the males dominated during the rainy season (Figure 4). Differences were registered between rainy and dry seasons ($X^2_{(12, 9)}$ = 7.812, p < 0.01). The multiple regression analysis showed that there is a correlation between the sex ratio and the abiotic variables (R = 0.34). Despite the low value of correlation, they prove to be acceptable since the test values and signficância confirmed this correlation (F = 3.25, p = 0.014). Among the variables used to do the analysis, the grain size was the variable that most influences the sex ratio (M:F) in the population (β = 0.24, p partial= 0.014).

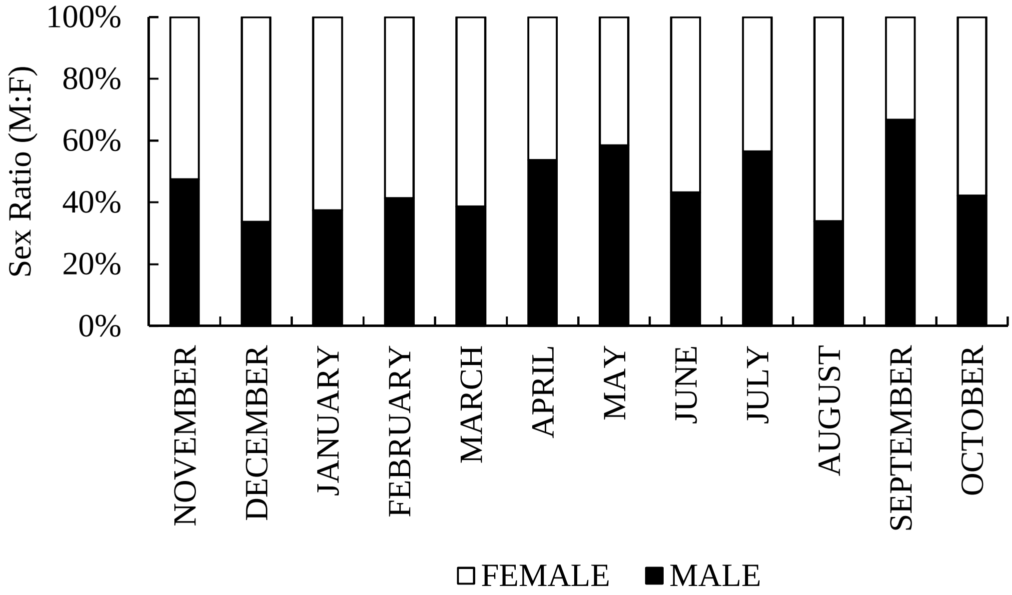

Figure 4. Monthly variational sex ratio (M:F) of *Encope emarginata* at Pernambuco littoral, tropical Southwestern Atlantic, from November/2011 to October/2012.

Recruitment Period

The monthly average of immature of *E. emarginata* entering the population along the sampled beaches was of 0.02 ± 0.1 Ind.m^{-2}. The largest entry of immature individuals occurred in August (0.08 ± 0.23 Ind.m^{-2}), followed by May (0.07 ± 0.20 Ind.m^{-2}). Immature individuals were not registered in the months of November and February. Among the sampled beaches of North coastal, Sossego presented the highest average density of immature entry on population (0.147 ± 0.245 Ind.m^{-2}), while no immature individual was registered on the beaches South coastal of Porto de Galinhas and Tamandaré. The analyses revealed that there is no difference between the sampled months ($H_{(12, 9)} = 7.2605$, $p = 0.78$) (Figure 5).

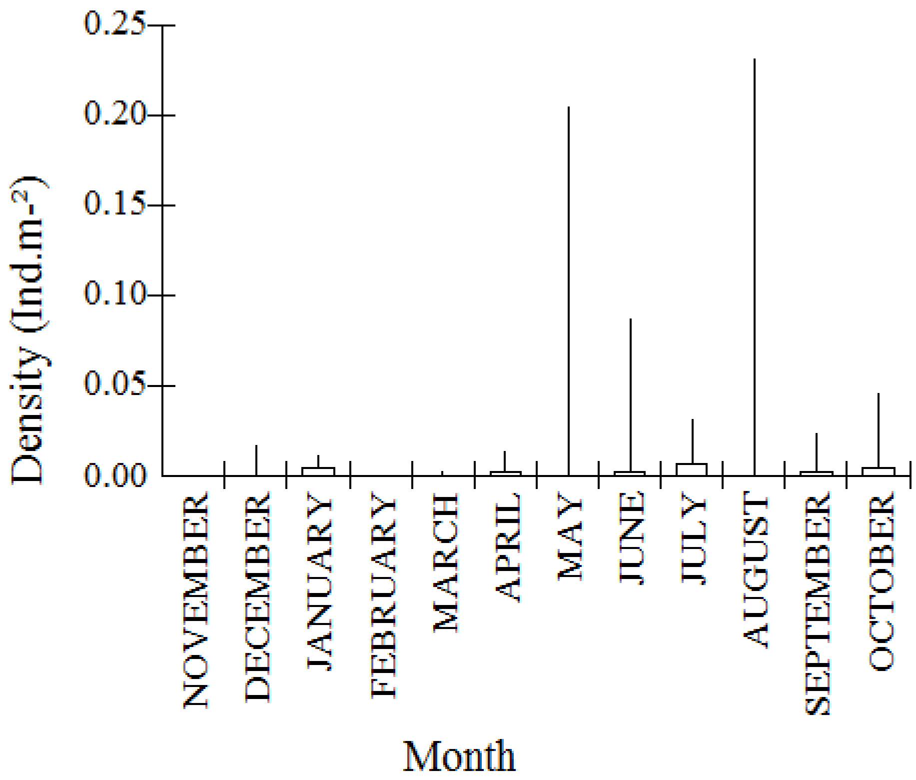

Figure 5. Distribution of avarege values of immature of *Encope emarginata* population, at Pernambuco littoral, tropical Southwestern Atlantic, from November/2011 to October/2012.

Growth

The sand dollar *E. emarginata* presented average values of biomass (50.09 ± 23.82 g) and size, (10.11 ± 1.92 cm). The average values of biomass and growth for each respective stage of development were: immature (16.17 ± 12.54 g and 6.81 ± 1.84 cm), male (53.70 ± 22.98 g and 10.33 ± 1.68 cm) and female (51.85 g ± 21.54 and 10.45 ± 1.63 cm). The 12 size classes were established from 1.5 cm each. The Figure 6 presents the relative frequency distribution (%) of length classes for *E. emarginata* sampled within the twelve months. The percentage distribution of frequencies *E. emarginata* by length class showed that the length varied from 1.51 to 18 cm. The length class with the highest frequency was 10.51 to 12.00 cm, followed by 9.01 to 10.50 cm. The length class 0.00 to 1.50 cm was not sampled.

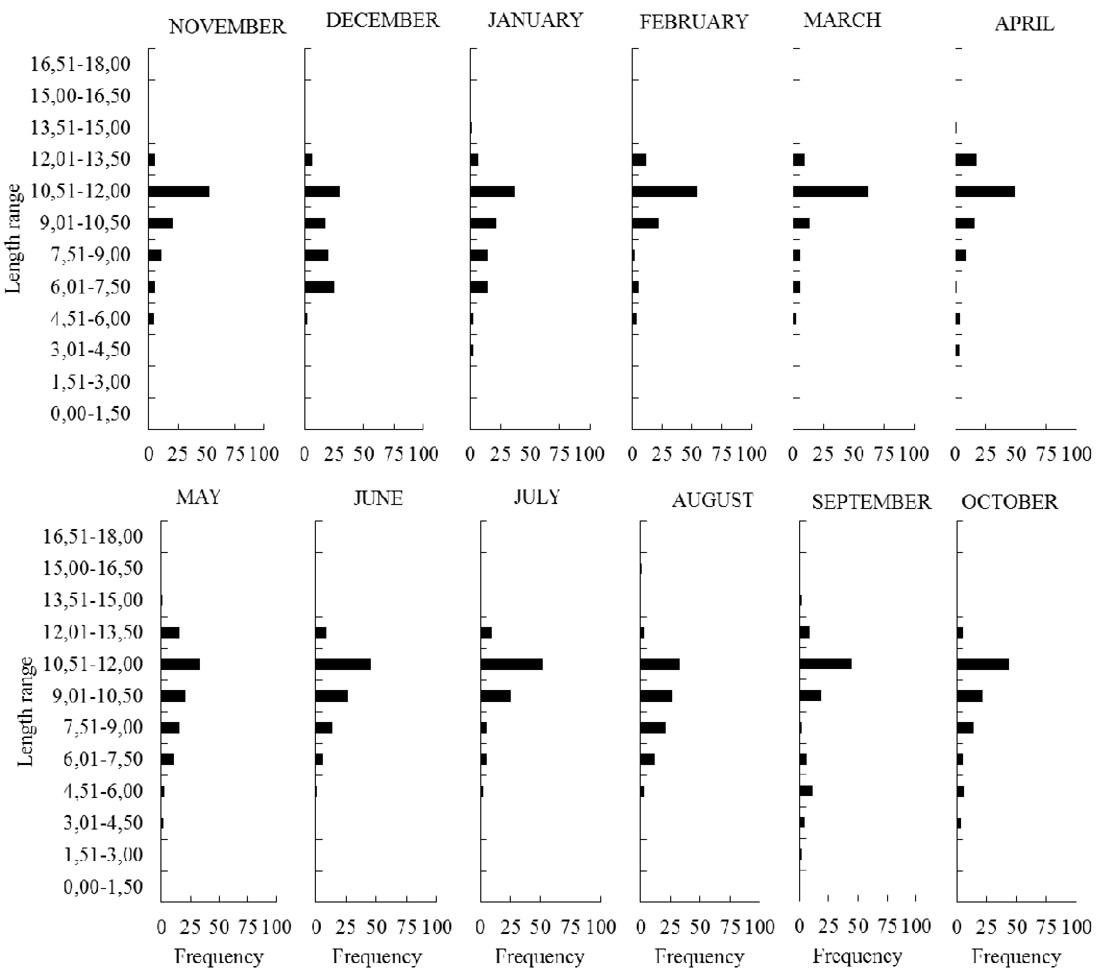

Figure 6. Frequency of *Encope emarginata* by length classes, collected at Pernambuco littoral, tropical Southwestern Atlantic, from November/2011 to October/2012.

The values of biomass and length of each sex of the specie showed perfect correlation, the male with a correlation of 86.38% and females 85.79%. From these values proportions residuals of males and females were analyzed. The specie *E. emarginata* presented no polyphasic growth, meaning that there were no changes in proportional residuals ($t_{(2; 2253)}$ = -0.2354, p = 0.4071). Along the length range, demonstrating that the specie present a similarity between growth the male and female and there is no change in the growth pattern from immature to adults (male and female), investing its resources independently in the same stage of development and sex. The polynomial relation (biomass x lengh) showed that *E. emarginata* presented negative allometric coefficient (Figure 7) ($y = 0.0567x^{2.8848}$), demonstrating that the species directs much of his energy to grows in greatest proportion of length than of biomass.

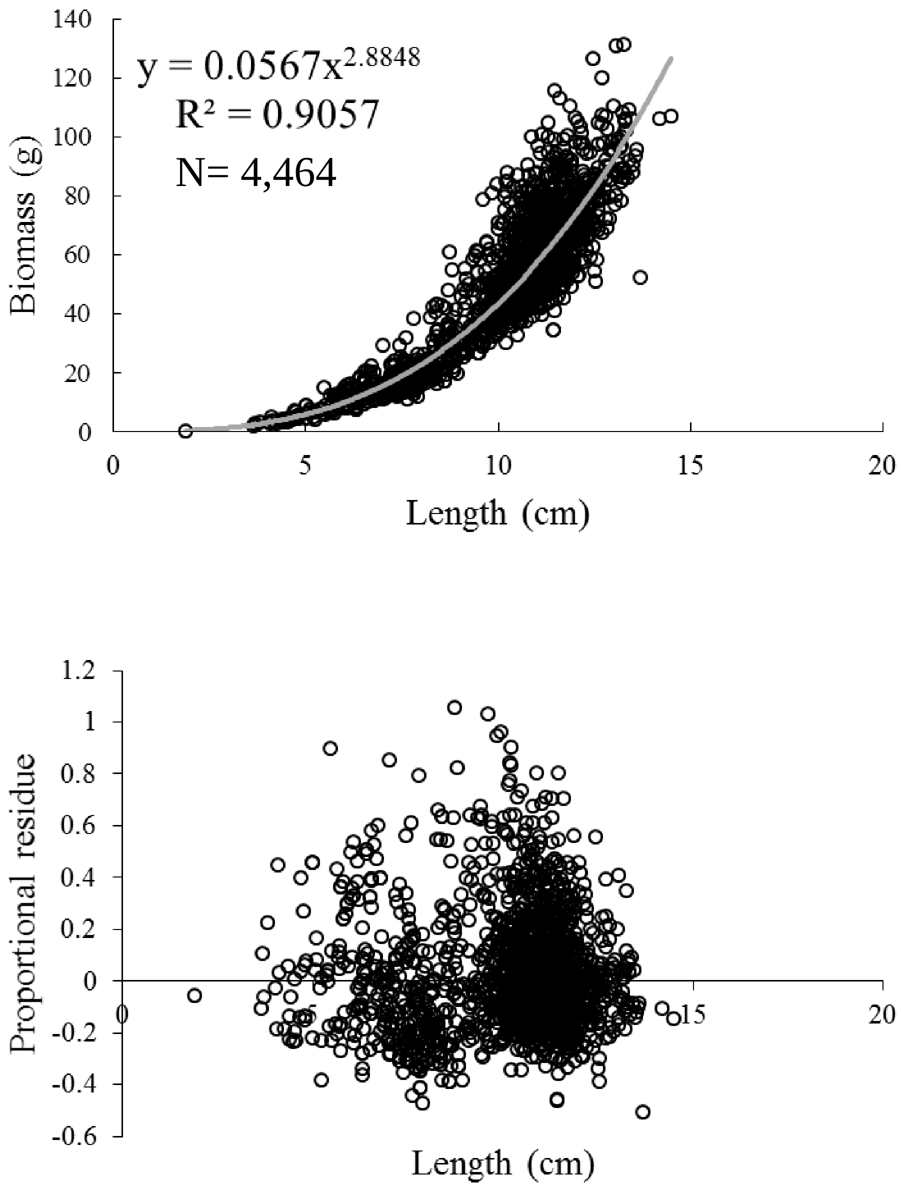

Figure 7. Growth curve and proportional residue of *Encope emarginata* at at Pernambuco littoral, tropical Southwestern Atlantic, from November/2011 to October/2012

Allometric condition factor

The minimum allometric condition factor was 0.03 in October and the maximum was 0.11 in January, with an annual average of 0.068±0.009 (rainy season: 0.065 ±0.008; dry season: 0.072 ±0.009). From the time it was observed, it may be an oscillation between monthly views of their values. Values that increase in a given month, and decreased the following month. Observed an imbalance in allometric condition factor values between the two periods of hydrological transition, the first (dry and rainy) there is an increase in condition factor, in the second (rainy and dry) there is a reduction in the factor allometric condition. During the studied months the condition factor presented a curve with higher values in January (dry season) followed by April and July (rainy season), indicating good environmental condition during these months (Figure 8).

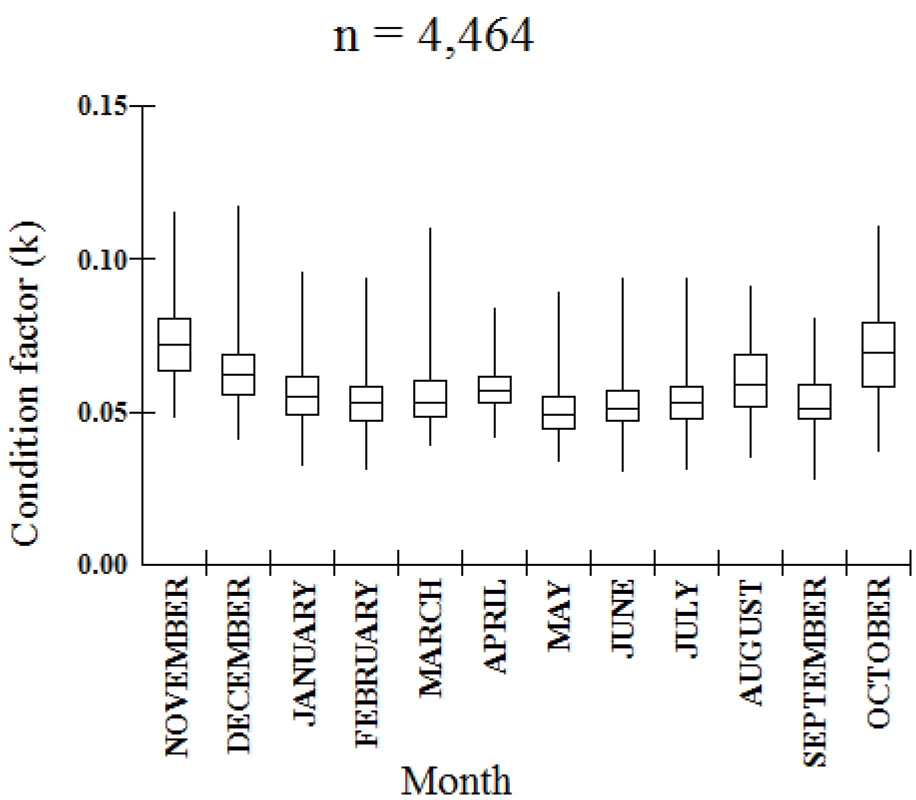

Figure 8. Average values of allometric condition factor of *Encope emarginata* at Pernambuco littoral, tropical Southwestern Atlantic, from November/2011 to October/2012.

Discussion

The sandy beaches direct predominantly by the interacting physical action of waves, tides and sediment (Jaramillo & McLachlan, 1993). In these systems, species of Echinoidea are closely linked to the fluctuations of abiotic variables (temperature, salinity and granulometry) resulting in temporal dynamics (Hendler, 1991; Sánchez-Pérez et al., 2001; Morgan & Jangoux, 2002), besides governing the larval settlement, conditioning the species to a characteristic aggregation or random behavior, relocating to areas with better abiotic conditions (Pompa et al., 1989).

In our study, no differences in densities of *E. emarginata* over the months. During the rainy season a decrease in rainfall occurred while in the dry season an unusual rainfall peack was registered in May, mainly to North littoral. In the years 2011-2012 an anomalous warming of sea surface temperature (SST) caused the Intertropical Convergence zone (ITCZ), main system responsible for precipitation in the Northeast, to act further north from January to October. Along with the weakening in the La Niña phenomenon, the amount of precipitation was nearly half of the historical average (Keller-Filho et al., 2005; Boening et al., 2012).

However, differences were registered between beaches, with very few individuals in the south littoral beaches. This fact can be directly related to the local hydrodynamics, lack of organic matter and indirectly to the substrate. Once the beaches on the south coast have beach rocks close to the beach, forming a zone of wave energy absorption before of beaches rocks (Borzone et al., 1996; Macedo et al., 2012) and a shaded area after these beaches rocks. These characteristics may result in more compressed sediments, once the sediment is not revolved with the action of the waves. Hindering the juvenile settlement, the displacement and the food search for new individuals between the sediment. What is not found in the north coast beaches, where the lines of beaches rocks are removed, submerged, with large area of coastal infrastructure and constant disturbance of sediment with all this caused by the movement of waves (Almeida & Manso, 2011).

Highest density of *E. emarginata* was registered to the Sossego beach. This high density observed at Sossego beach being pegged their unique morphological characteristics of the north coast. The Pernambuco coastline beaches have a predominance of current north / northeast (Lira et al., 2010). This ends up directing the organic matter from estuaries to the same direction of the current in the area. The beach Sossego would be getting much discharge of organic matter from the mouth south of the Santa Cruz Channel, the coastal region of Itamaracá as mainly Jaguaribe river estuary, which is used both as urban discharge, as the shrimp farming developed in this estuary. Furthermore, the Sossego beach has a texture face sand, sediment very fine and selected much, and carbonate composite of 0-39% (Almeida & Manso, 2011); accompanying of waves constantly of size ranging from 0:27 to 0:29 m (Oliveira et al., 2013). This favors the contante sediment stir by both waves like the sand dollars. This beach presents several sandy banks in the area of the underwater beach, a wide sandy beach, 110 m wide, with coastal vegetation on the berm (Silva et al., 2007). The junction all these features provide the best features for nesting, development, feeding and reproduction of *E. emarginata*.

Some of these features is repeated in other north coast beaches, providing favorable conditions for the registration of *E. emarginata*, which are scarce in the southern coast beaches.

In addition to the morphological characteristics of the beach Beach Sossego, the abiotic variables will raise the maintenance of the species on this beach. Among the abiotic variables, granulometry were positively correlated to *E. emarginata* density, showing the intimate dependency that the species has with the substrate being found almost exclusively in sandy sediment fine to meddle (Manso et al., 2008). In addition to the grain size, other authors highlight the importance to other variables studies, with the carried out by Borzone (1992/1993), in Rio Grande do Sul beaches showed that *Mellita quinquiesperforata* Lesk, 1778 (Mellitidae) migrate to regions further away from the coast when temperatures are lower in winter or salinities are lower in the rainy season. The variation of 2.5°C in temperature significantly influences the metabolism of the larvae and juveniles of echinoids (Highsmith & Emlet, 1986) and mostly influences the spawning (Muthiga & Jaccarini, 2005), the settlement of larvae, period of recruitment and growth of individuals (Sewell & Young, 1999). However, temperature is only a limiting variable under 16ºC or above 32ºC (Almeida, 1979; Sewell & Young, 1999). The salinity influence directly the recruitment, since abrupt fluctuations reduce the reproduction and newborns (Ebert & Dexter, 1975). In Panama low values of salinity due to strong rainfall resulted in high mortality of juveniles of *E. stokesi* L. Agassiz, 1841 (Dexter, 1977).

The presence of *E. emarginata* in different stages of development and classes of length, indicate that the sampled areas, mainly in the north coast, are places of settlement, development, feeding and reproduction. The despite finding all stages of development in all the Pernambuco coast beaches, the north coast beaches exhibit the best abiotic conditions for the species. A similar result was recorded to the echinoids *Echinometer lucunter* Linnaeus, 1758 (Mariante et al., 2009) and *Lytechinus variegatus* Lamarck, 1816 (Lage et al., 2011), showing a common characteristic to the Echinoidea family. A population density pattern occurs to echinoids from tropical regions (Mariante et al., 2009; Machado, 2007). Lane & Lawrance (1980) mention individuals' fluctuations in the development stages and length classes to the sand dollar *M. quinquiesperforata* along the year.

The sex ratio obtained in our study presented higher number of adult females during most months, mainly the summer dry season. A similar result was found to the echinoid *Tripneustes ventricosus* Lamarck, 1816 during summer, when it was registered more females (Machado, 2007). In general, echinoids sex ratio is around 1, meaning that there are a proportional number of males in relation to females (Williamson & Steinberg, 2002; Tavares & Borzone, 2006; Lawrence, 2007).

The *E. emarginata* is one of the largest species within the Order Clypeasteroidea, and is the largest species of the Family Mellitidae (Lane & Lawrence, 1980; Kier, 1975). This condition factor promotes the mobility of individuals and the search for favorable areas for recruitment, food and development, as well as avoiding unfavorable areas for the species. *E. emarginata* showed both aggregated and random distribution pattern as they move. Kier & Grant (1965) reported that *E. michelini* L. Agassiz, 1841 locomotion was up to 2.5 mm min^{-2}; and, Weihe & Gray (1968) reported that when no objects are found *M. quinquiesperforata* movements continues.

In our study *E. emarginata* presented a continuous reproduction throughout the year, with highest peak and larval settlement at the beginning (May) and the end (August) of the rainy season. This is a common fact mentioned by many authors (McPherson, 1969; Rumrill, 1989; Achituv & Sher, 1991; Mariante et al., 2009; Lima et al., 2009; Olivares-Bañuelos et al., 2012), that Echinoidea and Asteroidea from subtropical regions present period of spawning and recruitment during the summer rainy season.

Continuous reproduction is a common fact to tropical regions, with peaks in some seasons (Olivares-Bañuelos et al., 2012). This settlement coincides with the lowest annual values of temperature in others tropical regions (Williamson & Steinberg, 2002; Mariante et al., 2009). Larger females would present greater amount of eggs and higher rate of fertilization, while size doesn't present any relationship with fertilization of these eggs (Levitan, 1991).

The largest amount of individuals of *E. emarginata* in the intermediate classes (10.01-11 and 11.01-12), seems to be a pattern for the species of Echinoidea, as researches carried out with *E. lucunter* (Mariante et al., 2009) and *L. variegates* (Lage et al., 2011), presented a similar distribution. Once, polyphase growth can be a reflection of the need of individuals to achieve larger sizes, since larger individuals can get best resources, and avoid unfavorable conditions for their development. The allometric coefficient was below the isometric growth, showing that the species invests its resources in growth (Vazzoler, 1996).

It can be concluded that the population parameters of *E. emarginata* are influenced by abiotic variables, mainly the grain size. The north coast beaches presented more favorable environmental characteristics, as the reefs are located farther away from the beach, allowing waves to break with moderate intensity, enough to facilitate the thinner sediment movement in these beaches, facilitating settlement, development, feeding and breeding of *E. emarginata*. The sediment shown as the variable more influence the distribution of *E. emarginata*. The population of *E. emarginata* presented at female predominance. The specie *E. emarginata* does not use any month for intensify recruitment. The population of *E. emarginata* shows a predominance of intermediary individuals. The *E. emarginata* investment your energy to length, due to more favorable new search areas more favorable. And with that, these works contribute to better understanding of *E. emarginata* biology.

Acknowledgements

We thank the Postgraduate Program in Zoology and the Museu Paraense Emílio Goeldi, both from the Federal University of Pará – UFPA; the Department of Oceanography and the Museum of Oceanography from the Federal University of Pernambuco (UFPE). This study is derived from the research conducted for the doctoral thesis of AGC at Federal University of Pará/ Museu Paraense Emílio Goeldi (UFPA/MPEG), for which a scholarship was provided by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES). SNL (process: AUX-PE-CIENCIAS DO MAR 1136/2010) and LFAM (process: 301343/2012-8) was supported by the National Council for Scientific and Technological Development (CNPq).

References

Achituv, Y. & E. Sher, 1991. Sexual reproduction and fission in the sea star *Asterina burtoni* from the Mediterranean coast of Israel. Bulletin of Marine Science 48:670–678.

Allen, J. D. & J. A. Pechenik, 2010. Understanding the effects of low salinity on fertilization success and early development in the sand dollar *Echinarachnius parma*. The Biological Bulletin 2: 189–199.

Almeida, A. M. M. B., 1979. Efeito da salinidade e da temperatura no desenvolvimento e sobrevivência de ouriços do mar (Echinodermata, Echinoidea). Dissertação (Mestrado em Fisiologia) – Instituto de Biociências da Universidade de São Paulo, São Paulo. 74f.

Almeida, T. L. de M.; Manso, V. do A. V. 2011. Sedimentologia da plataforma interna adjacente a Ilha de Itamaracá-PE. Estudos Geológicos 21: 1.

Andrade, G. O. & R. Lins, 1965. Introdução à morfoclimatologia do Nordeste do Brasil. Arquivos do Instituto de Ciências da Terra 3-4: 11-28.

Aragão, J. O. R., 2004. A Influência dos Oceanos Pacífico e Atlântico na Dinâmica do Tempo e do Clima do Nordeste do Brasil. In Eskinazi-Leça, E., S. Neumann-Leitão, MF da Costa, (eds). Oceanografia: Um cenário tropical. Recife, 131-184.

Araújo, A. M., 2003. Desenvolvimento de procedimentos experimentais para avaliar a evolução de bancos dragados. I Simpósio de Recursos Hídricos da Amazônia, Fundação Rede Amazônica. Manaus 26-26.

Barnes, D. K. A. & A. C. Crook, 2001. Quantifying behavioural determinants of the coastal European sea urchin *Paracentrotus lividus*. Marine Biology 138:1205–1212.

Barros, F., C. A. Borzone & S. Rosso, 2001. Macroinfauna of six beaches near Guaratuba bay, southern Brazil. Brazilian Archives of Biology and Technology 4: 351-364.

Bell, J. L. & S. E. Stancyk, 1983. Population dynamics and reproduction of *Dissodactylus mellitae* (Brachyura: Pinnotheridae) on its sand dollar host *Mellita quinquiesperforata* (Echinodermata). Marine ecology - progress series 13: 141-149.

Boening, C., Willis, J. K., Landerer, F. W., Nerem, R. S., & Fasullo, J. 2012. The 2011 La Niña: So strong, the oceans fell. Geophysical Research Letters, 39: 19.
Borzone, C. A., 1992/1993. Spatial distribution and growth of *Mellita quinquiesperforata* (Leske, 1778) on a sandy beach of southern Brazil. Nerítica 1-2: 87-100.

Borzone, C. A., J. R. B. Souza, & A. G. Soares, 1996. Morphodynamic influence on the structure of inter and subtidal macrofaunal communities of subtropical sandy beaches. Revista Chilena de Historia Natural 69:565-577.

Chapman, M. G., 2005. Molluscs and echinoderms under boulders: tests of generality of patterns of occurrence. Journal of Experimental Marine Biology and Ecology 325:65–83.

Dexter, D. M., 1977. A natural history of the sand dollar *Encope stokesi* (L. Agassiz) in Panama. Bulletin of Marine Science 3: 544-551.

Dias, I. C. C. M., 2008. Biologia populacional de *Mellita quinquiesperforata* Leske (1778) (ECHINODERMATA: CLYPEASTEROIDA: MELLITIDAE) na praia da Taíba, Ceará, Brasil. Instituto de Ciências do Mar, UFC, Fortaleza 146 f.

Drouin, G., J. H. Himmelman, & P. Béland, 1985. Impact of tidal salinity fluctuations on echinoderm and mollusc populations. Canadian Journal of Zoology 63:1377-1387.

Ebert, T. A. & D. M. Dexter, 1975. A natural history study of *Encope grandis* and *Mellita grantii*, two sand dollars in the northern Gulf of California, Mexico. Marine Biology 32:397-407.

Ebert, T. A., 1983. Recruitment of echinoderms. In Jangoux, M. & J. M. Lawrence, (eds.) Echinoderm studies, Rotterdam, 169-203.

Fernandes, M. L. B., L. R. Tommasi, & E. J. B. Lima, 2002. Filo Echinodermata de Pernambuco, 405-428. In TABARELLI, M. & J. M. C. SILVA, (Eds). Diagnóstico da biodiversidade de Pernambuco. Massangana. Recife 722p.

Fonseca, R. S. da, J. Z. de O. Passavante, GB Maranhão, & K Muniz, 2002. Ecossistema Recifal da Praia de Porto de Galinhas (Ipojuca, Pernambuco): Biomassa Fitoplanctônica e Hidrologia. Boletim Técnico-Científico do Cepene 1:9-35.

Giberto, D. A., C. S. Bremec, E. M. Acha & H. Mianzan, 2004. Large-scale spatial patterns of benthic assemblages in the SW Atlantic: the Río de la Plata estuary and adjacent shelf waters. Estuarine, Coastal and Shelf Science 1:1-13.

Glynn, P. W., 1968. Mass mortalities of echinoids and other reef flat organisms coincident with midday low water exposures in Puerto Rico. Marine Biology 1:226–243.

Gondim, A. I., P. Lacouth, C. Alonso & C. L. C. Manso, 2008. Echinodermata da Praia do Cabo Branco, João Pessoa, Paraíba, Brasil. Biota Neotropica 2: 151-159.

Guizardi, P. S. & E. da C. G. Couto, 2014. *Encope emarginata* (LESKE, 1778) (Echinodermata, Echinoidea) na Enseada do Mutá, Santa Cruz Cabrália, Bahia, Brasil Enciclopédia Biosfera, Centro Científico Conhecer, 19:2205-2212.

Hagen, N. T. & K. H. Mann, 1992. Functional response of the predators American lobster *Homarus americanus* (Milne-Edwards) and Atlantic wolffish *Anarhichas lupas* (L.) to increasing numbers of the green sea urchin *Strongylocentrotus droebachiensis* (Muller), Journal of Experimental Marine Biology and Ecology 159:89-112.

Harold, A. S. & M. Telford, 1982. Substrate preference and distribution of the northern sand dollar *Echinarachnius parma* (Lamarck). Proc. InS. Echinoderm Conf, Tampa Bay (1981): 243-249.

Hendler, G. 1991. Echinodermata: Ophiuroidea. 355–511. In Giese, A. G., J. S. Pearse & V. B. Pearse, (Eds). Reproduction of marine invertebrates, The Boxwood Press, California.

Hereu, B., M. Zabala, C. Linares & E. Sala, 2004. Temporal and spatial variability in settlement of the sea urchin *Paracentrotus lividus* (Lamarck). Marine Biology 144:1011–1018.

Hernández, J.C. & Russell, M. P. 2010. Substratum cavities affect growth-plasticity, allometry, movement and feeding rates in the sea urchin *Strongylocentrotus purpuratus*. The journal of experimental biology 213: 520-525.

Hickson, R. G. 1980. Comportamento físico-químico da Baía de Tamandaré. Recife. Monografia de Graduação do Curso de Engenharia de Pesca da Universidade Federal Rural de Pernambuco. 54p.

Highsmith, R. C. & R. B. Emlet, 1986. Delayed metamorphosis: effect on growth and survival of juvenile sand dollars (Echinoidea: Clypeasteroida). Bulletin of Marine Science 39:347-361.

Jaramillo E. & A. McLachlan, 1993. Community and population response of the macroinfauna to physical factors over a range of exposed sandy beaches in south-central Chile. Estuarine Coastal and Shelf Science 37: 615-624.

Kaiser, M., M. Attrill, S. Jennings, D. N. Thomas, D. Barnes, A. Brierley, R. D. Polunin & P. L. B. Williams, 2005. Marine Ecology: Processes, Systems, and Impacts, Oxford: Oxford University Press.

Keller Filho, T., Assad, E. D., & Lima, P. D. R. 2005. Regiões pluviometricamente homogêneas no Brasil. Pesquisa Agropecuária Brasileira, 40 (4): 311-322.

Kier, P. M., 1975. The echinoids of Carrie Bow Cay, Belize. Smithsonian Contributions to Zoology 206: 1-20.

Kier, P. M. & R. E. Grant, 1965. Echinoid distribution and habits, Key Largo Coral Reef Preserve, Florida. Smitt. Misc. Coll. 149: 1-68.

Lage, A. M. C., J. C. Joyeux, L. C. Gomes, 2011. Reprodução de *Lytechinus variegatus* (Echinodermata: Echinoidea): efeito do ciclo lunar e características da população. Acta Scientiarum. Biological Sciences Maringá, 3:341-346.

Lane, J. E. M. & J. M. Lawrence, 1980. Seasonal variation in body growth, density and distribution of a population of sand dollars, *Mellita quinquiesperforata* (Leske). Bulletin of Marine Science 4:871-882.

Lawrence, J. M., J. Herrera & J. Cobb, 2004. Vertical posture of the clypeasteroid sand dollar *Encope michelini*. Journal Marine Biology Association of the UK 84:407-408.

Lawrence, J. M., 1996. Mass mortality of echinoderms from abiotic factors. Echinoderm Studies 5:103-137.

Lawrence, J. M., 2007. Edible sea urchins: biology and ecology, Elsevier, Amsterdam

Le-Cren, E. D., 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). Journal of Animal Ecology 2:201-219.

Levitan, D. R., 1991. Influence of body size and population density on fertilization success and reproductive output in a free-spawning invertebrate. Biological Bulletin 181:261-268.

Lima, E. J. B. & M. L. J. Fernandes, 2009. Diversidade de equinodermos (Echinodermata) no Estado de Pernambuco (Brasil). Zoociências 1: 55-63.

Lima, E. J. B., P. B. Gomes & J. R. B. Souza, 2009. Reproductive biology of *Echinometra lucunter* (Echinodermata: Echinoidea) in a northeast Brazilian sandstone reef. Anais da Academia Brasileira de Ciências 81: 51-59.

Lira, L., Hazin, F. H., Wor, C., & Junior, H. A. (2010). Estudo de correntes marinhas por meio do lançamento de cartões de deriva no litoral do estado de Pernambuco, Brasil. Arquivos de ciências do mar, Fortaleza, 43:1 30-37.

Mabesoone, J. M. & P. N. Coutinho, 1970. Litoral and shallow marine geology of Northeastern Brazil. Trabalhos do Instituto Oceanográfico da Universidade Federal de Pernambuco 12: 1-214.

Macedo, R. J. A. de, V. do A. V. Manso, N. S. Pereira & L. G. de França, 2012. Transporte de Sedimentos e Variação da Linha de Costa em Curto Prazo na Praia de Maracaípe (PE), Brasil. Revista de Gestão Costeira Integrada 3:343-355.

Machado, A. A. 2007. Descrição do ciclo gametogênico do ouriço-branco, Tripneustes ventricosus (Lamarck, 1816), no Arquipélago de Fernando de Noronha – PE, Brasil. Dissertação. Bioecologia Aquática. Universidade Federal do Rio Grnade do Norte, 47f.

Magalhães, M. K., E. Eskinasi – Leça, M. A. Moura Junior, 1997. Morfometria e biomassa da fanerógama marinha *Halodule wrightii* Ascherson no litoral norte de Pernambuco. Trabalho Oceanografico Universidade Federal Pernambuco, 25:83-92.

Manso, C. L. C., O. F. S. Alves, & L. R. Martins, 2008. Echinodermata da Baía de Todos os Santos e da Baía de Aratu (Bahia, Brasil). Biota Neotropica, 3: 179-196.

Mariante, F. L. F., G. B. Lemos, F. J. Eutropio & L. C. Gomes, 2009. Biologia reprodutiva de *Echinometra lucunter* (Echinodermata: Echinoidea) na Praia da Costa, Vila Velha, Espírito Santo. Zoologia 4:641-646.

Martinelli-Filho J. E., R. B. dos Santos & C. C. Ribeiro, 2014. Host selection, host-use pattern and competition in *Dissodactylus crinitichelis* and *Clypeasterophilus stebbingi* (Brachyura: Pinnotheridae). Symbiosis 63:99–110.

McPherson, B. F., 1969. Studies on the biology of the tropical sea urchins, *Echinometra lucunter* and *Echinometra viridis*. Bulletin of Marine Science 19: 194-213.

Menge, B. A., 1992. Community regulation: Under what conditions are bottom-up factors important on rocky shores? Ecology 73: 755–765.

Morgan, R. & M. Jangoux, 2002. Reproductive cycle and spawning induction in the gregarious brittle star *Ophiothrix fragilis* in the Oosterschelde. Inv. Repro. Dev. 42:145-155.

Morin, J. G., J. E. Kastendiek, A. Harrington & N. Davis, 1985. Organization and patterns of interactions in a subtidal sand community on an exposed coast. Marine Ecology Progress Series 27:163-185.

Muthiga, M. A. & V. Jacarrini, 2005. Effects of seasonality and population density on the reproduction of the Indo-Pacific echinoid *Echinometra mathaei* in Kenyan coral reef lagoons. Marine Biology 146: 445-453.

Olivares-Bañuelos T., S. Figueroa-Flores, E. Carpizo-Ituarte, 2012. Gonad index and larval development of the sand dollar *Dendraster excentricus* (Echinodermata; Echinoidea) in Baja California, Mexico. Ciencias Marinas 38: 411–425.

Oliveira, P. F. P. de, da Silva, H. A., Barreto, E. P., Valença, L. M. M., & Manso, V. D. A. V. 2013. Variação longitudinal dos sedimentos de praia e sua relação com a inclinação da face praial e a morfodinâmica, município de paulista-PE. Estudos Geológicos, 23: 2.

Pompa L., A. S. Prieto & R. Manrique, 1989. Abundancia y distribución espacial en una población del erizo *Echinometra lucunter* (L) en el Golfo de Cariaco, Venezuela. Acta Científica Venezolana 40: 289-294.

Reichholf, J., 1981. Some data on a sample of the sand dollar *Encope emarginata* (Leske, 1778) from the coast of Santa Catarina, Brazil. Spixiana 1:111- 114.

Rumrill, S. S., 1989. Population size structure, juvenile growth, and breeding periodicity of the sea star *Asterina miniata* in Barkley Sound, British Columbia. Marine Ecology Progress Series 56: 37-47.

Sala, E., 1997. Fish predators and scavengers of the sea urchin *Paracentrotus lividus* in marine protected areas of the northwestern Mediterranean. Marine Biology 129:531-539.

Sánchez-Pérez, P., A. Cesar, F. S. Cortez, C. D. S. Pereira, S. L. R. Silva, 2001. Distribución espacial de las poblaciones de erizos más abundantes de la costa sudeste del litoral de São Paulo (Brasil). Ciencias Marinas 1:139-153.

Schwalme, K. & Chouinard, G. A. 1999. Seasonal dynamics in feeding, organ weights, and reproductive maturation of Atlantic cod (*Gadus morhua*) in the southern Gulf of St Lawrence. Journal of Marine Science 56: 303–319.

Sewell, M. A. & C. M. Young, 1999. Temperature limits to fertilization and early development in the tropical sea urchin *Echinometra lucunter*. Journal of Experimental Marine Biology and Ecology 236: 291-305.

Silva I. R., A. C. S. P. Bittencourt, J. M. L. Dominguez & S. B. M. Silva, 2007. Pontencial de Danos Econômicos Face à Erosão Costeira, Relativo às Praias da Costa do Descobrimento – Litoral Sul do Estado da Bahia. Pesquisas em Geociências 1: 35 – 44.

Solan, M., B. J. Cardinale, A. L. Downing, K. A. M. Engelhardt, J. L. Ruesink, & D. S. Srivastava, 2004. Extinction and ecosystem function in the marine benthos. Science 306: 1177–1180.

Suguio, K. 1973. Introdução à sedimentologia. Edgard Blucher/EDUSP, São Paulo. 312 pp.

Swigart, J. P. & J. M. Lawrence, 2008. Small scale distribution of the sand dollars *Mellita tenuis* and *Encope michelini* (Clypeasteroida: Echinodermata) off the central Florida gulf coast. Gulf of Mexico Science 26:46–56.

Tavares, Y. A. G. & C. A. Borzone, 2006. Reproductive cycle of *Mellita quinquiesperforata* (Lesk) (Echinodermata, Echinoidea) in two contrasting beach environments. Revista Brasileira de Zoologia 2: 573-580.

Tavares-Dias, M., S. H. C. Schalch & F. R. Moraes, 2003. Hematological characteristics of brasilian teleosts. VII. Parameters of seven species collected in Guariba, São Paulo State, Brazil. Boletim Instituto da Pesca 2:109-115.

Tegner, M. J. & P. K. Dayton, 1981. Population structure, recruitment and mortality of two sea urchins (*Strongylocentrotus franciscanus* and *S. purpuratus*) in a kelp forest. Marine Ecology Progress Series 5:255-268.

Tommasi, L. R., 1964. Observações sobre equinóides do Brasil. Revista Brasileira de Biologia 1:83-93.

Tyler, P. A., C. M. Young, A. Clarke, 2000. Temperature and pressure tolerances of embryos and larvae of the Antarctic sea urchin *Sterechinus neumayeri* (Echinodermata: Echinoidea): potential for deep-sea invasion from high latitudes. Marine Ecology Progress Series 192: 173-180.

Underwood, A. J. & M. G. Chapman, 1996. Scales of spatial patterns of distribution of intertidal invertebrates. Oecologia 107:212–224.

Vázquez-Bader, A. R., A. Laguarda-Figueras, A. Gracia-Gasca, F. A. Solís-Marín, E. V. Celaya-Hernández & A. Durán-González, 2008. Seasonal changes in the density and species composition of the epifaunal echinoderms recorded from the southwester Gulf of Mexico. Revista Biología Tropical 56: 297-310.

Vazzoler, A. E. A. de M., 1996. Biologia da reprodução de peixes teleósteos: teoria e prática. EDUEM. Maringá, 169p.

Weihe, S. C. & I. E. Gray, 1968. Observations on the biology of the sand dollar *Mellita quinquiesperforata*. Journal of the Elisha Mitchell Scientific Society 84:315-327.

Williamson, J. E. & E. P. D. Steinberg, 2002. Reproductive cycle of the sea urchin *Holopneustes purpurascens* (Temnopleuridae: Echinodermata). Marine Biology 140: 519-532.

Young, C. M. & F. S. Chia, 1982. Factors controlling spatial distribution of the sea cucumber *Psolus chitonoides*: settling and post-settling behaviour. Marine Biology 69:195–205.

Zar, J. H., 1999. Biostatistical Analysis. Prentice-Hall. New Jersey. 663p.

CAPÍTULO II – Structure populational of *Dissodactylus crinitichelis* Moreira 1901 (Decapoda: Pinnotheridae) on the Pernambuco coast: Relationships to environmental variables

Cunha, A. G.; Neumann-Leitão, S.; Montag, L. F. A.

Capítulo a ser submetido para a revista *Hydrobiologia* (ISSN: 1573-5117)

Abstract

Studies about *Dissodactylus crinitichelis*, were carried out in tropical Brazilian Coast to assess the influence of abiotic variables and seasonality over the population structure, residence in the sand dollars. It was sampled 200 m² in each of the nine beaches. Abiotic variables were simultaneously collected. It was obtained the density, carapace width, abdomen width, developmental stage and sex of crabs. The monthly average of crabs was 6.41 Crabs/Sand dollar, the Sossego beach in the north littoral presented the highest with 21.22 Crabs/Sand dollar. The average density of the immature was 66.41 Crabs/Sand dollar, adult male – 0.25 Crabs/Sand dollar and females – 0.16 Crabs/Sand dollar. The sex ratio were of 2.03:1 (M:F), more input of recruit was in May. The specie presented highest correlation between juvenile, immature and male adult. The species showed a polyphasic growth with trend of development stages to be Allometric positive for the juvenile, immature and adult male, and well pronounced for adult females. It was observed a constant maintenance of the population, influenced by abiotic variables, primarily the sediment. The recruitment period is common in the tropical region. The intrinsic factor suggests an imbalance in the sex ratio and growth of each individual in the population. The crab *Dissodactylus crinitichelis* is keeping constant along the beaches**.** This article contributes to the spatial and seasonal distribution of *Dissodactylus crinitichelis*. Demonstrating its importance for the preservation of areas important to all marine biodiversity.

Key-words: Seasonal, Abiotic variables, Population biology, Sand beach, Tropical Atlantic.

Introduction

Pinnotheridae (Decapoda, Brachyura) are composed of small size crabs, living in marine or estuarine environments, usually known as “pea crabs”, because its rounded shape and smooth carapace (Schmitt et al., 1973; Martins & D’Incao, 1996). Adults can occur free in the environment, especially the males, or associated with other animals as commensal or parasitic in echinoderms, polychaets, bivalve, decapod crustaceans and fishes (Williams, 1984). In general, a high degree of specificity occurs between the crabs and its hosts. Pinnotherid crabs of the genus *Dissodactylus* Smith 1870 are limited to the Atlantic and Pacific coasts of America. The small crabs are known to live on irregular sea urchins, although some species are cited as free living. The life style seems to be largely parasitic, commensal or symbiotic (Campos et al., 2009). Telford (1982) described the feeding habits of four Western Atlantic species and found that all of them forage extensively upon their hosts, causing visible damage to them. *Dissodacylus crinitichelis* Moreira, 1901 is the only species of the genus known to occur from North Carolina (USA) to South Argentina in Western Atlantic (Rathbun, 1918; Melo, 1999).

Despite their ecological importance, the need to expand the knowledge to Pinnotheridae family in Brazil, and most studies mention the group taxonomy and systematics (Bezerra et al., 2006), despite a few pappers on growth rates (Fumis et al., 2006) and symbiosis (Martinelli-Filho et al., 2014). Crabs of this family are known for their remarkable morphological and ecological diversity (Ross, 1983), and life cycle strategy which makes an interesting group in which to study evolutionary relationships. Among the pinnotherid, *D. crinitichelis* has been observed maintaining symbiotic relationships with several species of irregular echinoids in Brazil (Coelho & Ramos-Porto, 1995; Martins & D’lncao, 1996; Wirtz et al., 2009; Queiroz et al., 2011; Martinelli Filho et al., 2014). However, the population structure of this species is still rarely studied (Telford, 1978), since itt is unknow how its populations are influenced by the environment. Among the parameters that could influence this population, the variation in salinity, temperature, are highlighted by hydrological regimes (Morgan, 1992; Morgan, 1995; Anger, 2001; Anger, 2003).

The abiotic variables directly affect the growth of individuals and the survival of each developmental stage of the population (Costlow et al., 1960; Anger et al., 1990; Anger, 1996; Larez et al., 2000; Anger et al., 2000; Anger, 2001; Anger, 2003; Luppi et al., 2003). In addition, it way change the metabolism of the individual, directly affecting food consumption and digestive process (Smith, 1989). It also accelerates or delaies the life cycle changes of the crab and the intermoult throughout the population (Barnwell & Thurman, 1984). Moreover, it influences the behavior of individuals (Forward, 1989), indicating the best place and time of year for sexual maturation, production of eggs, reproduction, larval dispersal and recruitment (Christy, 1982; Forward et al., 1982; Anger et al., 1994; O'Connor & Epifanio, 1985). Finally, abiotic factors serve as basic information for the study of demographic relationships of the respective stages of development, growth and biogeography (Barnwell & Thurman, 1984; Bond & Buckup, 1988).

The abiotic variables (temperature and salinity) govern many times the annual variation of crabs, as well as their respective stages of development (Ventura & Pires, 2002). The affects the reproduction and growth, causing variations over the months of the year, and also the carapace width/ abdomen width ratio (condition factor) of the individuals, the proportion of males and females (Lage et al., 2011). According to Albuquerque et al. (2012), the hydrological regimes directly influence the salinity and temperature values in the environment and consequently the density of organisms that live in these places. In addition, it influences the structure dynamics of the population, especially the immature stage, the maintenance of different classes of length and different development stages (Cameron & Rumrill, 1982; Epifanio, 1988; Daltov, 2000; Posey et al., 2005). And the influence the sex ratio, growth and condition factor (Braga, 1986; Braga, 1993; Braga, 1997).

This study was carried out to assess the seasonal variation of the main abiotic variables influencing the population of the crab *D. crinitichelis*, resident in the three species of sand dollars from Pernambuco coastal area, located in the tropical Western Atlantic. We hypothesize that abiotic variables that vary along the year and beaches may explain the variations of density population, sex ratio and allometric condition factor. Furthermore, the growth species presents a polyphasic.

Material and methods

Study area

The Coast of Pernambuco is inserted in the Southwest Atlantic Tropical (Figure 1). The Pernambuco beaches are composed of two deposits of sediment, the surface is rich in sandy sediment (fine - rough) rich in quartz and silt; this coastal, there are seagrass banks (*Halodule wrightii* Ascherson) and fragments of calcareous algae Halimeda spp. (Magalhães et al., 1997; Barros et al., 2001; Fonseca et al, 2002;. Araujo, 2003). The outstanding features of this coast is the presence of sandstone reefs that occur on multiple lines (distant - North Coast, 2,000 m and near - South Coast, 50 m) parallel to the coast; representing lines of "rock beaches", sometimes with a thin overgrowth of calcareous algae and corals (Mabesoone & Coutinho, 1970). The Coast of Pernambuco is inserted in the Southwest Atlantic Tropical (Figure 1). The Pernambuco beaches are composed of two deposits of sediment, the surface is rich in sandy sediment (fine - rough) rich in quartz and silt; this coastal, there are seagrass banks (*Halodule wrightii* Ascherson) and fragments of calcareous algae Halimeda spp. (Magalhães et al., 1997; Barros et al., 2001; Fonseca et al, 2002;. Araujo, 2003). The outstanding features of this coast is the presence of sandstone reefs that occur on multiple lines (distant - North Coast, 2,000 m and near - South Coast, 50 m) parallel to the coast; representing lines of "rock beaches", sometimes with a thin overgrowth of calcareous algae and corals (Mabesoone & Coutinho, 1970).

The collections were carried out monthly, from November 2011 to October 2012, during low tide. For the purpose of standardization, these sampling were held in the interval between two days before and after new moon. Nine beaches along the coast were selected, about 20 km from one another, with four on the north and five on the south coast (Figure 1).

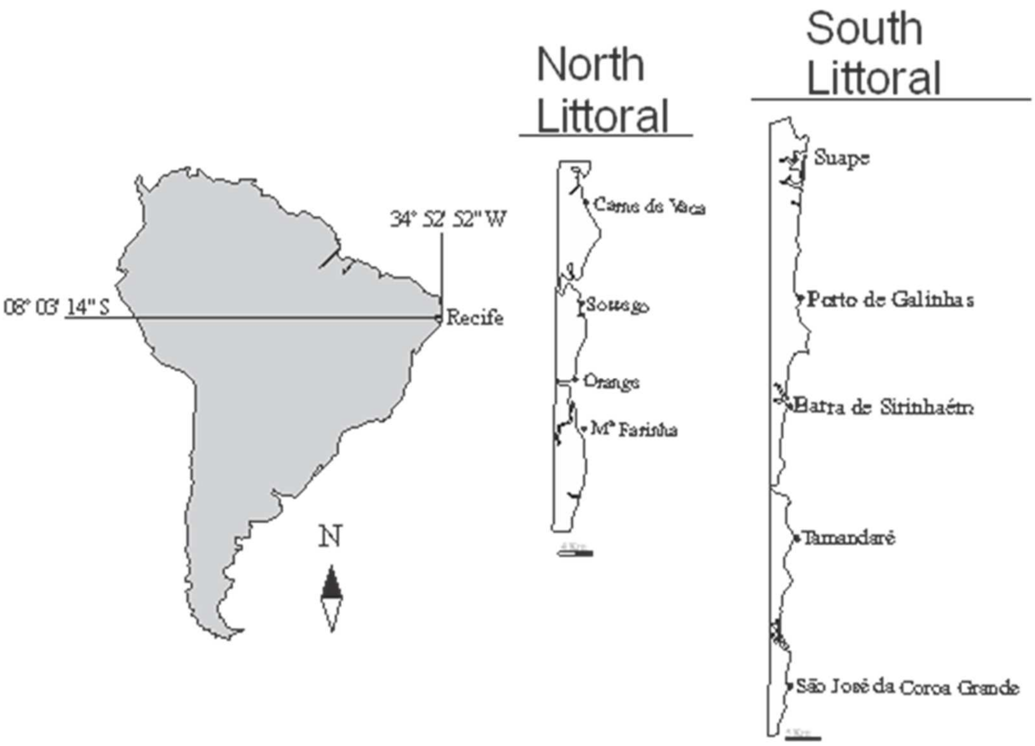

Figure 1. Studied area and sampling stations at nine beaches of Pernambuco littoral, Sowthwestern Atlantic, from October/2011 to September/2012.

The beaches from the north coast: Carne de Vaca (07º35.352' S e 034º49.216W), Sossego (07º42.987'S; 34º49.877'W), Orange (07º48.522'S; 34º50.161'W) and Maria Farinha (07º51.804'S; 34º50.063'W). South coast: Suape (08º21.851'S e 34º57.496´W), Porto de Galinhas (08º 30.247'S; 35º00.009'W), Barra de Sirinhaém (08º36.721'S; 35º02.814'W), Tamandaré (08º44.926'S; 35º 05.203'W) and São José da Coroa Grande (08º52.718'S; 35º08.242'W).

Design experimental

All samples were obtained from a fixed quadrant of 600 m² (20 m x 30 m) positioned parallel to the beach line at diurnal low tide. This quadrant was subdivided into three areas with 200 m² (20 m x 10 m), with one selected at random to be sampled, and this area was not used in the following month, avoiding the overlap of sampling.

As these crabs live in the oral and aboral surface of sand dollar (Telford, 1978; Pohle & Telford, 1981; Griffith, 1987), it was collected individuals of sand dollars, inside the quadrant of 200 m², were manually collected using diving equipment (mask and breathing tube) according to Bell & Stansik (1983). Each individual was packaged inside a plastic tray and placed in a plastic bag, properly labeled, packed in coolers with ice and brought to the Zooplankton laboratory of the Federal University of Pernambuco (Brazil), and kept cooled in freezers until the analysis. Parallel collections of biological material, has measured up abiotic variables that could influence the metabolism of species (temperature) and the spatial distribution (salinity and grain size). For this, mostred a sampled of water temperature (mercury thermometer ºC) and salinity (Optical refractometer) were obtained in each sampling site. Sediment samples were taken for analysis of granulometry, according to Suguio (1973).

Laboratory proceeding

In the laboratory, the species of crabs and sand dollars were identified with specific literature (Melo, 1999; Martins & D'Incao, 1996; Fernandes et al., 2002; Manso et al., 2008). Then, for each crabs it was measured the total carapace width and abdomen width fifth somite abdomen under a microscope using a 0,0001 mm precision caliper rule, according Hartnoll (1978) and Hartnoll (1982).

Individuals *D. crinitichelis* were classified (morphological characteristics of the abdomen), juvenile, immature and adult (males and females). The juveniles were individuals who survived the pelagic benthic/transition and became first crabs molt, corresponding to the smaller individuals collected and which form the first size class (Pardo et al., 2007). The immature were all individuals presenting the pleopods slightly differentiated and united to the animal cephalothorax. The adult males have the pleopods located on the first and second abdominal segments, with their pleopods long and thin. The adult females presented the pleopods located from the second to fifth wide abdominal segment (Narchi, 1973). Adult females with eggs were identified due to the presence of eggs adhered to the pleopods.

Initially, the population data of *D. crinitichelis* was obtained the number of crab residing in sand dollars (crabs/sand dollars). Except the recruitment period, where it was used every juveniles who entered the population in the month. Posteriorly, this data was check as to normal distribution (Kolmogorov-Smirnov test) and homocedasticity (test Levene). As the data did not reach this assumption, these were logarithmic ($Log_{10}(x + 1)$). These were reassessed in their normal and homocedasticity, for from there using parametric tests or non - parametric. Subsequently, in order to verify differences in population densities (total, immature (juvenile and immature), adult male and adult female) during the months in which the samples were held it was used the Kruskal-Wallis. The influence of the abiotic variables on population density was calculated through multiple and single regressions (Zar, 1999). Sex ratio was obtained by Chi-quadrat-test (X^2) considering male and female abundance.

For analyses of growth of *D. crinitichelis*, initially was developed a simples linear regression analyses between carapace width an fifth somite abdomen to give a potency equation for male and female, from these equations proportional residual of male and female were obtained. After, the values of proportional residuals (male and female) was verified if existence of polyphasic growth for specie. For this, it was found in the carapace width / fifth somite abdomen width of male and female individuals, through the distribution of its proportional residuals, compared with a *t* test (Zar, 1999). If differences were observed between the proportion residues of males and females, growth was considered whether or not polyphasic. Carapace width and fifth somite abdomen measurements were conducted to allometric equation, following the model of Huxley ($y=a.x^b$), where “y” is the individual fifth somite abdomen, “x” is the individual carapace width, “a” is proportionality coefficient and “b” is allometric coefficient. The coefficient of allometric growth (b) can be isometric (= 1), negative (<1) or positive (> 1). For adjust the values of allometric conditions factor was plotted a potency equation. The condition factor (k) was developed by the formula "$k= Wc/Wa^b$", B = individual carapace width, L = individual fifith somite abdomen width and "b" = Allometric coefficient of its beach and month in which the individual was collected. From there was adjusted a polynomial equation that best represents the plotted data.

The tests described were calculated in statistical software "R", in its version 3.1.1, and it was considered a significance level of $\alpha = 0.05$ “package stats”.

Results

Population Parameters

We collected 79,760 crabs of the species *Dissodactylus crinitichelis*. The monthly average was 6.41 ± 12.68 Crabs/Sand dollar, varying from 2.17 Caranguejo/Sand dollar in May to 20.20 Crabs/Sand dollar in November (Figure 2a).

Among the stages of development, the immature stage presented the highest total average density with 6.41 ± 12.40 Crabs/Sand dollar (Figure 2b). The higher density for this stage was collected in November (19.46 Crabs/Sand dollar) and the lowest value was obtained in September (1.66 Crabs/Sand dollar) (Figure 2b). The adult male crabs submitted an average 0.25 ± 0.38 Crabs/Sand dollar; its greatest value was obtained in December (0.52 Crabs/Sand dollar), and the lowest value was obtained in May (0.15

Crabs/Sand dollar) (Figure 2c). The adult female crabs presented an average 0.16 ± 026 Crabs/Sand dollar; highest value was obtained in November and December (0.29 Crabs/Sand dollar), and lowest value was obtained in May (0.04 Crabs/Sand dollar) (figure 2d). The tests showed that there is no difference between the density of crabs in the month ($H_{(12, 9)} = 7.0353$, $p = 0.7962$). Ever as in the development stages, immature ($H_{(12, 9)} = 4.4413$, $p = 0.9552$), adult male ($H_{(12, 9)} = 6.3331$, $p = 0.8502$) and adult female ($H_{(12, 9)} = 8.4617$, $p = 0.6714$).

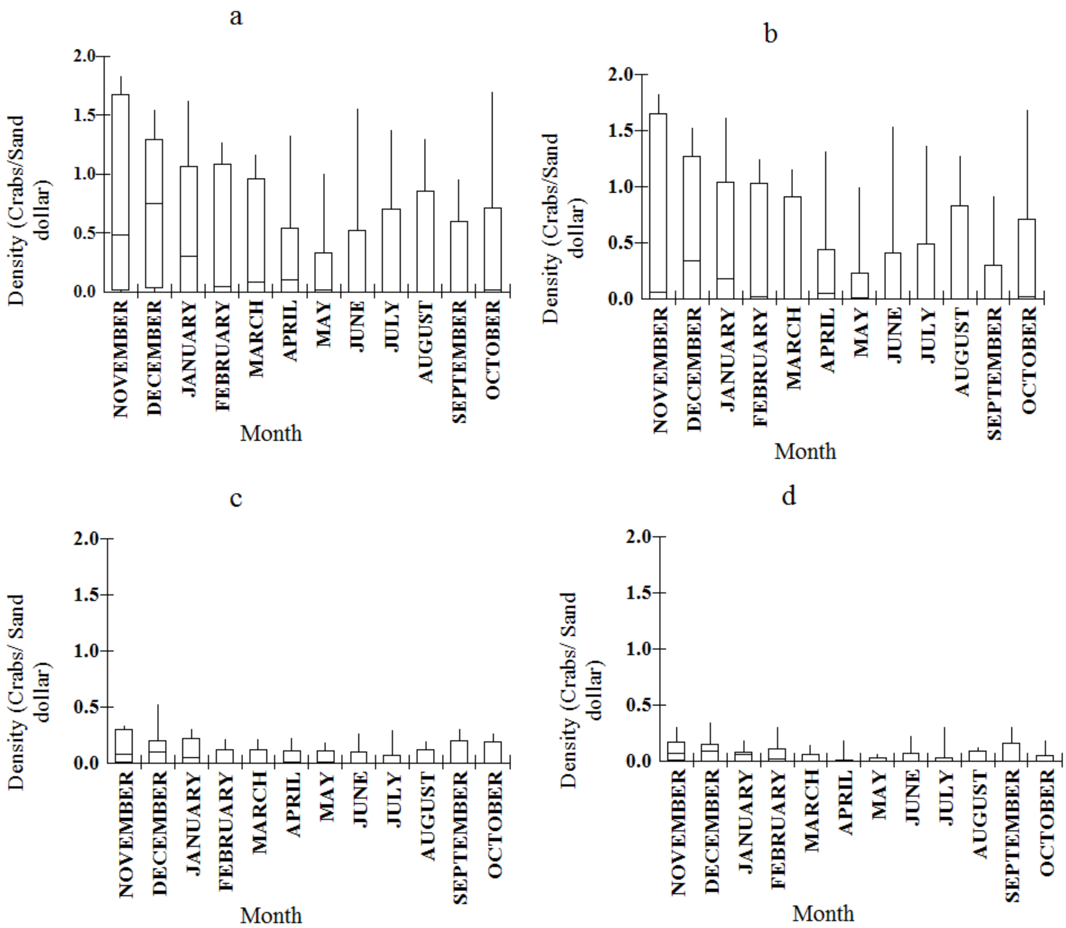

Figure 2. Average density (Crabs/ Sand dollar) of *Dissodactylus crinitichelis* at Pernambuco littoral, “a” total density, “b” immature, “c” male and “d” female, tropical Southwestern Atlantic, from November/2011 to October/2012.

Already in the beaches of the coast of Pernambuco, the higher density was collected in Sossego (21.22 Crabs/Sand dollar) and no was obtained crabs in Porto de galinhas (Figure 3a). The immature its greatest value was obtained in Sossego (20.62 Crabs/Sand dollar) (Figure 3b). The adult male crabs presented its highest value was obtained in Orange (0.62 Crabs/Sand dollar) (figure 3c). The adult female crabs presented its highest value was obtained in Mª farinha (0.39 Crabs/Sand dollar) (figure 3d). We did not record any crab in the Porto de galinha beach. The tests showed that there is difference between the density of crabs in the beches ($H_{(9, 12)} = 64.2215$, $p < 0.001$). Ever as in the development stages, immature ($H_{(9, 12)} = 65.3140$, $p < 0.001$), adult male ($H_{(9, 12)} = 52.1203$, $p < 0.001$) and adult female ($H_{(9, 12)} = 44.3244$, $p < 0.001$).

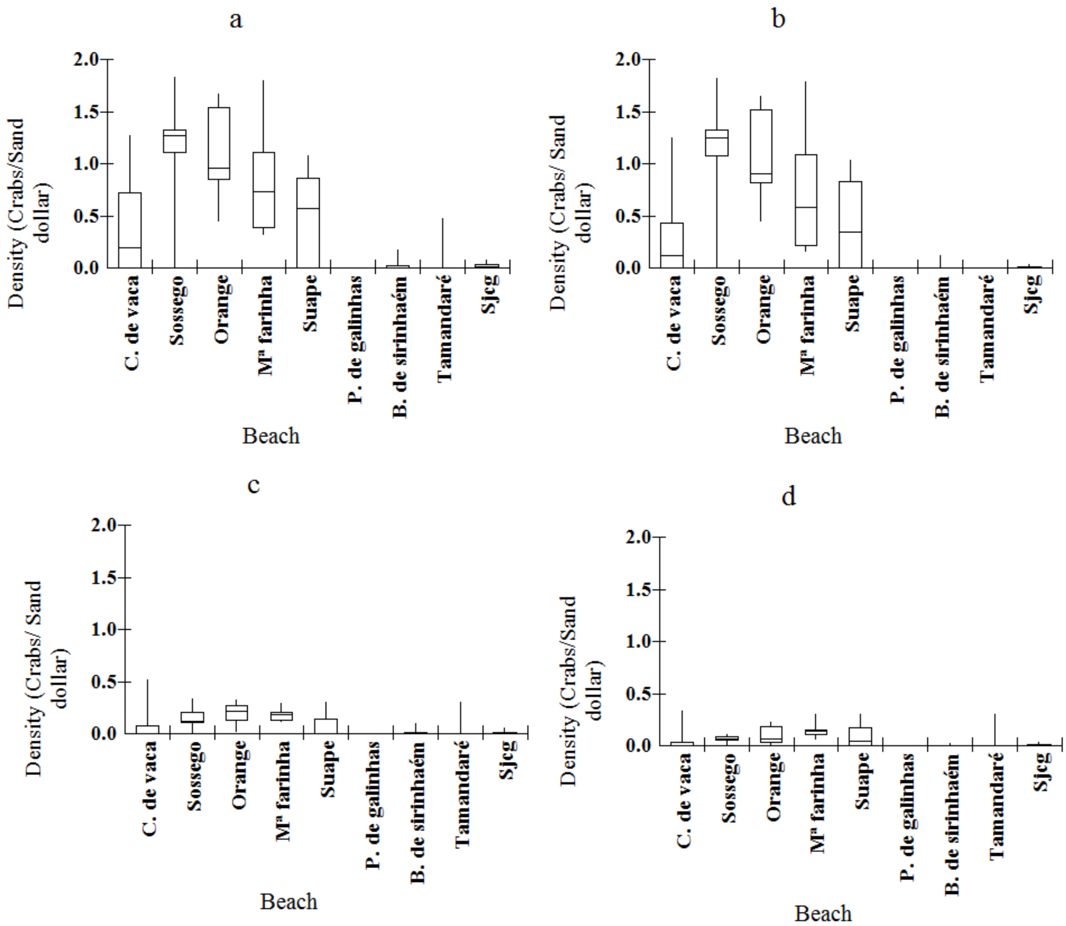

Figure 3. Density (Crabs/Sand dollar) of *Dissodactylus crinitichelis* at Pernambuco littoral, “a” total density, “b” immature, c” adult male, “d” adult female, tropical Southwestern Atlantic, from November/2011 to October/2012.

Environmental variables x population structure

Multiple regression analysis showed that all the abiotic variables sampled, influenced the individuals of *D. crinitichelis* (Table 1). However, not all the stages respond the same way. Since the immature have significant values (R = 0.31; p = 0.04), with a similar correlation and significant values to total data of the species (R = 0.30; p = 0.04) (Table 1), since these individuals were recently in the water column. While noting that the abiotic variables influence the population and only the immature stages, relationship of values (R) were between 30 - 31%, indicating acceptable correlation, between these variables. The high values observed in the regression coefficients (β) to the grain size suggests that this variable governs the density variation of the population of this crab (Table 1), with acceptable values and significance of correlation (R = 0.25; p = 0.01) (Table 1). However, the adults did not show dependence on the abiotic variables, living beneath the sand dollars and isolated from the abiotic conditions of the water column (Table 1).

Table 1. Multiple regression of population *D. crinitichelis* "R", the regression coefficient "β", the sampling error "ε", the test value "F", the total and partial significance of "p", temperature “T”, salinity “S”, rainfall “P” and granulometry “G”.

	R	B				ε	F	**p**
		β T	β S	β P	β G			
Total	0.31	0.09	0.04	0.02	0.25	12.31	2.65	**0.04**
p partial		0.33	0.65	0.82	**0.01**			
Immature	0.30	0.10	0.04	0.02	0.25	12.04	2.63	**0.04**
p partial		0.33	0.68	0.80	**0.01**			
Male	0.20	0.09	0.08	-0.0	0.11	0.38	1.09	0.38
p partial		0.37	0.40	0.61	0.24			
Female	0.15	-0.0	0.08	-0.0	0.12	0.26	0.60	0.66
p partial		0.95	0.40	0.92	0.24			

Sex Ratio

The sex ratio showed an annual average of 2.03:1 (M:F), with highest proportions in May (3.23:1) and smaller proportion recorded in June (1.24:1) (Figure 4). Tests have revealed differences between the number of males and females collected over the sampling period ($X^2_{(2, 12)} = 33.959$ $p < 0.001$), since 66.20% of the listed individuals were males (Figure 4).

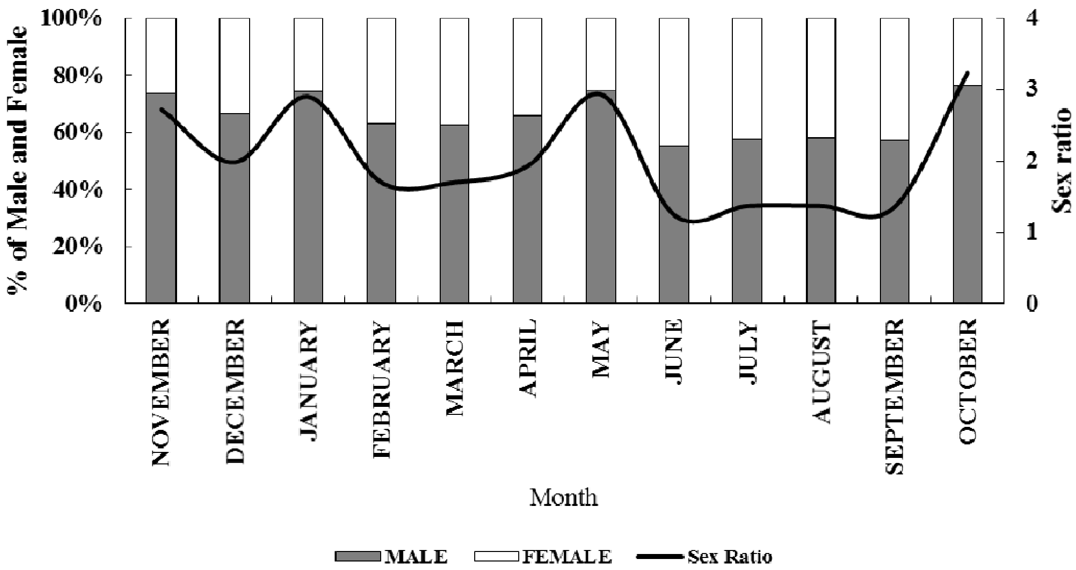

Figure 4. Sex ratio of *Dissodactylus crinitichelis* in Pernambucuco littoral, Northeastern Brazil from November/2011 to October/2012.

Recruitment Period

The average abundance of juvenile was of 18 ± 131.02 Crabs/Sand dollar, the biggest entry of juvenile individuals in population occurred in May with 151.70 Crabs/Sand dollar and they were not registered juveniles in November, January, March, August, September and October. The analyses revealed that there is no difference between the abundance of juveniles in the population ($H_{(12, 9)} = 8.1070$, $p = 0.7037$) over the studied months.

Growth

Individuals of different stages of benthic development presented different average values for both the width of the carapace and width of the abdomen.

The amounts used of the carapace width and abdomen width of the development stages showed a positive correlation above 54%. However, the immature stages and male, had greater correlations, respectively 72% and 75%, while juveniles correlated 65%, and adult females correlations of 55%. Moreover, these show different stages allometric coefficients. Immature and juvenile tending to isometry (b=1). The males tend to allometric negative (b<1) and females tend to allometric positive (b> 1) (Figure 5b). Despite the juvenile, immature and adult male stages have different Allometric coefficients, the breadth of the carapace of these stages overlap, thus the union of these stages have a allometric factor tending to isometric (b = 1) and a correlation between carapace width and width of the fifth abdominal somite was 82.23% (figure 5a). The specie presented polyphasic growth, since the analysis of proportional residuals demonstrated that male and female individuals exhibit different growth ($t_{(2;\ 2,313)}$ = -2.9059, p=0.002).

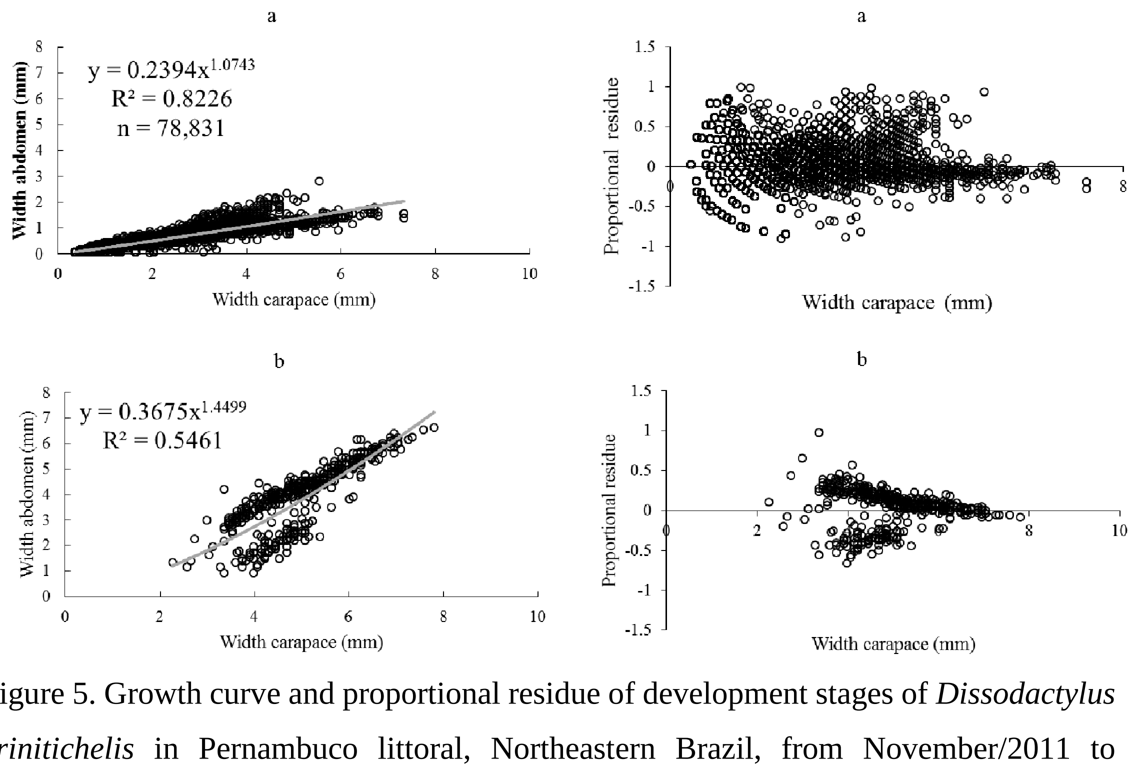

Figure 5. Growth curve and proportional residue of development stages of *Dissodactylus crinitichelis* in Pernambuco littoral, Northeastern Brazil, from November/2011 to October/2012.

Condition Factor

The condition factor showed an average of 1.28 ± 0.23, with the highest value observed in January (1.63 ± 0.08) and the lowest in September (0.73 ± 0.70). The rainy season presented higher values in the condition factor of species with average of 1.36 ± 0.09, while the dry season presented an average value of 1.20 ± 0.31. Can observe an imbalance in the condition factor between the months of hydrological transition (February and March – dry/rainy and August and September – rainy/dry), with a tendency to increase in the coming months and a peak in its respective hydrological period (January – dry and June - rainy). During the studied months, the condition factor presented a curve with higher values in January (dry season) and May (rainy season), indicating good environmental condition during these months (Figure 6).

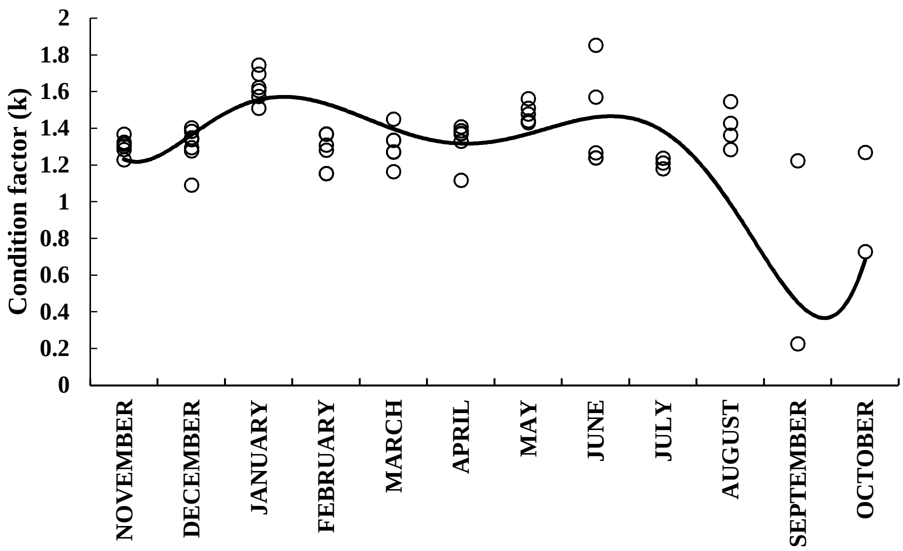

Figure 6. Average condition factor of *Dissodactylus crinitichelis* of nine in the Pernambuco littoral, Northeastern Brazil, from November/2011 to October/2012.

Discussion

The density of *Dissodactylus crinitichelis* was considered very high, as Furlan (2010) found an average of only 2 individuals of the same species, in the coastal of Ubatuba - SP. Even as Gómez-Lemos et al. (2010), also registered few individuals on the coast of Colombia. Moreover, Gomez-Lemos et al. (2010), relates the low density of Pinnotheridae and this is a commom fact to this family, that occur associated with other phyla (echinoderms, mollusks, polychaete and ascidians), being difficult to sample. Martinelli-Filho et al. (2014), mention that the crab population of *D. crinitichelis* is closely linked to the density of its host. Additionally, in our research the high density of crabs was recorded only in the north coast of the state of Pernambuco, where there are less wave protection, since the reefs are further away than in the south coast. This would decrease the intensity of coastal currents facilitating the dispersion, settling, reproduction and displacement of their host, while in the south coast, the lack of shock waves, make it difficult to cause sediment resuspension, resulting in sediment compaction, hindering the displacement of the hosts. This fact was noted by Bell (1981), which registered the sand dollar (*Mellita quinquiesperforata* Leske, 1778) invading areas with low current flow, facilitating the movement of the crab. This species of crab can live in many hosts as *Encope emarginata* Leske, 1778, *E. Michelini* Agassiz, 1841, *Clypeaster subdepressus* Gray, 1825 and *Leodia sexiesperforata* Leske, 1778 (Telford, 1978, Pohle & Telford, 1981; Griffith 1987).

The similarity in the general density between the months for the sampled crabs suggests a balance between the input of individuals in the population (recruitment), characteristic typical of tropical coastal environments (Macintosh, 1989; Litulo, 2004; Litulo, 2005) and constant migration and mortality of individuals (Diaz & Conde, 1989; Moura et al., 2000). These characteristics condition the population to a monthly balance, over the hydrological season. Bell & Stancyk (1983), described that the life cycle of another species of the same genus (*D. mellitae* Rathbun, 1900) is 12-15 months. Furthermore, Bell (1981) reports a 50% reduction of the population of this species (*D. mellitae*) in only five months.

All stages of benthic population of *D. crinitichelis* were found, from juvenile, through the immature (male and female), and adults (male, female, adult female without egg and adult female with egg). The present study registered a predominance of juveniles, with decline in subsequent stages, a fact noted by Baptista et al. (2003) studying the population of *Callinectes ornatus* Ordway, 1863 and Kowalczuk & Masunari (2000) with the population of *Armases angustipes* Dana, 1852, both on the coast of Paraná. This decrease is caused probably by the pressure of the migration of newly settled individuals (juvenile) and mortality of subsequent classes (immature) (Moura et al., 2000). However, Lima et al. (2006) studied two species of decapod (*Potimirim glabra* Kingsley, 1878 and *P. potimirim* Muller, 1881) and found the opposite, with the more advanced stages (adult) presenting higher density than younger stages (juvenile). However, this distortion was linked to sampling error (Lima et al., 2006).

Some authors have described the influence of abiotic variables on the population of brachyuras crabs (Chacur et al., 2000; Bertini et al., 2001; Bertini & Fransozo, 2004). Furthermore, they demonstrated that the sand particle size is one of the most important factors for the spatial distribution of Brachyura. An example of this was registered with the crab *Hepatus pudibundus* Herbst 1785 (Pinnotheridae) inhabitant of regions with predominance of fine sand (Mantelatto et al., 1995; Bertini & Fransozo, 2004). This may be needed to protect the crab from predators in a fast way, since they would bury more easily (Williams, 1984). Gómez-Lemos et al. (2010), studying Pinnotheridae from Colombia, described the need of these crabs for certain areas becoming endemic in sandy banks, from rivers and estuaries.

It has been observed along the year, both adult females without and with eggs (ovigerous), and juveniles, not showing a characteristic season or month. Similar fact was observed for *D. mellitae* living in *M. quinquiesperforata* (Bell, 1988), in which the author reports that females of this crab produce planktonic larvae throughout the year. Besides this, the females foresee the need to produce eggs (Bell 1981; Bell & Stancyk, 1983). This behavior was also observed for other species of crabs *Austinixa aidae* Righi, 1967 (Pinnotheridae) (Peiró & Mantelatto, 2011), *C. danae* Smith, 1869 (Portunidae) (Costa & Negreiros-Fransozo, 1998), *Portunus spinimanus* Latreille, 1819 (Santos & Negreiros-Fransozo, 1999), *C. ornatus* (Mantelatto & Fransozo, 1999), and *Arenaeus cribrarius* (Lamarck, 1818) (Pinheiro & Terceiro, 2000). This crab present reproduction throughout the year, a characteristic behavior of crabs living in tropical regions, (Sastry, 1983). However, it was noticed a higher recruitment in the summer months, similar behavior observed by Bell (1988), who studied *D. mellitae* residing in *M. quinquiesperforata* in South Carolina (USA).

The imbalance in the sex ratio is common to the species of Brachyura (Wenner, 1972), and this imbalance showed little variation throughout the year, always with highest proportion of males compared to females. The same fact was observed by Ramirez et al. (1992) to species of the family Portunidae *Callinectes rathbunae* Contreras, 1930, *C. similis* Williams, 1966 and *C. sapidus* Rathbun, 1896. The largest proportion of males was also observed for the genus *Callinectes* (Buchanan & Stoner, 1988; Moreira et al., 1988; Pita et al., 1985), *C. ornatus* to São Paulo littoral (Mantelatto & Fransozo, 1999) and Paraná (Branco & Lunardon-Branco, 1993). The increase in the sex ratio in the month of October coincide with the largest entry of juveniles in the population, during the next month (November), suggesting that females leave or leave its host (October) for larvae release in the plankton. This suggests that the species has a reproductive strategy, common to other genus (*Callinectes* and *Uca*) (Van Engel 1958), relocating to another region for better larval dispersion, where the larvae would migrate to new areas (Hines et al., 1987; Guerin & Stickle, 1997).

The individuals collected from the coast of Pernambuco showed similar carapace width to the data described by Fumis et al. (2006), where the author described only two stages of benthic development (juvenile and adult) subdivided, however, the two stages in five class each. The smallest individuals fit in first class (juvenile), 0.8 – 1.3 mm, while the largest individuals belong in the last class of length (adult) 5.3 - 5.8 mm (Fumis et al., 2006). The differences with our results can be associated with the constant availability of food under controlled conditions (temperature and salinity) and absence of turbulence, developed by the experiment in the laboratory (Fumis et al., 2006).

The polyphasic growth observed in *D. crinitichelis* may be related to the behavior that each individual plays in the population. The positive allometry observed for *D. crinitichelis* is consistent with the observations described by Hartnoll (1974) for other species of Brachyura. However, not all developmental stages described showed the same kind of growth. Males invest in abdominal width, in order to enhance its reproductive character, while females invest in carapace width, this feature would increase the ability to have carry eggs. This was not observed for the juvenile individuals, with isometric growth, due to the lack of well defined sexual characteristics. The isometry for juveniles was not observed for crabs from other families with 0.85 to Portunidae (Pinheiro & Fransozo, 1993), 1.15 to Calappidae (Mantelatto & Fransozo, 1994), 1.21 to Majidae (Hiyodo & Fransozo, 1995) and 1.13 to Grapsidae (Kowalczuk & Masunari, 2000). However, all these families are composed by free-living crabs.

It can be concluded that the population parameters of crab *D. crinitichelis* resident in the sand dollars are influenced by abiotic variables, mainly the grain size. Once the highest densities of crabs and all stages of development were found in months of the dry season (November and December) and the lowest values recorded in one month of the rainy season (May). Already, over the beaches sampled, we observed a higher density on the north coast beaches, while the densities were reduced on the beaches of the south coast and non-existent on the beach of Porto de Galinhas. The north coast beaches presented more favorable environmental characteristics, both crabs and for sand dollars. The high densities are tied the best conditions observed by the north coast beaches. Once the reefs are located farther away from the beach, allowing waves to break with moderate intensity, enough to facilitate the thinner sediment movement in these beaches of species of sand dollars and consequently and thus better abiotic and biotic conditions for feeding, development and reproduction of individuals for this species. The sediment shown as the variable more influence the distribution of *D. crinitichelis*. The population of D. crinitichelis presented at male predominance (60.20%). The specie D. crinitichelis does not use any month for intensify recruitment. However, the highest recruitment was in the May and non-existent recruitment in four monts in the dry period and two in the transitional period of the rainy season to dry season. Therefore, the recruitment of population of crab occurs with greater intensity during the rainy season. The individuals have a slight positive allometric growth, while the females the growth was markedly positive. This shows that the crabs invest much of their energy to the growth of the carapace, which would be responsible for both the best accommodation of the eggs from the female, as best able to obtain resource and defend your playing. The condition factor showed that species have a better development in characteristic months at a time, with little rain (drought) or too much rain (rainy). The condition factor decay in the months of transition between the hydrological periods, suggesting reproductive peaks. These work contribute to better understanding of *D. crinitichelis* biology. Mainly to characterize the temporal and spatial distribution of a crab that lives in other species, besides demonstrating its growth and better conditions for nesting, development and reproduction.

Acknowledgements

We thank the Postgraduate Program in Zoology and the Museu Paraense Emílio Goeldi, both from the Federal University of Pará – UFPA; the Department of Oceanography and the Museum of Oceanography from the Federal University of Pernambuco (UFPE). This study is derived from the research conducted for the doctoral thesis of AGC at Federal University of Pará/ Museu Paraense Emílio Goeldi (UFPA/MPEG), for which a scholarship was provided by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES). SNL (process: AUX-PE-CIENCIAS DO MAR 1136/2010) and LFAM (process: 301343/2012-8) was supported by the National Council for Scientific and Technological Development (CNPq).

References

Albuquerque, M. C. P. de, J. F. Ferreira, G. C. Salvador & C. Turini, C. 2012. Influência da temperatura e da salinidade na sobrevivência e crescimento de larvas da ostra perlífera *Pteria hirundo*. Boletim do Instituto de Pesca 3: 189 – 197.

Andrade G. O. & R. Lins 1965. Introdução à morfoclimatologia do Nordeste do Brasil. Arquivos do Instituto de Ciências da Terra 3-4: 11-28.

Anger, K., J. Harms, M. Montú & C. D. Bakker, 1990. Effects of salinity on the larval development of a semi terrestrial tropical crab, Sesarma angustipes (Decapoda: Grapsidae). Marine Ecology Progress Series 62: 89-94.

Anger, K., E. Spivak, C. Bas, D. Ismael, T. Luppi, 1994. Hatching rhythms and dispersion of decapod crustacean larvae in a brackish coastal lagoon in Argentina. Helgoländer Meeresuntersuchungen 48: 445-466.

Anger, K., K. Riesebeck & C. Püschel, 2000. Effects of salinity on larval and early juvenile growth of an extremely euryhaline crab species, *Armases miersii* (Decapoda: Grapsidae). Hydrobiologia 1: 159-166.

Anger, K., 2001. The biology of decapod crustacean larvae. Crustacean Issues, A.A. Balkema, Lisse, Netherlands.

Anger, K., 2003. Salinity as a key parameter in the larval biology of decapod crustaceans. Invertebrate Reproduction & Development 1: 29-45.

Anger, K., 1996. Salinity tolerance of the larvae and first juveniles of a semiterrestrial grapsid crab, *Armases miersii* (Rathbun). Journal Experimental Marine Biology and Ecology 202: 205-223.

Aragão, J. O. R., 2004. A Influência dos Oceanos Pacífico e Atlântico na Dinâmica do Tempo e do Clima do Nordeste do Brasil. In, Eskinazi-Leça, E., S. Neumann-Leitão, M. F da Costa, (Eds). Oceanografia: Um cenário tropical. Recife.

Araújo, A. M., 2003. Desenvolvimento de procedimentos experimentais para avaliar a evolução de bancos dragados. I Simpósio de Recursos Hídricos da Amazônia, Anais do I SRH, Fundação Rede Amazônica, Manaus.

Baptista, C., M. A. A. Pinheiro, A. Blankensteyn, & C. A. Borzone, 2003. Estrutura populacional de *Callinectes ornatos* Ordway, 1863 (Crustacea, Portunidae) no Balneário Shangrilá, Pontal do Paraná, Paraná, Brasil. Revista Brasileira de Zoologia 4:661-666.

Barnwell, F. H & C. L. Thurman, 1984. Taxonomy and biogeography of the fiddler crabs (Ocypodidae: Genus Uca) of the Atlantic and Gulf Coasts of Eastern North America. Zoological Journal of the Linnean Society 81 (1): 23-87.

Barros, F., C. A. Borzone & S. Rosso, 2001. Macroinfauna of six beaches near Guaratuba bay, southern Brazil. Brazilian Archives of Biology and Technology 4: 351-364.

Bell, J. L. & S. E. Stancyk, 1983. Population dynamics and reproduction of *Dissodactylus mellitae* (Brachyura: Pinnotheridae) on its sand dollar host *Mellita quinquiesperforata* (Echinodermata). Marine Ecology Progress Series 13: 141-149.

Bell, J. L., 1981. Life history and ecology of *Dissodactylus mellitae* (Brachyura: Pinnotheridae) on the sand dollar *Mellita quinquiesperforata*. Master thesis, University of South Carolina, Columbia.

Bell, J. L. 1988. Distribution and abundance of *Dissodactylus mellitae* Rathbun (Pinnotheridae) on *Mellita quinquiesperforata* (Leske) (Echinodermata). Journal of Experimental Marine Biology and Ecology 117:93–114.

Bertini, G. & A. Fransozo, 2004. Bathymetric distribution of brachyurans (Crustacea, Decapoda) communities in soft bottom from southeastern Brazil. Marine Ecology Progress Series 279: 193-200.

Bertini, G., A. Fransozo, & R. C. Costa, 2001. Ecological distribution of three species of Persephona (Brachyura, Leucosiidae) in the Ubatuba region, São Paulo, Brazil. Nauplius 1:31-41.

Bezerra, L. E. A., A. O. de Almeida & P. A. Coelho, 2006. Occurrence of the family Pinnotheridae De Haan (Crustacea, Decapoda, Brachyura) on the coast of Ceará State, Brazil. Revista Brasileira de Zoologia, 4:1038-1043.

Bond, G. & L. Buckup, 1988. O ciclo da intermuda em *Macrobrachium borelii* (Nobili, 1896) (Crustacea, Decapoda, Palaemonidae): a influência da temperatura e do comprimento do animal. Revista Brasileira de Zoologia 1:45-59.

Braga, R. A. P., 1986. Caracterização preliminar da zona estuarina de sirinhaém. CPRH, Recife.

Braga, R. A. P., 1993. Prioridades de Conservação na Zona Costeira e Marinha do Brasil. Wwf Sne, João Pessoa.

Braga, F. M. S., 1997. Análise da equação alométrica na relação peso e comprimento e o fator de condição em Plagioscion squamosissimus (Teleostei, Sciaenidae). Revista Brasileira de Biologia 3: 417-425.

Branco, J. O. & M. J. Lunardon-Branco, 1993. Aspectos da biologia de *Callinectes ornatus* Ordway, 1863 (Decapoda, Portunidae) da região de Matinhos, Paraná, Brasil. Arquivos de Biologia e Tecnologia 3:489-496.

Buchanan, B. A. & A. W. Stoner, 1988. Distributional patterns of blue crab (*Callinectes* sp.) en a tropical estuarine lagoon. Estuaries 11: 231 - 239.

Cameron, R. A. & S. S. Runrill, 1982. Larval abundance and recruitment of the sand dollar *Dendraster excentricus* in Monterey Bay, California, USA. Marine Biology, 2: 197-202.

Campos E., A. R. de Campos & J. A. de León-González, 2009. Diversity and ecological remarks of ectocommensals and ectoparasites (Annelida, Crustacea, Mollusca) of echinoids (Echinoidea: Mellitidae) in the Sea of Cortez, Mexico. Parasitol Research 105:479–487.

Chacur M. M., C. B. Mansur & M. L. Negreiros-Fransozo, 2000. Distributional patterns, seasonal abundance and moult cycle of *Callinectes danae* Smith, 1869 in the Ubatuba region, Brazil. Nauplius 2: 215-226.

Christy, J. H., 1982. Adaptive significance of semi lunar cycles of larval release in fiddler crabs (genus *Uca*): Test of a hypothesis. Biological Bulletin 163: 251-263.

Coelho, P. A. & M. Ramos-Porto, 1995. Crustáceos da Região de Tamandaré, estado de Pernambuco, Brasil. Boletim Técnico Científico do CEPENE, 1: 49-56.

Costa, T. M. C. & M. L. Negreiros-Fransozo, 1998. The reproductive cycle of *Callinectes danae* Smith, 1869 (Decapoda, Portunidae) in the Ubatuba region, Brazil. Crustaceana 71: 615-627.

Costlow, J. D., C. G. Bookhout & R. Monroe, 1960. The effect of salinity and temperature on larval development of *Sesarma cinereum* (Bosc) reared in the laboratory. Biological Bulletin 118: 183-202.

Dautov, S. S., 2000. Distribution, species composition, and dynamics of echinoderm larvae in an area of the tumen river estuary and of the far east state marine reserve. Russian Journal of Marine Biology, 1:12-17.

Díaz, H. & J. E. Conde, 1989. Population dynamics and life history of the mangrove crab *Aratus pisonii* (Brachyura, Grapsidae) in a marine environment. Bulletin of Marine Science, 1:148-163.

Epifanio, C. E., 1988. Dispersal strategies of two species of swimming crab on the continental shelf adjacent to Delaware Bay. Marine Ecology Progress Series, 49: 243-248.

Fernandes, M. L. B., L. R. Tommasi, & E. J. B. Lima, 2002. Filo Echinodermata de Pernambuco, 405-428. In TABARELLI, M. & J. M. C. SILVA, (Eds). Diagnóstico da biodiversidade de Pernambuco. Massangana. Recife 722p.

Fonseca, R. S. da; J. Z. de O. Passavante, G. B. Maranhão, K. Muniz, 2002. Ecossistema Recifal da Praia de Porto de Galinhas (Ipojuca, Pernambuco): Biomassa Fitoplanctônica e Hidrologia. CEPENE, 1:9-35.

Forward R. B., Lohmann, K.; Cronin, T. W. 1982. Rhythms in larval releas by an estuarine crab (Rhithropanopeus harrisii). Biol. Bull. Mar. Biol. Lab., Woods Hole 163: 287-300.

Forward, R.B. 1989. Behavioral responses of crustacean larvae to rates of salinity change. Biological Bulletin, 170: 229-238.

Fumis, P. B.; Fransozo, A.; Bertini, G.; Braga, A. A.; Pie, M. R. 2006. Growth rate of the crab *Dissodactylus crinitichelis* Moreira, 1901 (Crustacea: Decapoda: Pinnotheroidea) under laboratory conditions. Proceedings of the biological society of Washington, 119 (3):395–403.

Furlan, M. 2010. Crustáceos Decápodos do Substrato não consolidado da Região de Ubatuba (SP): Composição, Abudância e Distribuição Ecológica. Dissertação, Ciências Biológicas, Universidade Estadual Paulista (UNESP). 114f.

Gomez-Lemos, L., N. Cruz-Castano & G. Duque-Nivia, 2010. Composición y Estructura Del Ensamblaje de Crustáceos Brachyura de La Plataforma Continental de La Guajira Colombiana y Su Relación Con La Profundidad y Las Características Del Sedimento. Boletín de Investigaciones Marinas y Costeras 2:359-379.

Griffith, H., 1987. Phylogenetic relationships and evolution in the genus Dissodactylus Smith, 1870 (Crustacea: Brachyura: Pinnotheridae). Canadian Journal of Zoology, 65: 2292–2310.

Guerin, J. L. & W. B. Stickle, 1997. A comparative study of two sympatric species within the genus *Callinectes*: osmoregulation, long-term acclimation to salinity and the effects of salinity on growth and moulting. Journal of Experimental Marine Biology and Ecology 2:165–186.

Hartnoll, R. G., 1974. Variantion in growth pattern between some secondary sexual characters in crabs (Decapoda, Brachyura). Crustaceana 27:131-136.

Hartnoll, R. G., 1978. The determination of relative growth in Crustacea. Crustaceana 3:281-293.

Hartnoll, R. G., 1982. Growth. In, Bliss, D. E. & L. G. Abele, (eds). The biology of Crustacea: embryology, morphology, and genetics. Academic, New York.

Hickson, R. G., 1980. Comportamento físico-químico da Baía de Tamandaré. Recife. Monografia de Graduação do Curso de Engenharia de Pesca da Universidade Federal Rural de Pernambuco.

Hines, A. H., R. N. Lipcius, A. M. Haddon, 1987. Population dynamics and habitat partitioning by size, sex, and molt stage of blue crabs *Callinectes sapidus* in a subestuary of central Chesapeake Bay. Marine Ecology Progress Series 36:55-64.

Hiyodo, C. M. & A. Fransozo, 1995. Relative growth of spider crab *Acanthonyx scutiformis* (Dana, 1851) (Crustacea, Decapoda, Majidae). Brazilian Archives of Biology and Technology 383: 969-981.

Kowalczuk, V. G. L. & S. Masunari. 2000. Crescimento relativo e determinação da idade na fase juvenil de Armases angustipes (Dana) (Decapoda, Brachyura, Grapsidae). Revista Brasileira de Zoologia 1: 17-24.

Lage, A. M. C., J. C. Joyeux & L. C. Gomes, 2011. Reprodução de *Lytechinus variegatus* (Echinodermata: Echinoidea): efeito do ciclo lunar e características da população. Acta Scientiarum. Biological Sciences 3: 341-346.

Lárez, M. B., J. L. Palazón-Fernández & C. J. Bolaños, 2000. The effect of salinity and temperature on the larval development of *Mithrax caribbaeus* Rathbun, 1920 (Brachyura, Majidae) reared in the laboratory. Journal of Plankton Research 10: 1855-1869.

Lima, M. S., K. O. A. Lacerda, I. X. Martins, & H. Matthews-Cascon, 2006 – Análise quali-quantitativa da fauna de equinodermos (Echinodermata) na região entremarés da praia do Pacheco (Caucaia, CE). In, Resumos do I Congresso de Biologia Marinha. Niteroi, UFF.

Litulo, C., 2004. Reproductive aspects of a tropical population of the fiddler crab *Uca annulipes* (H. Milne Edwards, 1837) (Brachyura: Ocypodidae) at Costa do Sol Mangrove, Maputo Bay, southern Mozambique. Hydrobiologia 525: 167-173.

Litulo, C., 2005. Breeding season of the hermit crab *Dardanus deformis* H. Milne Edwards, 1836 (Anomura, Diogenidae) in Maputo Bay, southern Mozambique. Journal of Natural History 39: 2137-2144.

Luppi, T. A., E. D. Spivak & C. C. BAS, 2003. The effects of temperature and salinity on larval development of *Armases rubripes* Rathbun, 1897 (Brachyura, Grapsoidea, Sesarmidae), and the southern limit of its geographical distribution. Estuarine, Coastal and Shelf Science 3: 575-585.

Mabesoone, J. M. & P. N. Coutinho., 1970. Litoral and shallow marine geology of Northeastern Brazil. Trabalhos do Instituto Oceanográfico da Universidade Federal de Pernambuco 12: 1-214.

MacIntosh, D. J., 1989. The ecology and physiology of decapods of mangrove swamps. Proceedings of the Zoological Society of London 59: 325-341.

Magalhães, M. K., E. Eskinasi–Leça & M. A. Moura-Junior, 1997. Morfometria e biomassa da fanerógama marinha *Halodule wrightii* Ascherson no litoral norte de Pernambuco. Trabalho Oceanografico Universidade Federal Pernambuco, 25:83-92.

Manso, C. L. C., O. F. S. Alves, & L. R. Martins, 2008. Echinodermata da Baía de Todos os Santos e da Baía de Aratu (Bahia, Brasil). Biota Neotropica, 3: 179-196.

Mantelatto, F. L. M. & A. Fransozo. 1994. Crescimento relativo e dimorfismo sexual em *Hepatus pudibundus* (Herbst, 1785) (Decapoda, Brachyura) no litoral norte paulista. Papéis Avulsos de Zoologia 4: 33-48.

Mantelatto, F. L. M. & A. Fransozo, 1999. Reproductive biology and moulting cycle of the crab *Callinectes ornatus* Ordway, 1863 (Decapoda, Brachyura, Portunidae) from Ubatuba Region, São Paulo, Brazil. Crustaceana 1:63-76.

Mantelatto F. L. M., A. Fransozo & M. L. Negreiros-Fransozo, 1995. Distribuicão do caranguejo *Hepatus pudibundus* (Herbst, 1785) (Crustacea, Decapoda, Brachyura) na Enseada da Fortaleza, Ubatuba, SP, Brasil. Boletins do Instituto Oceanográfico 1: 51–61.

Martinelli-Filho J. E., R. B. dos Santos & C. C. Ribeiro, 2014. Host selection, host-use pattern and competition in *Dissodactylus crinitichelis* and *Clypeasterophilus stebbingi* (Brachyura: Pinnotheridae). Symbiosis 63:99–110.

Martins, S. T. S. & F. D'incao, 1996. Os Pinnotheridae de Santa Catarina e Rio Grande do Sul, Brasil (Decapoda, Brachyura). Revista Brasileira de Zoologia 1: 1-26.

Melo, G. A. S. 1999. Manual de identificação dos Crustacea Decapoda do litoral brasileiro: Anomura, Thalassinidea, Palinuridea Astacidea. Plêiade/Fadesp, São Paulo.

Moreira, P. S., A. M. Paiva-Filho, C. M. Okida, M. M. Schimiegelow & R. Giannini, 1988. Bioecologia de crustáceos decápodas, brachyúrus no sistema baía-estuário de Santos e São Vicente, SP. I – ocorrência e composição. Boletim do Instituto Oceanografico 1/2: 55-62.

Morgan, S. G. 1992. Predation by planktonic and benthic invertebrates on larvae of estuarine crabs. Journal Experimental Marine Biology and Ecology 1: 91-110.

Morgan, S. G. 1995. Life and death in the plankton: larval mortality and adaptation. In, L. R. McEdward (ed.), Ecology of Marine Invertebrate Larvae, Fl: CRC Press, Boca Raton.

Moura, N. F. O., P. A. Coelho-Filho & P. A. Coelho, 2000. Captura de *Goniopsis cruentata* Latreille (1803) em um manguezal do litoral norte de Pernambuco - Brasil (Crustacea, Brachyura, Grapsidae). In, Anais do Mangrove 2000. Universidade Federal Rural de Pernambuco.

Narchi, W., 1973. Crustáceos: Estudos Práticos. Edusp, São Paulo.

O'Connor, N. J. & C. E. Epifanio, 1985. The effect of salinity on the dispersal and recruitment of fiddler crab larvae. Journal of Crustacean Biology, 5: 137-145.

Pardo, L. M., F. Piraud, F. L. Mantelatto & F. P. Ojeda, 2007. Ontogenetic pattern of resource use by the tiny hermit crab *Pagurus villosus* (Paguridae) from the temperate Chilean coast. Journal of experimental marine biology and ecology, 1: 68 – 79.

Peiró, D. F. & F. L. Mantelatto, 2011. Population dynamics of the pea crab *Austinixa aidae* (Brachyura, Pinnotheridae): a symbiotic of the ghost shrimp *Callichirus major* (Thalassinidea, Callianassidae) from the southwestern Atlantic. Iheringia Série Zoologia 101: 5−14.

Pinheiro, M. A. A. & A. Franzoso, 1993. Análise da Relação Biométrica do peso úmido pela largura da carapaça para o siri *Arenaeus cribarius* (Lamarck, 1818) (Crustacea, Brachyura, Portunidae). Arquivos de Biologia e Tecnologia 2: 331-341.

Pita J. B., E. S. Rodrigues, R. Graça-Lopes & J. A. P. Coelho, 1985. Observações bioecológicas sobre o siri *Callinectes danae* Smith 1869 (Crustacea, Portunidae), no Complexo Baía- Estuário de Santos, São Paulo, Brasil. Bolelins do Instituto de Pesca 4: 35–43.

Pohle, C. & M. Telford, 1981. The larval development of *Dissodactylus crinitichelis* Moreira, 1901 (Brachyura, Pinnotheridae) in laboratory culture. Bulletin of Marine Science 31:753–773.

Posey, M. H., T. D. Alphin, H. Harwell & B. Allen, 2005. Importance of low salinity areas for juvenile blue crabs, *Callinectes sapidus* Rathbun, in the river-dominated estuaries of southeastern United States. Journal of Experimental Marine Biology and Ecology, 319:81-100.

Queiroz V., L. Sales, E. Neves & R. Johnsson 2011. *Dissodactylus crinitichelis* Moreira, 1901 and *Leodia sexiesperforata* (Leske, 1778): first record of this symbiosis in Brazil. Nauplius 1: 63-70.

Ramírez, R., A. C. Olivera & S. M. P. M. Meier, 1992. Ecología del género *Callinectes* (Brachyura: Portunidae) en seis cuerpos de aguacosteros del Estado de Veracruz, México. Anales del Instituto de Ciencias del Mar y Limnología 1: 33-41.

Rathbun, M. J., 1918. The Grapsoid crabs of America. Bulletin of the United States National Museum 97: 1-445.

Ross, D. M., 1983. Symbiotic relations. In, Vernberg, F. J. & W. B. Vernberg (Eds). The biology of Crustacea: behavior and ecology. Academic Press, New York.

Santos, S. & M. L. Negreiros-Fransozo, 1999. Reprodutive cycle of the swimming crab *Portunus spinimanus* Latreille (Crustacea, Decapoda, Brachyura) from Ubatuba, São Paulo, Brazil. Revista Brasileira de Zoologia 4:1183-1193.

Sastry, A. N., 1983. Ecological aspects of reproduction. In, Vernenberg, W. B. (Ed.). The Biology of Crustacea: Environment Adaptations. Academic Press, New York.

Schmitt, W. L., J. C. McCain & E. S. Davidson, 1973. Decapoda I: Brachyura I: Fam. Pinnotheridae. Crustaceorum Catalogus 3: 1–160.

Smith, R. R. 1989. Nutritional energetics. In, Halver, J. E. (Ed). Fish Nutrition. Academic Press, San Diego.

Suguio, K., 1973. Introdução à sedimentologia. Edgard Blucher/EDUSP (ed.), São Paulo.

Telford. M. 1982. Echinoderm spine structure, feeding and host relationships of four species of *Dissodactylus* (Brachyura: Pinnotheridae). Bulletin of Marine Science 32: 584-594.

Telford, M. 1978. Distribution of two species of Dissodactylus (Brachyura: Pinnotheridae) among their echinoid host populations in Barbados. Bulletin of Marine Science, 28:651–658.

Pinheiro, M. A. A. & O. S. L. Terceiro, 2000. Fecundity and reproductive output of the speckled swimming crab, *Arenaeus cribrarius* (Lamarck, 1818) (Brachyura, Portunidae). Crustaceana 9: 1121-1137.

Van Engel, W. A., 1958. The blue crab and its fishery in Chesapeake Bay. Part 1. Reproduction, early development, growth and migration. Commercial Fisheries Review 6:6-17.

Ventura, C. R. R. & D. O. Pires, 2002. Ciclos de vida de invertebrados marinhos. In, Pereira, R. C. & A. Soares-Gomez, (Ed.). Biologia marinha. Interciência, Rio de janeiro.

Wenner, A. M., 1972. Sex-ratio as a function of size in marine Crustacea. The American Naturalist 106: 321-350.

Williams, A. B., 1966. The western Atlantic swimming crabs *Callinectes ornatus*, *C. danae*, and a new, related species (Decapoda, Portunidae) Tulane. Zoological Studies 13:83-93.

Williams, A. B., 1984. Shrimps, lobsters and crabs of Atlantic coast of the eastern United States, Maine to Florida. Smithsonian Institution Press, Washington.

Wirtz, P., G. A. S. Melo & S. Grave, 2009. Symbioses of the decapod crustaceans along the coast of Espirito Santo, Brazil. Marine Biodiversity Records 2:1-9.

Zar, J. H., 1999. Biostatistical Analysis. Prentice-Hall. New Jersey.

CAPÍTULO III - Influence of host *Encope emarginata* Leske, 1778 (Echinoidea: Clypeasteroida) over the crab the crab *Dissodactylus crinitichelis* Moreira, 1901 (Brachyura: Pinnotheridae) in a Tropical Brazilian Coast

Cunha, A G; Neumann-Leitão, S; Montag, L. F. A.

Capítulo a ser submetido para a revista *Journal of Experimental Marine Biology and Ecology (ISSN: 0022-0981)*

Abstract

The crab *Dissodactylus crinitichelis* residents in the sand dollar *Encope emarginata*, were carried out in tropical Brazilian Coast, to assess the influence the stages benthic, sex and area class of sand dollars, about the population structure benthic and sex ratio. Nine beaches were sampled, and all crabs in the *E. emarginata* area were collected. It was obtained the abundance of total and development stage, as carapace width and abdomen width of the crabs. It collected 72, 497 immature; 2,179 male and 1,167 female of *D. crinitichelis,* in *E. emarginata* 4,464. It was observed an average 18.32 crabs/sand dollars. The development stage and sex of *E. emarginata*, with more crab was the adult females it average 19.27 crab/sand dollar. The crabs were observed in all classes of body area of sand dollars. In relation to average of crab *D. crinitichelis* residents in *E. emarginata* area classes, there was an average of 18.20 crabs/class. Was observed a greater amount of males crabs the number, both for benthic developmental stages and sex, as with in the classes areas, except in two areas class who had not male crabs. It was observed is difference between the residuals proportional of adults male and female crabs, for both stages of development and sex of sand dollars. The high crab infestation demonstrates the strong link between species. Furthermore this is relationship suggests that the crabs resident the adult sand dollars, without distinction of sex. All stages of benthic development of the crab *D. crinitichelis* showed a tendency to infest the intermediate classes. The sex ratio of the crab *D. crinitichelis* always above 1, suggests that all classes, with the exception of the first and last, are infested by more than one adult male crabs, while the adult females would seek intermediate classes. There is an increasing amount of males crab *D. crinitichelis* in all development stages of *E. emarginata*. This study demonstrates the need to protect areas with sand dollars, as they would be protecting a

species of crab, besides serving as dispersion area, settlement, protection and feeding of other species.

Key-words: Crab, Sand dollar, Interation host, Atlantic Ocean, Tropical.

Introduction

Crustacea is a high diversified Subphylum and many families have separately developed interaction with other invertebrates (Thiel and Baeza, 2001). From the interactions that can be found the mutualistic, commensalistic, and parasitic are highlight (Douglas, 2010). The wide diversity of lifestyles makes the group appropriate for understanding the evolution of social behavior and interactions with others invertebrates (Duffy and Thiel, 2007). The relationships involving brachyuran are relatively frequent and are common in seven Decapoda Families: Porcellanidae, Eumedonidae, Portunidae, Xanthidae, Hapalocarcinidae, Majidae and Pinnotheridae (Rinkevich et al., 1991; Ng and Jeng, 1999).

The Pinnotheridae (pea crabs) is a family with 52 genera and more than 300 described species (Salas-Moya et al. 2014). This family includes small crabs, which interact with other species, living communality (solitary or in groups of the same species) in many benthic hosts, generally invertebrates including gastropods, bivalves, ascidians, holothurians, and echinoids (Williams, 1984; Schmitt et al., 1973; Harrison and Hanley, 2005; Palacios-Theil et al., 2009).

Among the irregular equinoids in which *Dissodactylus crinitichelis* Moreira, 1901 has already been registered, is *Encope emarginata* Leske, 1778, *E. michelini* Agassiz, 1841, *Clypeaster subdepressus* Gray, 1825, *Leodia sexiesperforata* Leske, 1778 and *Mellita quinquiesperforata* Leske, 1778 (Gray et al., 1968; Telford, 1978; Pohle and Telford, 1981; Griffith, 1987). However, it is still unknown how these species interact between these two species (Telford, 1978).

Studies carried out with *D. mellitae* Rathbun, 1900 and its host *M. isometra* Harold and Telford, 1990 showed that the high density of crabs on the sand dollar damage the feeding capacity of the host (George and Boone, 2003). As the crabs inhabit the oral region, the big sand dollars biggest would offer greater amount of food and consequently better development for the crab, making it more attractive to juvenile or megalopa (George and Boone, 2003), which present a more pronounced development. Furthermore, Quijano and Gómez (2001) the female echinoides present mostly larger sizes compared to males. This difference in the sand dollars female crabs provide to residents in these sand dollars females larger amount of food. And with that, find a successful development (Pohle and Telford, 1981), with a greater food supply and protection (Gray et al, 1968; Dexter, 1977). Once the growth of crabs would depend on the capacity of their host feeding (George and Boone, 2003). The crabs also decrease the host is capacity of moving around (Castro, 1978; Derby and Atema, 1980). Research with *Pinnotheris maculatus* Say, 1818, showed that the females did not produce eggs during winter (low temperatures) and, retarded its development within its host (Mollusca), until temperature and salinity were favorable (Pearce, 1964). An increase in resident crabs were recorded during summer and decreasing in autumn (Bell, 1988).

Despite the large amount of information generated for both of the species, little is known about the interaction of these two species and the effects that a species exerts on the other. Among the relevant interaction of these species, we highlighted the need that the crab has of its host, since the crab only could pass from planktonic life to benthic life with the presence of the sand dollar (Pohle and Telford, 1981). The crab species *D. crinitichelis* occurs nearly exclusively in irregular echinoids (Mellitidae and Clypeasteridae) (Mantins and D'Incao, 1996; De Bruyn et al. 2010), and rarely are found out of the host (Melo, 2008).

All these information are important, although do not explain the real effects that the sand-dollar (*E. emarginata*) exerts on the crab (*D. crinitichelis*). Thus, our hypothesis is that there are no differences in the overall abundance, therefore as there are no differences in the abundance of benthic stages of the crab *D. crinitichelis*, living in different stages of development, sex and area class of *E. emarginata*. Furthermore, if there are differences in the sex ratio and that the *D. crinitichelis* present that like growth in the different stages of development and sex of *E. emarginata*.

Material and methods

Study Area

The Coast of Pernambuco is inserted in the Southwest Atlantic Tropical (Figure 1). The Pernambuco beaches are composed of two deposits of sediment, the surface is rich in sandy sediment (fine - rough) rich in quartz and silt; this coastal, there are seagrass banks (*Halodule wrightii* Ascherson) and fragments of calcareous algae Halimeda spp. (Magalhães et al., 1997; Barros et al., 2001; Fonseca et al, 2002;. Araujo, 2003). The outstanding features of this coast is the presence of sandstone reefs that occur on multiple lines (distant - North Coast, 2,000 m and near - South Coast, 50 m) parallel to the coast; representing lines of "rock beaches", sometimes with a thin overgrowth of calcareous algae and corals (Mabesoone & Coutinho, 1970).

Data collect

The collections were carried out monthly, from November 2011 to October 2012, during low tide. For the purpose of standardization, these sampling were held in the interval between two days before and after new moon. Nine beaches along the coast were selected, about 20 km from one another, with four on the north and five on the south coast (Figure 1).

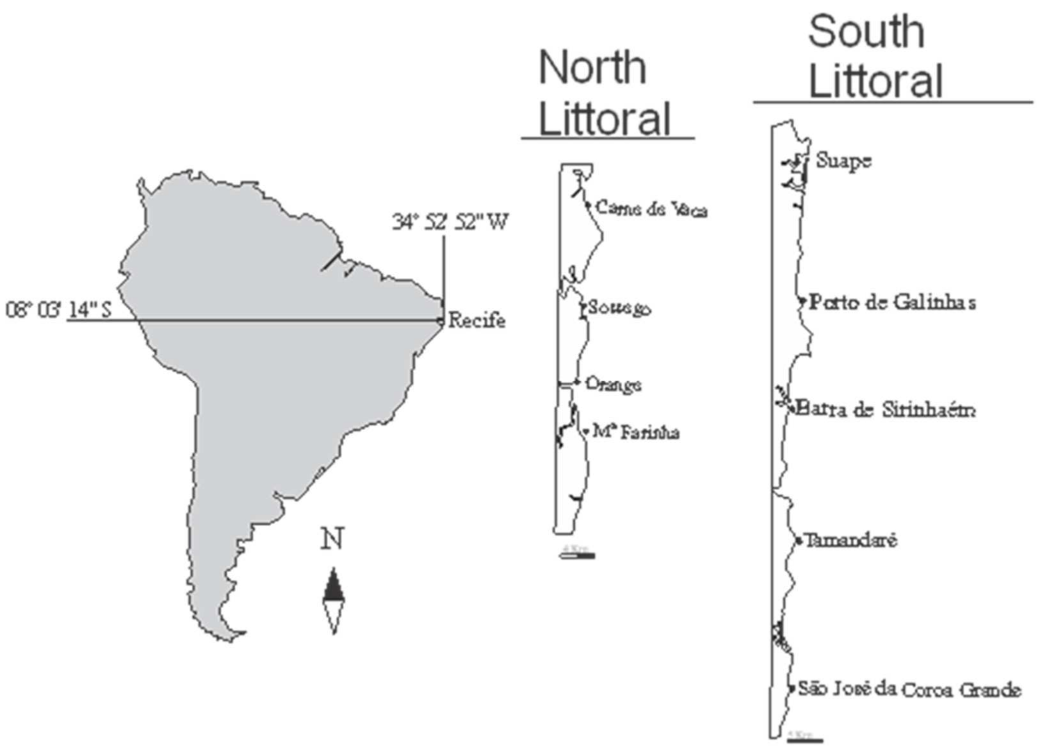

Figure 1. Studied area and sampling stations at nine beaches of Pernambuco state Brazil littoral, Sowthwestern Atlantic, from October/2011 to September/2012.

The beaches from the north coast Carne de Vaca (07º35.352' S e 034º49.216W), Sossego (07º42.987'S; 34º49.877'W), Orange (07º48.522'S; 34º50.161'W) and Maria Farinha (07º51.804'S; 34º50.063'W). In addition, from the South coast: Suape (08º21.851'S e 34º57.496´W), Porto de Galinhas (08º 30.247'S; 35º00.009'W), Barra de Sirinhaém (08º36.721'S; 35º02.814'W), Tamandaré (08º44.926'S; 35º 05.203'W) and São José da Coroa Grande (08º52.718'S; 35º08.242'W).

All samples were obtained from fixed quadrants of 600 m² (20 x 30 m) positioned parallel to the beach line at diurnal low tide. This quadrant was subdivided into three areas of 200 m² (20 x 10 m), with one randomly selected to be sampled, and this area was not used in the following month, avoiding the overlap of sampling.

As these crabs live in the oral and aboral surface of sand dollar (Telford, 1978; Pohle and Telford, 1981; Griffith, 1987), individuals of sand dollars, inside the quadrant of 200 m², were manually collected using free diving equipment (Bell and Stansik, 1983). Each individual was placed inside a plastic tray and packed in a plastic bag, properly labeled, inserted in coolers with ice and brought to the laboratory of the Federal University of Pernambuco (Brazil), and kept cooled in freezers until the analysis.

Laboratory proceedings

In the laboratory, the species were identified with specific literature (Melo, 1999; Martins and D'Incao, 1996; Fernandes et al., 2002; Manso et al., 2008). Then, for each individual it was measured the total carapace width and abdomen width fifth somite abdomen under a microscope using a 0,0001 mm precision caliper rule (Hartnoll, 1978; Hartnoll, 1982).

Individuals *D. crinitichelis* were classified (morphological characteristics of the abdomen) into juveniles, immature (males and females), adult (males and females) and females without eggs and female with eggs (egg case). The juveniles were individuals who survived the pelagic benthic/transition and became first crabs molt, corresponding to the smaller individuals collected (Pardo et al., 2007). The immature were all individuals presenting the pleopods slightly differentiated (immature male - long, thin; immature female-wide), however united to the animal cephalothorax. The adult males have the long and thin pleopods located on the first and second abdominal segments. The adult females presented the wide pleopods located from the second to fifth abdominal segment (Narchi, 1973). Adult females with eggs were identified due to the presence of eggs adhered to the pleopods.

The *E. emarginata* specimens were classified in two gonad maturity stages: immature (with undefined sexual glands) and adults (with developed sexual glands). These adults were subdivided into adult male, when the gonads presented colors ranging from cream to brown; and, adult female, when the gonads ranged around lilac color (Dias, 2008). It was established the number of area classes based in "Sturges model" ($k=1+3.3*\log(n)$), that determines "k" in function of "n", where "*k*" is the number of classes and “*n*” is the number of individuals. It was established 12 area class (15 cm interval). To define the area of sand dollars were measured the total length, total width, one and two transverse. Area was used circumference having as radius “r” the sum of four steps (total length, total width, transverse one and two) divided by 2.

Data analysis

Initially, it each sand dollar was defined as sample unit, after it was verified whether population data of *D. crinitichelis*, resident in *Encope emarginata* (sand dollar), was normally distributed (Kolmogorov-Smirnov test) and homocedasticity (Levene test). It was tested (ANOVA) differences in population total abudance of crabs between maturation stages and sex (immature, adult male and adult female) of sand dollars. To check whether there were differences on density development stages of *D. crinitichelis* (immature, adult male and adult female) residents in the maturation stages and sex (immature, adult male and adult female) of sand dollars, it was applied through a contingency table. For the analysis of the number of residents crabs in the respective area classes (cm^2) of sand dollars classes it was used initially, an ANOVA to determine whether there is a difference in the number of residents crabs in the different classes of sand dollars lengths.

In order to verify possible imbalance in the sex ratio of male and female crabs, for the different stages of development, sex and class areas (cm^2) of sand dollars, it was used the abundance of crabs. For this, we used two Qui-quadratic (X^2) tests (Zar, 1999), one for the abundance of males and females crabs in different stages of benthic development and sex of sand dollars. Another for the abundance of male and female crabs in the different classes of areas of sand dollars.

The tests described were calculated in statistical software "R", in its version 3.1.1, and it was considered a significance level (α=0.05).

Results

The total number of crabs *D. crinitichelis* collected was 75,843 individuals, of which 72, 497 immatures and 3,346 adults, which 2,179 adult male and 1,167 adult female. It was collected 4,464 *E. emarginata*, of which 410 were immature, 1,801 male and 2,253 female. These 4,265 sand dollar presented with crabs were found, representing 95.36% of the collected sand dollars.

Crab density x Developmental stages of E. emarginata

It was observed an average of 18.32 ± 17.95 Crabs/Sand dollars. The development stage of *E. emarginata*, that presented more crab was the adult females with 40,742 crabs (average 19.27 ± 19.44 Crabs/Sand dollar); followed by adult male 31,658 crabs (18.59 ± 20.28 Crabs/Sand dollar) and immature stage 3,443 crabs (8.63 ± 9.25 Crabs/Sand dollar). This corresponds respectively to 53.7%, 41.7% and 4.5% of the collected crabs, living in *E. emarginata* (Figure 2). It was found differences between development stage of *E. emarginata* ($F_{(3;\ 75,843)} = 17.8661$, $p < 0.001$), since the biggest difference observed in average values was recorded between immature and females (10.60 crabs) and followed by immature and males (10.00 crabs) (Figure 2), this values corresponds respectively to 49.2% and 37.2%.

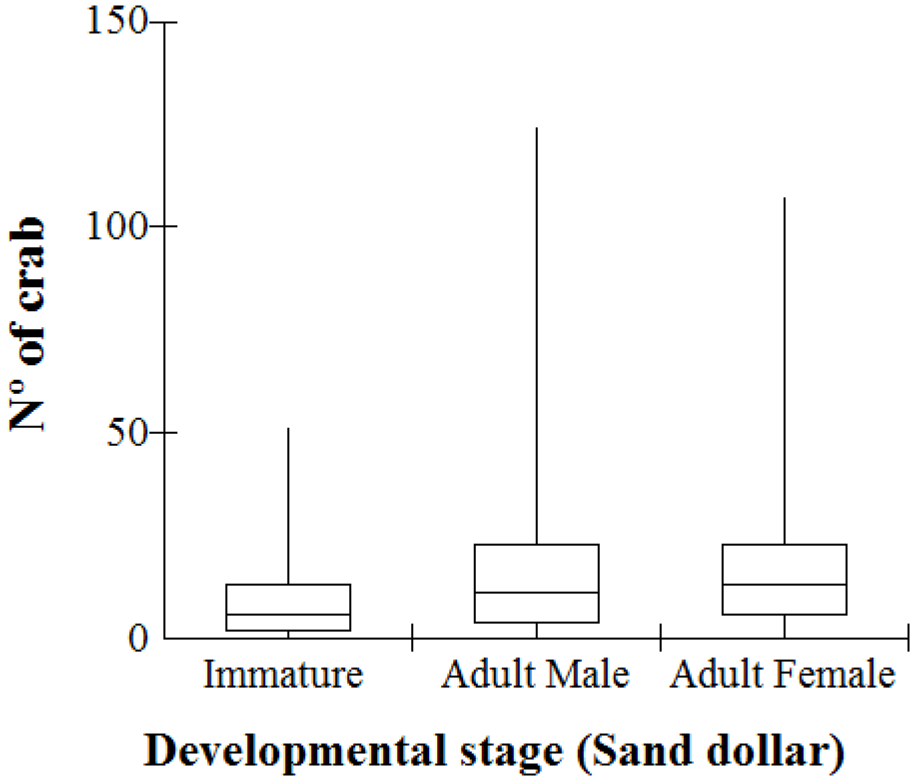

Figure 2. Average number of crab *Dissodactylus crinitichelis* (n=75, 843) found in the developmental stage (immature n=410, adult males n=1,801, adult female n=2,253) of sand dollar *Encope emarginata*, in Pernambuco littoral, from November/2011 to October/2012.

All stages of *D. crinitichelis* were observed in all stages of sand dollar *E. emarginata*. In the sand dollar adult female it was registered 39,072 immature, 1,095 adult male, 575 adult female crabs. These values correspond respectively to 94.49%, 2.69% and 1.41%. In the sand dollar adult male it was registered 41,564 immature, 975 adult male and 521 adult female. These values correspond respectively to 93.63%, 3.08% and 1.65%. In the immature sand dollar it was found 29,000 immature, 82 adult male and 61 adult female, corresponding respectively to 93.07%, 2.38% and 1.77% (Figure 3). The test showed differences between abundances ($X^2_{(3, 3)}$ =20.893, $p < 0.001$), as the immature represented 95.64% of crab population this species, of these, 53.72% live in sand dollar female and 41.74% live in sand dollar male (Figure 3).

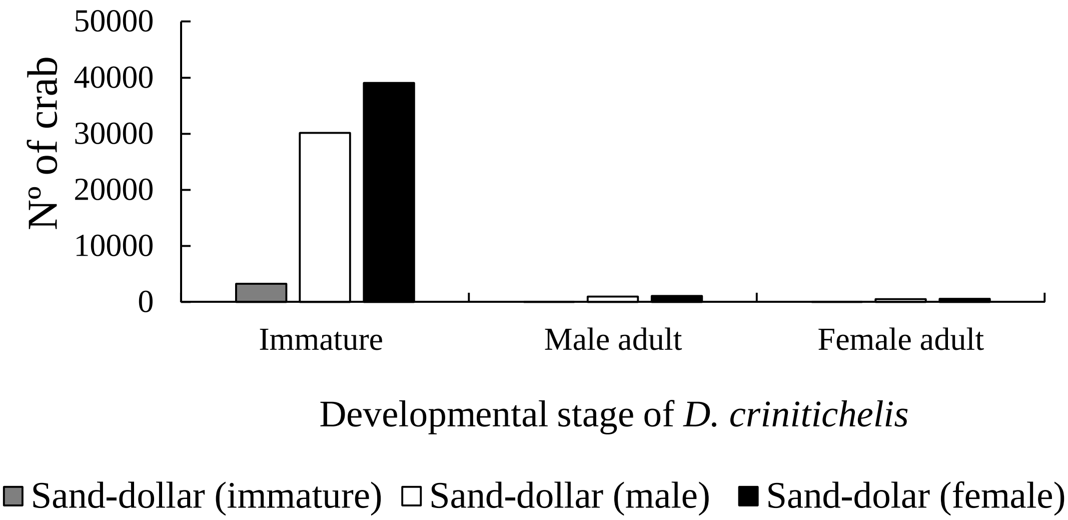

Figure 3. Total number of crabs residents in the stage found in the immature, adult females and adult male stages of *Encope emarginata*, in Pernambuco littoral, from November/2011 to October/2012.

Crabs (interval of class)

The crabs were observed in all area classes of *E. emarginata*. In relation to average abundance of crab *D. crinitichelis* residents in *E. emarginata* area classes, there was an average abundance of 18.20 ± 19.42 crabs/class. The highest average abundance (24.67 crabs/area class) was observed in the class 165.01-170.00 cm² and the lowest average abundance (0.78 ± 1.30 crabs/class) was observed in the class 0.01-15.00 cm² (Figure 4).

The *D. crinitichelis* the immature had an average abundance 17.44±18.70 Crab/Sand dollar; the highest average abundance of immature (36 Crabs/Sand dollar), recorded in the corresponding class 150.01-165.00 cm² and lowest average abundance

(1.75 Crabs/Sand dollar) was observed in the class 0.01-15.00 cm². The male had an average abundance 1.23±0.65 Crab/Sand dollar; the highest average abundance of male crab was three Crabs/Sand dollar, recorded in the corresponding class 150.01-165.00 cm² and was not registered males crabs in the corresponding class 0.01 - 15:00 cm² and 165.01-170.00 cm² (Figure 4). The female had an average abundance 1.03±0.23 Crab/Sand dollar; the highest average abundance of male crab was 1.14 Crabs/Sand dollar, recorded in the corresponding class 135.01 -150.00 cm² and was not registered females crabs in the corresponding classes 0.01 - 15:00 cm² and 165.01-170.00 cm² (Figure 4).

The ANOVA revealed that there are differences between the abundance of crabs: in the total crabs $F_{(12; 502)} = 12.99$, $p < 0.001$; immature $F_{(12; 432)} = 5.003$, $p < 0.001$; male $F_{(12; 201)} = 4.825$, $p < 0.001$; female $F_{(12; 129)} = 12.483$, $p < 0.001$. However, the regression analysis demonstrated that there is no influnce between the total number of crabs and areas of sand dollars classes (Table 1), showing that the crabs do not seek the larger sand dollars to live.

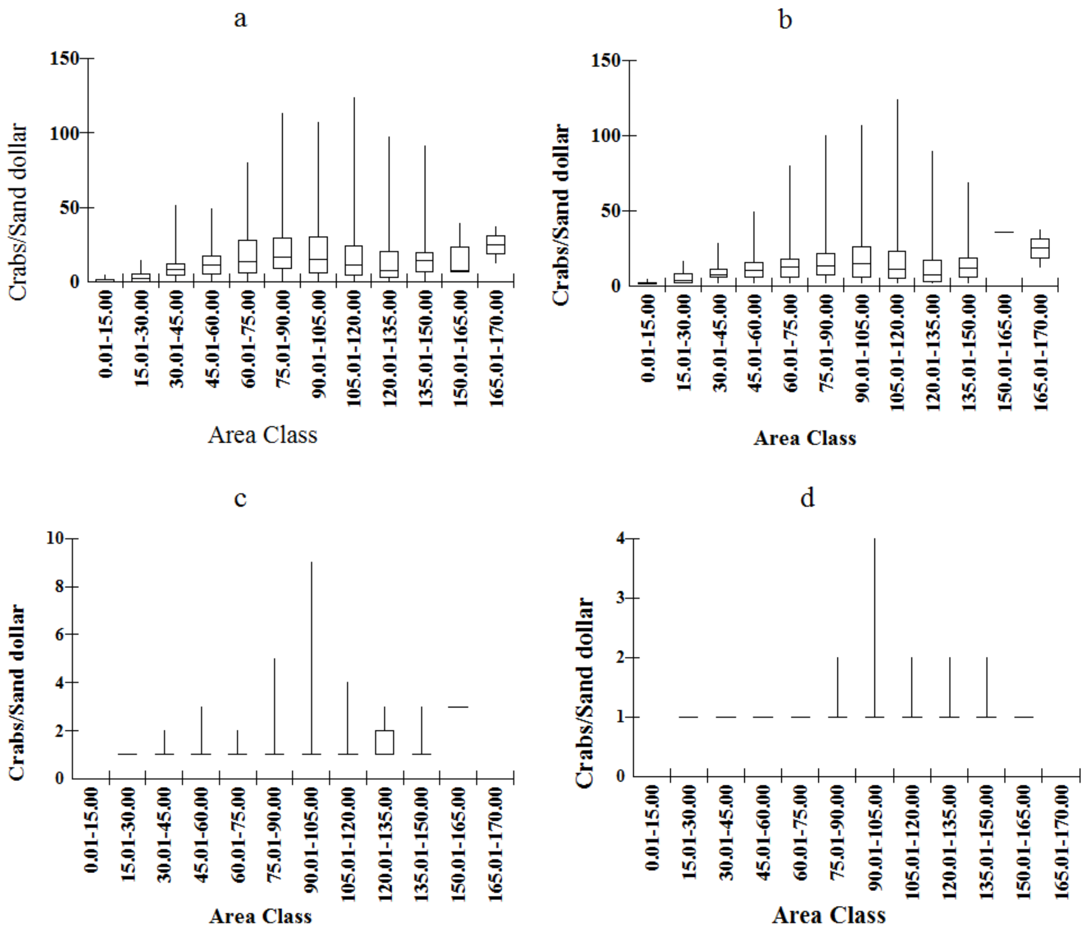

Figure 4. Numbers of *Dissodactylus crinitichelis* in the *Encope emarginata* of area class (cm²) of, in Pernambuco littoral, from November/2011 to October/2012, total - "a", immature – "b", adult male – "c" and adult female – "d"; observe their respective scales.

Abundance (M:F) of crab (benthic development stage, sex and area classes of sand-dollar)

It was registered a greater amount of males crabs than females, both for benthic developmental stages and sex, as well as for the different classes of sand dollars areas, except for 0.00 to 15.00 and 165.01 - 170.00 cm² when no male crabs occurred. It was found a sex ratio of 1.8:1 (M:F) crabs in the immature sand dollars. The crabs sex ratio increased in the adults male and females of sand dollars, with a ratio of 2.8:1 (M:F). Differences occurred in sex ratio of crabs living in different stages of development and sex of sand dollars ($X^2_{(3, 2)} = 28{,}310$, $p < 0.001$), since 73.2% of the crabs were male corresponding to a ratio 2.7:1 (M:F) (Figure 5).

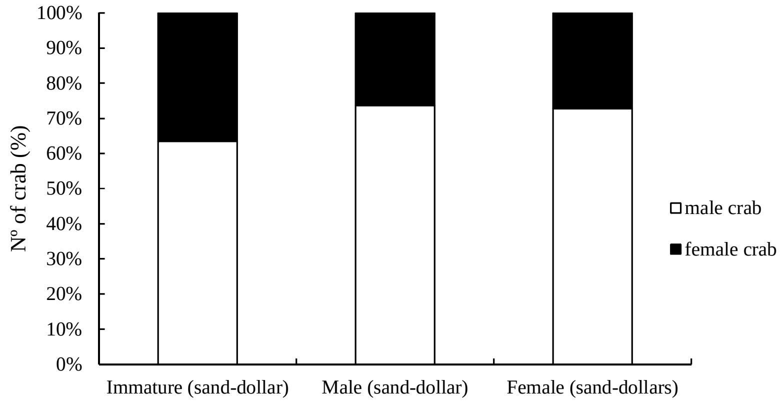

Figure 5. Relative abundance of the crab *Dissodactylus crinitichelis* by development stagy and sex of *Encope emarginata*, in Pernambuco littoral, from November/2011 to October/2012.

It was found for the crabs a sex ratio average of 2.49:1 (M: F) among sand dollars body area classes. In ten of the total of twelve classes it was registered more males, except for the first and last classes where only females were recorded. The eleventh class presented the highest sex ratio with 5:1 (M:F), and the class with the lowest proportion was the third with 2.11:1 (M:F) (Figure 6). The test revealed that there is an imbalance between the proportion of male and female in different body area classes of *E. emarginata* ($X^2_{(12, 2)}$= 40.605, $p < 0.001$).

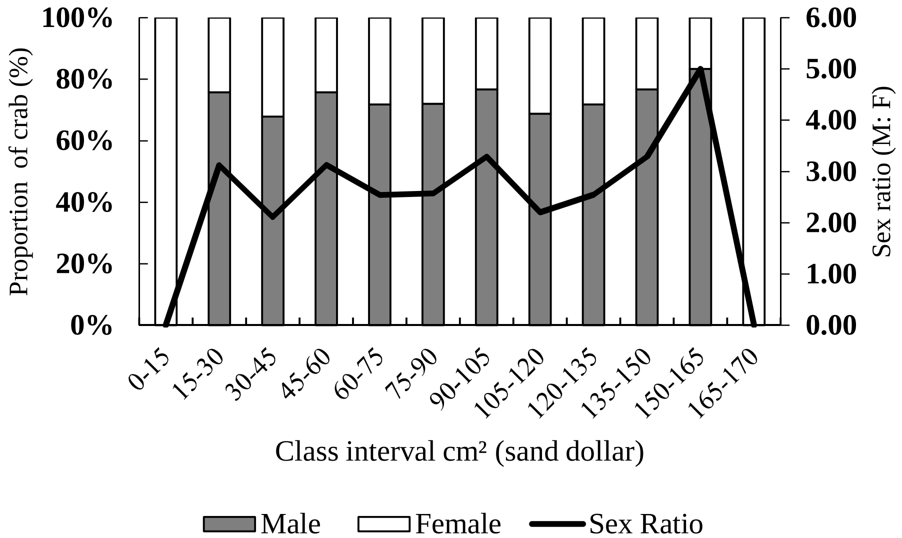

Figure 6. Sex ratio of the crab *Dissodactylus crinitichelis* by class body area of *Encope emarginata*, in Pernambuco littoral, from November/2011 to October/2012.

Discussion

The large quantities crab *D. crinitichelis* suggestes that by the sand dollar *E. emarginata*, exploring other species only if *E. emarginata* is already occupied by other organism, and in this case, the crab would associate itself with other sand dollar. This specificity has been recorded for the species this family, as the crab *Clypeasterophylus stebbingi* Rathbun, 1918 with the sand dollar *Clypeaster subdepressus* Gray, 1825 (Martinelli-Filho et al., 2014). The pinnotherid crabs live out from its host for a very short time (De Bruyn et al., 2010; Martinelli-Filho et al., 2014). In our research we observed that the crab tend to occupy in its sand dollars when adult female preferred the sand dollar intermediate body area, migrating to these.

The high infestation (95.3%) of the crab (*D. crinitichelis*) on the sand dollar (*E. emarginata*) reinforces the strong link between species. The values found here were similar to those obtained by Bell (1988), when it was encountered an infestation ranging from 36-96% and by Martinelli-Filho et al., 2014 with 87% of infestation. Telford (1978), found an infestation of 90-100% of the crab *D. primitivus* Bouvier, 1917 and from 30-60% of the crab *D. crinitichelis* in *M. quinquiesperforata*. Dexter (1977) found only 6% infestation by two species of crabs (*D. nitidus* Smith, 1870 and *D. xuntusi* Glassell, 1936), in *E. stokesi* L. Agassiz, 1841.

These high number of crabs living in *E. emarginata* had not been registered before to the family Pinnotheridae. The data available refers to other species, like the crab *D. mellitae* in *M. quinquiesperforata,* that presented an infestation from 0.4 to 2.7 individuals by sand dollar (Bell, 1988). Other study presented an average of 4.3 of the crab *D. primitivus* and 0.4 - 1.3 of the crab (*D. crinitichelis*) by sand dollar (*M. quinquiesperforata*) (Telford, 1978). According to Bell (1981) this reduction was due to the larger adult competition, leading to death or migration of individuals. Dexter (1977) found an average crab infestation on *E. stokesi* of 0.07, and this sand dollar was infested by two species of crabs *D. nitidis* and *D. xuntusi*. Other studies developed with the interaction of other species such as with *Pinnotheres pisum* Linnaeus, 1767 (Atkins, 1926; Christensen, 1958), *P. ostreum* Say, 1817 (Christensen and McDermott, 1958), *Fabia subquadrata* Dana, 1851 (Pearce, 1966) all residents in bivalves, verified that the amount of crab did not exceed three individuals. Differently the values found in this work where media was to 18.32 *D. crinitichelis* to *E. emarginata* and 18.20 crabs to area class.

Others studies on the interactions of crabs with sand dollars found a maximum of eight crabs in different stages of benthic development, in a single echinoid; and, this number was considered high, whereas, the crabs could harm the development of the sand dollar (Gray et al., 1968; Harold and Telford, 1990; Hendler et al., 1995). Number similar was obtained for Martinelli-Filho et al. (2014). No more than nine crabs has been registered by sand dollar, evidencing this is the maximum number supported by host (Bell, 1981). However, the presence of a crab in its host does not prevent the entry of new crabs (George and Boone, 2003)

Besides the high number of sand-dollar infested with high number of crabs, differences were found between developmental stages (immature and adult) of sand-dollar, with higher density of crabs in adults, however, no density differences were found in relation to the sex (male and female) of sand-dollar. This suggests that the crabs would avoid to settle in immature preferring the adult sand-dollar, without distinction of sex. Similar behavior was observed by Zuk and McKean (1996), which made researches with species associates in field and laboratory and found differences in infestation between stages of development and/or sex, with a difference in the density of infested individuals, around 15%. In our research with *D. crinitichelis* x *E. emarginata* the difference in the stages of development was around 97%, and between the sexes 9.9%.

All stages of benthic development of the crab *D. crinitichelis* showed a tendency to infest the intermediate size classes of *E. emarginata.* This contributes to the idea that new infestations do not occur in sand dollar without the the crab, or that would occur at random and independent of the number of crabs (Bell, 1988), suggesting an attraction to new crabs that will become. It has been mentioned that the juvenile crab stage of *D. mellitae* resident in the sand dollar *M. quinquiesperforata* would present a gregarious behavior, independent of the presence of other individuals of sand dollar, while immature and adult crabs would live lonely, accepting the presence of individuals of the opposite sex (Telford, 1978; Bell, 1988). However, other species of the same family (*F. subquadrata, P. ostreum, P. novaezelandiae* Filho 1885 and *Pinnotheres* spp.) show random and uniform settlement in Mollusca (Christensen and McDermott, 1958; Pearse, 1966; Silas and Alagarswami, 1967; Jones, 1977), and the crab *Pinnaxodes floridensis* Wells and Wells, 1961, in Holothurian (Wells and Wells, 1961).

We found an increase in the number of crabs, with increase in area of the sand dollar, a fact also mentioned by Baeza and Thiel (2003) and Martlinelli-Filho et al. (2014). In our study a size limit was not observed for the sand dollar infestation by crab as described by Baeza and Stotz (2001). However, it was noted that larger and smaller sand dollar are avoided (Baeza and Stotz, 2001).

The sex ratio of the crab *D. crinitichelis* was always above 1, suggesting that all classes, except the first and the last, are infested by more than one adult male crabs, while the adult females would infest intermediate classes. The size is an important factor in the infestation success, survival and growth of individuals (Mousseau and Fox, 1998). However, some of the Pinnotheridae presents a pair of individuals of the opposite sex, as mentioned in the researches with *P. ostreum* (Christensen and McDermott, 1958), *P. novaezelandiae* (Jones, 1977) and *D. crinitichelis* (Telford, 1978).

It has been proposed a general interaction evolutionary model between pattern of host usage, mating pattern (e.g. monogamy, polygyny, or polyandry) and social arrangement of symbiotic crustaceans (Baeza and Thiel, 2007). The mating pattern would depend on host body size and/or availability (showing the relative expenses of protecting a host for 'territorial' symbionts) and on the facility of symbionts to move between hosts (showing a potential cost of predation out the protection given by the host).

Studies developed for any species of *Dissodactylus* on the ratio carapace width /abdomen width, can be extrapolated to the others of the same genus, due the similarity of their carapaces (Telford, 1978). Even *D. crinitichelis* showing a polyphasic growth in all stages of sand-dollars, demonstrating that crabs invest its resources according to the need of energy investment of each development stage, for a better survival. And that can compared in different biotic and abiotic conditions (Telford, 1978), however, it is clear that residents crabs in the sand adult dollars develops more quickly, compared to the immature sand dollars, demonstrating better development conditions in adult sand dollars.

An experimential base for the model was provided by Baeza and Thiel (2007), Baeza (2008), but they argued that more case studies were necessary to reinforce their demonstration. In crustaceans, while many host–symbiont relations have been described, little is documented about the population biology and the nature of the relationship (e.g. mutualism *vs.* parasitism) (Thiel, 2000). Host utilization will depend on mating or social systems of the symbionts, and about the character of the symbiotic association. A commensal using its host, principally as a refuge or chemical protection will not exploit it in the same way as a parasite using its host as a food resource, per example. In turn, the pattern of host exploitation could control the symbiont social system. For instance, in the case of parasitism, host resistance could adjust the number of infecting symbionts, whatever their mating system, and consequently force their social organization. Thus, knowledge on the nature of the relationship is a requisite for understanding symbiosis evolution and ecology.

Thus, it can be concluded that the crabs *D. crinitichelis* reside with greater intensity adult sand-dollar, avoiding immature individuals. Initially inhabit adult females, with these very busy, probably inhabit the male and then the immature. However, this stage (immature) can be visited if the adults are already occupied. There is a decrease in the individuals that make up the population structure of the crab *D. crinitichelis*, with the highest densities in the first benthic stage, reducing their values, regardless of the stage of development and sex sand-dollar. Theses demonstred that regarding the area classes of sand dollar, the stages of development in each every is inhabited by about an average of 17.44 immature, 1.23 male and 1.03 female crabs. In addition, the sex ratio was different between the stages of development of the crab, with higher male, residing in all the sand dollars stages of development. As well as in the area of classes of sand dollars. The studies show the close relationship between the two species (*D. crinitichelis* and *E. emarginata*). The showing the need to preserve the beach Sossego for maintaining sandy beaches, throughout the surrounding coastline.

Acknowledgements

We thank the Postgraduate Program in Zoology and the Museu Paraense Emílio Goeldi, both from the Federal University of Pará – UFPA; the Department of Oceanography and the Museum of Oceanography from the Federal University of Pernambuco (UFPE). This study is derived from the research conducted for the doctoral thesis of AGC at Federal University of Pará/ Museu Paraense Emílio Goeldi (UFPA/MPEG), for which a scholarship was provided by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES). SNL (process: AUX-PE-CIENCIAS DO MAR 1136/2010) and LFAM (process: 301343/2012-8) was supported by the National Council for Scientific and Technological Development (CNPq).

References

Andrade, G.O., Lins, R., 1965. Introdução à morfoclimatologia do Nordeste do Brasil. Arq. do Inst. de Ciên. da Terra, Recife (3-4): 11-28.

Aragão, J.O.R., 2004. A Influência dos Oceanos Pacífico e Atlântico na Dinâmica do Tempo e do Clima do Nordeste do Brasil, In: Eskinazi-Leça, E., Neumann-Leitão, S., Costa, M.F. da. (Org.). Oceanografia: Um cenário tropical. Recife/PE, p. 131-184.

Araújo, A.M., 2003. Desenvolvimento de procedimentos experimentais para avaliar a evolução de bancos dragados. I Simpósio de Recursos Hídricos da Amazônia, Anais do I SRH, Fund. Rede Amazônica. Manaus-AM, p.26-26.

Atkins, D. 1926. The moulting stages of the pea-crab (*Pinnotheres pisum*). J. mar. Biol. Ass. U. K. 14: 475-493

Baeza, J.A., Stotz, W., Thiel, M., 2001. Life history of Allopetrolisthes spinifrons, a crab associate of the sea anemone *Phymactis clematis*. J. Mar. Biol. Assoc. U.K. 81:69–76

Baeza, J.A., Thiel, M., 2003. Predicting territorial behavior in symbiotic crabs using host characteristics: a comparative study and proposal of a model. Mar. Biol. 142:93–100.

Baeza, J.A., Thiel, M., 2007. The mating system of symbiotic crustaceans: a conceptual model based on optimality and ecological constraints, In: Duffy J.E., Thiel M. (eds) Evolutionary ecology of social and sexual systems. Crustaceans as model organisms. Oxford University Press, Oxford.

Baeza, J.A., 2008. Social monogamy in the shrimp *Pontonia margarita*, a symbiont of *Pinctada mazatlantica*, off the Pacific coast of Panama. Mar. Biol. 153:387–395.

Barros, F., Borzone, C.A., Rosso, S., 2001. Macroinfauna of six beaches near Guaratuba bay, southern Brazil. Braz. Arch. of Biol. and Techn. 44(4): 351-364.

Bell, J.L., Stancyk, S.E., 1983. Population dynamics and reproduction of *Dissodactylus mellitae* (Brachyura: Pinnotheridae) on its sand dollar host *Mellita quinquiesperforata* (Echinodermata). Mar. ecol. Prog. Ser. 13: 141-149.

Bell, J.L., 1981. Life history and ecology of *Dissodactylus mellitae* (Brachyura: Pinnotheridae) on the sand dollar *Mellita quinquiesperforata*. M. S. thesis, University of South Carolina, Columbia.

Bell, J.L., 1988. Distribution and abundance of *Dissodactylus mellitae* Rathbun (Pinnotheridae) on *Mellita quinquiesperforata* (Leske) (Echinodermata). J. of Exp.Mar. Biol. and Ecol. 117: 93–114.

Castro, P., 1978. Settlement and habitat selection in the larvae of *Echinoecus pentagonus* (A. Milne Edwards), a brachyuran crab symbiotic with sea urchins. J. of Exp. Mar. Biol. and Ecol. 34: 259-270.

Christensen, A.M., McDermott, J.J., 1958. Life-history and biology of the oyster crab *Pinnotheres ostreum* Say. Biol. Bull. 114:146–179

Christensen, A.M., 1958. On the life history and biology of *Pinnotheres pisum*. Proc. 15th Internat. Zool. Congr. Sect. II, Paper 15: 267-270.

De Bruyn, C., Rigaud, T., David, B., De Ridder, C., 2010. Symbiosis between the pea crab *Dissodactylus primitivus* and its echinoid host *Meoma ventricosa*: potential consequences for the crab mating system. Mar. Ecol. Progr. Ser. 375: 173–183.

Derby, C.D., Atema., J., 1980. Induced host odor attraction in the pea crab *Pinnotheres maculatus*. Biol. Bull., 158:26-33.

Dexter, D.M., 1977. A natural history of the sand dollar *Encope stokesi* (L. Agassiz) in Panama. Bull. Mar. Sci., 3, 544-551.

Dias, I.C.C.M., 2008. Biologia populacional de *Mellita quinquiesperforata* Leske (1778) (Echinodermata: Clypeasteroida: Mellitidae) na praia da Taíba, Ceará, Brasil. Instituto de Ciências do Mar, U.F.C., 146 f.

Douglas, A.E., 2010. The symbiotic habit, New Jersey: Princeton University Press, 5–12.

Duffy, J.E., Thiel, M., 2007. Evolutionary ecology of social and sexual systems. Crustaceans as model organisms. Oxford University Press, Oxford.

Fernandes, M.L.B., Tommasi, L.R., Lima, E.J.B., 2002. Filo Echinodermata de Pernambuco, 405-428, In: Tabarelli, M., Silva, J.M.C. (orgs.). Diagnóstico da biodiversidade de Pernambuco. Recife, Editora Massangana.

Fonseca, R.S. da, Passavante, J.Z. de O., Maranhão, G.B., Muniz, K., 2002. Ecossistema Recifal da Praia de Porto de Galinhas (Ipojuca, Pernambuco): Biomassa Fitoplanctônica e Hidrologia. CEPENE, Tamandaré, 1, 9-35.

George, S.B., Boone, S., 2003. The ectosymbiont crab *Dissodactylus Mellitae* — sand dollar *Mellita isometra* relationship. J. of Exp. Mar. Biol. and Ecol., 294:235–255.

Gray, I.E., McCloskey, L.R., Weihe, S.C.,1968. The commensal crab *Dissodactylus mellitae* and its reaction to sand dollar host-factor. J. of the El. Mitc. Sci. Soc., 84, 472-481.

Griffith, H., 1987. Phylogenetic relationships and evolution in the genus *Dissodactylus* Smith, 1870 (Crustacea: Brachyura: Pinnotheridae). Can. J. of Zool., 65, 2292–2310.

Harold, A.S., Telford, M., 1990. Systematics, phylogeny and biogeography of the genus *Mellita* (Echinoidea: Clypeasteroida). J. of Nat. Hist., 24, 987- 1026.

Harrison, J.S., Hanley, P.W., 2005. *Austinixa aidae* Righi, 1967 and *A. hardyi* Heard and Manning, 1997 (Decapoda: Brachyura: Pinnnotheridae) synonymized, with comments on molecular and morphometric methods in crustacean taxonomy. J. of Nat. Hist., 42,: 3649-3662.

Hartnoll, R.G., 1978. The determination of relative growth in Crustacea. Crustaceana, 3, 281-293.

Hartnoll, R.G., 1982. Growth, In: Bliss, D.E., Abele, L.G. eds. The biology of Crustacea: embryology, morphology, and genetics. Academic. New York, 111-196.

Hendler, G., Miller, J. E., Pawson, D. L., Kier, P. M., 1995. Sea Stars, Sea Urchins, and Allies: Echinoderms of Florida and the Caribbean. Smithsonian Institute Press, Washington D.C., p. 390.

Hickson, R.G., 1980. Comportamento físico-químico da Baía de Tamandaré. Recife. Monografia de Graduação do Curso de Engenharia de Pesca da Universidade Federal Rural de Pernambuco. 54p.

Jones, A., 1977. 'Molluscan Remains' in Rogerson, A. 'Excavations at Scole 1973' East Anglian Archaeology Report Nº. 5, 97-222.

Mabesoone, J.M., Coutinho. P.N., 1970. Litoral and shallow marine geology of Northeastern Brazil. Trabalhos do Instituto Oceanográfico da Universidade Federal de Pernambuco, 12: 1-214.

Magalhães, M.K., Eskinasi – Leça, E., Moura Junior, M.A., 1997. Morfometria e biomassa da fanerógama marinha *Halodule wrightii* Ascherson no litoral norte de Pernambuco. Trab. Ocean. Univ. Fed. Pe., 25:83-92.

Manso, C.L.C., Alves, O.F.S., Martins, L.R., 2008. Echinodermata da Baía de Todos os Santos e da Baía de Aratu (Bahia, Brasil). Biota Neot., 3, 179-196.

Martins, S.T.S., D'Incao, F., 1996. Os Pinnotheridae de Santa Catarina e Rio Grande do Sul, Brasil (Decapoda, Brachyura). Ver. Bras. de Zool., 1, 1-26.

Martinelli-Filho J.E., Santos, R.B. dos, Ribeiro, C.C., 2014. Host selection, host-use pattern and competition in *Dissodactylus crinitichelis* and *Clypeasterophilus stebbingi* (Brachyura: Pinnotheridae). Symb., 63:99–110.

Mousseau, A.T., Fox, C.W., 1998. The adaptive significance of maternal effects. Tree., 10.

Melo, G.A.S., 1999. Manual de identificação dos Crustacea Decapoda do litoral brasileiro: Anomura, Thalassinidea, Palinuridea Astacidea. Plêiade/Fadesp, São Paulo, 370-371.

Melo, G.A.S., 2008. The Brachyura (Decapoda) of ilha grande bay, Rio de Janeiro, Brazil. Naup., 1, 1-22.

Narchi, W., 1973. Crustáceos: Estudos Práticos. São Paulo, Edusp, 116p.

Ng P.k.l., Jeng, M.S., 1999. The brachyuran crabs (Crustacea: Decapoda: Eumedonidae and Portunidae) symbiotic with echinoderms in Taiwan. Zool. Stud., 38,268–274.

Palacios-Theil, E., Cuesta, J.A., Campos, E., Felder, D.L., 2009. Chapter 23. Molecular genetic re-examination of Subfamilies and polyphyly in the Family Pinnotheridae (Crustacea: Decapoda), In: Martin J.W., Crandall K.A., Felder D.L. (eds) Crustacean Issues: Decapod Crustacean Phylogentics. Taylor & Francis/CRC Press, Boca Raton, Florida, 423-442.

Pardo, L.M., Piraud, F., Mantelatto, F.L., Ojeda, F.P., 2007. Ontogenetic pattern of resource use by the tiny hermit crab *Pagurus villosus* (Paguridae) from the temperate Chilean coast. J. of exp. Mar. boil. and ecol., 1, 68 – 79.

Pearce, J.B., 1964. On reproduction in Pinnotheres maculatus (Decapoda: Pinnotheridae). Biol. Bull., 127:384.

Pearce, J.B., 1966. The biology of the mussel crab, *Fabia subquadrata*, from the waters of San Juan Archipelago, Washington. Pac. Sci. 20: 3-35.

Pohle, C., Telford, M., 1981. The larval development of *Dissodactylus crinitichelis* Moreira, 1901 (Brachyura, Pinnotheridae) in laboratory culture. Bulletin of Marine Science, 31:753–773.

Quijano, S.M., Gómez, A.G., 2005. Ciclo reproductivo de *Lytechinus variegatus* (Ecninoidea: Toxopneustidae) en el sur de la Isla de Margarita, Venezuela. Rev. de Biol. Trop., 3, 305-312.

Rinkevich, B., Wolodarsky, Z., Loya, Y., 1991. Coral crab association: a compact domain of multilevel trophic system. Hydrob., 216, 279-284.

Salas-Moya C., Mena S., Wehrtmann I.S. 2014. Reproductive traits of the symbiotic pea crab *Austinotheres angelicus* (Crustacea, Pinnotheridae) living in *Saccostrea palmula* (Bivalvia, Ostreidae), Pacific coast of Costa Rica. In: Wehrtmann IS, Bauer RT (Eds) Proceedings of the Summer Meeting of the Crustacean Society and the Latin American Association of Carcinology, Costa Rica, July 2013. ZooKeys 457: 239–252.

Schmitt, W.L., McCain, J.C., Davidson, E.S., 1973. Decapoda I: Brachyura I: Fam. Pinnotheridae. Crust. Cat., 3, 1–160.

Silas, E.G., Alagarswami, K., 1967. On an instance of parasitisation by the peacrab (*Pinnotheres* sp.) on the backwater clam (*Meretrix casta* (Chemntz)) from India with a review of the work on the systematics, ecology, biology and ethology of the pea-crabs of the genus *Pinnotheres* Latreille. Mar. Biol. Ass. India.1161-1227,

Telford, M., 1978. Distribution of two species of *Dissodactylus* (Brachyura: Pinnotheridae) among their echinoid host population in Barbados. Bull. of Mar. Sci., 28, 651-658.

Thiel, M., Baeza J.A., 2001. Factors affecting the social behavior of symbiotic Crustacea: a modelling approach. Symb., 30,163–190

Thiel, M. 2000. Population and reproductive biology of two sibling amphipod species from ascidians and sponges. Mar. Biol., 137, 661–674.

Wells, H., Wells, M., 1961. Observations on *Pinnaxodes floridensis*, a new species of pinnotherid crustacean commensal in holothurians. Bull. of Mar. Sci. Gulf of Caribbean, 11, 267-279.

Williams, A.B., 1984. Shrimps, lobsters and crabs of Atlantic coast of the eastern United States, Maine to Florida. Smithsonian Institution Press, Washington. 550p.

Zar, J.H., 1999. Biostatistical Analysis. 4ª ed. Prentice-Hall. New Jersey. 663p.

Zuk, M., McKean., K.A., 1996. Sex differences in parasite infections: patterns and processes. Int. J. for Parasitol., 26, 1009–1023.

CONSIDERAÇÕES FINAIS

Essa obra contribuir para uma melhor compreensão da biologia de um Echinoidea *Encope emarginata*, um Crustacea Brachyura *Dissodactylus crinitichelis* e o efeito que o Echinoidea exerce sobre o Brachyura, sendo todo este trabalho desenvolvido em praias tropicais do Atlântico Sudoeste.

Como a espécie de Echinoidea *E. emarginata* foram regidos, ao longo dos meses, principalmente pela granulometria das paias. Além disso, as praias do litoral norte demonstraram ter as melhores condições para o assentamento, desenvolvimento e reprodução da espécie. Estudos dessa natureza contribuem para o monitoramento espacial e mensal da espécie, demonstrando condições tenues entre as variáveis biótica da espécie e abióticas de cada praia, e caracterizando locais com condições para preservação ambiental. Uma vez que a espécie apresenta características biológicas importantes para a manutenção de espécies residentes e visitantes nas praias arenosas. A ocorrência de ambos os sexos e dos imaturos, de *E. emarginata*, e suas flutuações ao longo dos meses, demonstram uma manutenção constante da população. E áreas como o litoral norte estão servido como locais de dispersão para as praias arenosas circunvizinhas, mantendo o registro dessa espécie em outras praias, com exceção de praias que não apresentam condições para o assentamento dessa espécie. As praias apresentaram na população de *E. emarginata* uma predominância de indivíduos intermediários. Os quais estão obtendo os melhores recursos na região e dificultando a obtenção dos recursos tanto dos indivíduos maiores, como dos menores. Sendo os indivíduos intermediários os responsáveis por toda a manutenção populacional de *E. emarginata*. A espécie apresenta um investimento energético ao comprimento, o que tornaria os indivíduos aptos a buscar áreas mais favoráveis ao desenvolvimento, alimentação e reprodução. A partir de todas essas características biológicas a espécie *E. emarginata* estaria apresentando um papel importantíssimo para a manutenção da comunidade biológica das praias arenosas e locais adjacentes, e que esta sendo regido pelas variáveis abióticas.

Assim como em *Encope emarginata* a população do caranguejo *D. crinitichelis* residente nas bolachas-da-praia são influenciados indiretamente pelas variáveis abióticas, principalmente pela granulometria. Uma vez que as os caranguejos estão residindo e dependem da sobrevivência das bolachas-da-praia. Isto ratifica a íntima relação do caranguejo *D. crinitichelis* com as espécies de bolachas-da-praia das praias arenosas. Além disso, estudos dessa natureza demonstram as melhores condições espacial e temporal para o *D. crinitichelis*. Uma vez que, as maiores densidades das espécies, geralmente, representam as melhores condições ambientais em que são encontrados. As maiores densidades de *D. crinitichelis* foram encontradas no período de estiagem, a espécie estaria permanecendo em locais com condições mais estáveis para o desenvolvimento. E estaria evitando ou deslocando-se para outra região com condições menos favoráveis (nos meses do período chuvoso). Ou seja, a espécie acaba saindo das áreas nos meses com baixa salinidade e menores temperaturas. As praias do litoral Norte demonstram ter as melhores características ambientais ao longo do ano para a ocorrência do caranguejo. O sedimento mostrado ser a variável abiótica que rege a distribuição do caranguejo nas praias ao longo do ano. Distúrbios nas condições abióticas na região, como excesso ou redução da pluviometria, acarretaria em uma alteração no aporte de sedimento e consequentemente na matéria orgânica, que restrigiriam a ocorrência da espécie, com predominância de apenas um sexo, e consequentemente; redução no recrutamento da população de *D. crinitichelis*. Com os indivíduos apresentando um crescimento alométrico a espécie estaria investindo no desenvolvimento da carapaça, como isso ficou mais evidente nas fêmeas, essas estariam investindo muito mais que os outros indivíduos da população, e quanto mais as fêmeas investirem na largura da carapaça, mais ovos estariam aptas para fecundar e transporta. Além disso, a espécie não estaria investindo da mesma forma o ano todo, uma vez que mudanças nas variáveis abióticas acarretariam em um menor aporte de sedimento e consequentemente menor aporte de matéria orgânica (período de estiagem). Em condições mais estáveis as espécies se utilizariam para adquirir mais recurso, e nos momento de desequilíbrio a espécie despejaria toda a energia acumulada para lançar-se a reprodução. Com todo esse conhecimento construído sobre *D. crinitichelis*, desvedou um pouco da biologia da espécie. Além disso, pode-se caracterizar a distribuição temporal e espacial de um caranguejo que vive em outras espécies, correlacionando-os as variáveis abíoticas; além de demonstrar o seu crescimento e melhores condições para a nidificação, desenvolvimento e reprodução.

Como este caranguejo apresenta uma dependência com uma bolacha-da-praia para transitar do ambiente plactônico ao bentônico, estudo dessa natureza esclarecem dúvidas dessa relação e norteiam novas pesquisas. Além de ratificar a necessidade de preservação da região, para não deixar de verificar e elucidar qual seria interação ecológica dessas duas espécies. O caranguejo *D. crinitichelis* residem com maior intensidade nas bolachas-da-praia adulta, evitando indivíduos imaturos. As quais estariam proporcionando as melhores condições de abrigo e alimentação do caranguejo. Nessas condições os caranguejos desse gênero provavelmente estaria habitando espécies de bolacha-da-praia menores, ou indivíduos menores de espécies grandes, como alternativa para o assentamento, até encontrar as espécies maiores, para poder transcorrer todo o seu desenvolvimento. A diminuição que ocorre nos estágios de desenvolvimento subsequentes da população do caranguejo *D. crinitichelis*, evidenciam a elevada predação sofrida pelos caranguejos residentes nas bolachas-da-praia. Isso acaba demonstrando a participação dos caranguejos na trofia das praias arenosas, que teoricamente seriam "inabitadas". Sendo responsáveis pela manutenção alimentar das espécies residentes, assim como das espécies visitantes das praia arenosa. A presença de um valor médio dos indivíduos adultos, demonstra que em cada bolacha-da-praia ocorre a presença de um casal reprodutivo. Que será substituído por outro caranguejo pretendente, com características reprodutivas evidentes. Os estudos mostram a estreita relação entre as duas espécies (*D. crinitichelis* e *E. emarginata*). O que mostra a necessidade de preservar a praia do Sossego para a manutenção de praias de areia, ao longo das praias circundante.

REFERÊNCIA DA INTRODUÇÃO GERAL

ALBUQUERQUE, M.C.P. de; FERREIRA, J.F.; SALVADOR, G.C.; TURINI, C. 2012. Influência da temperatura e da salinidade na sobrevivência e crescimento de larvas da ostra perlífera *Pteria hirundo*. **Bol. Inst. Pesca**, São Paulo, *38*(3): 189 – 197.

ALLEN, J.A. 2000. A new deep-sea species of the genus *Neolepton* (Bivalvia; Cyamoidea; Neoleptonidae) from the Argentine Basin. **Malacologia**. 42:123 -129.

AMARAL, A.C.Z.; LANA, P.C.; FERNANDES, F.C.; COIMBRA, J.C. 2003. **Biodiversidade bêntica da região sul-sudeste da costa brasileira. Programa de avaliação do potencial sustentável dos recursos vivos da zona econômica exclusiva.** Ministério do Meio Ambiente – MMA.

BELL, B. M.; FREY, R. W. 1969. Observation on ecology and the feeding and burrowing mechanisms on *Mellita quinquiesperforata.* **Journal of Paleontology,** v. 43, p. 553- 560.

BELL, J.L. 1984. Changing residence: dynamics of the symbiotic relationship between *Dissodactylus mellitae* Rathbun (Pinnotheridae) and *Mellita quinquiesperforata* (Leske) (Echinodermata). **Journal of Experimental Marine Biology and Ecology**. 82:105 – 115.

BOND, G. & BUCKUP, L. 1988. O ciclo da intermuda em *Macrobrachium borelii* (Nobili, 1896) (Crustacea, Decapoda, Palaemonidae): a influência da temperatura e do comprimento do animal. **Revista Brasileira de Zoologia.** 5 (1):45-59.

BORGES, M.; MONTEIRO, A.M.G.; AMARAL, A.C.Z. 2002. Taxonomy of ophiuroidea (echinodermata) from the continental shelf and slope of the southern and southeastern brazilian coast. **Biota Neotropica**, v2 (2).

BREWER, R. 1994. **The science of ecology**. Philadelphia, Saunders. 773p.

BUCHANAN, B.A.; STONER, A.W. 1988. Distributional patterns of blue crab (*Callinectes* sp.) en a tropical estuarine lagoon. **Estuaries**. 11: 231 - 239.

CAMERON, R.A.; RUNRILL, S.S. 1982. Larval abundance and recruitment of the sand dollar *Dendraster excentricus* in Monterey Bay, California, USA. **Marine Biology**, 71(2): 197-202.

CASTIGLIONI, D. da S; NEGREIRO-FRANSOZO, M.L. 2006. Ciclo reprodutivo do caranguejos violinista *Uca rapax* (Smith) (Crustacea, Brachyura, Ocipodidae) habitante de um estuário degradado em Paraty, Rio de Janeiro, Brasil. **Revista brasileira de Zoologia**, 23 (2): 331-339.

DAUTOV, S. S. 2000. Distribution, species composition, and dynamics of echinoderm larvae in an area of the tumen river estuary and of the far east state marine reserve. **Russian Journal of Marine Biology**, Vol. 26, No. I, pp. 12-17.

DEXTER, D.M. 1977. A natural history of the sand dollar *Encope stokesi* (L. Agassiz) in Panama. **Bulletin Marine Science**., v.27, n.3, p. 544-551.

DORNELLAS E. J.; SILVA F. M.; MOTTA D. G.; SIMÕES C. B.; SÁ, F. S. 2011. Ocorrência de *Macrobrachium olfersii* (CRUSTACEA, DECAPODA, PALAEMONIDAE) em um afluente do Rio Santa Maria da Vitória, em Santa Leopoldina, ES, sudeste do Brasil. **Natureza on line**, 9 (1): 19-26.

EPIFANIO, C. E. 1988. Dispersal strategies of two species of swimming crab on the continental shelf adjacent to Delaware Bay. **Marine Ecology Progress Series**, 49: 243-248.

FERNANDES, M.L.B.; TOMMASI, L.R.; LIMA, E.J.B. 2002. **Filo Echinodermata de Pernambuco**, pp.405-428. In: TABARELLI, M. & SILVA, J.M.C. (orgs.). Diagnóstico da biodiversidade de Pernambuco. Recife, Editora Massangana. 722p.

GEORGE, S. B.; BOONE, S. 2003. The ectosymbiont crab *Dissodactylus Mellitae* — sand dollar *Mellita isometra* relationship. **Journal of Experimental Marine Biology and Ecology**, 294:235–255.

GRAY, I. E., MCCLOSKEY, L. R., WEIHE, S. C. 1968. The commensal crab *Dissodactylus mellitae* and its reaction to sand dollar host-factor. **Journal of the Elisha Mitchell Scientific Society**, 84: 472-481.

GRIFFITH, H. 1987. Phylogenetic relationships and evolution in the genus *Dissodactylus* Smith, 1870 (Crustacea: Brachyura: Pinnotheridae). **Canadian Journal of Zoology**, 65: 2292–2310.

HECK, K.L.; ABLE, K.W.; ROMAN, C.T.; FAHAY, M.P. 1995. Composition, abundance, biomass and production of macrofauna in a New England estuary: comparsions among eelgrass meadows and other nursery habitats. **Estuaries** 18 (2), 379-389.

HENDLER, G.; MILLER, J. E.; PAWSON, D. L.; KIER, P. M. 1995. Sea Stars, Sea Urchins, and Allies: Echinoderms of Florida and the Caribbean. **Smithsonian Institute Press**, Washington D.C., p. 390.

HINES, A. H.; HADDON, A. M.; WIECHERT, L. A. 1990. Guild structure and foraging impact of blue crabs and epibenthic sh in a subestuary of Chesapeake Bay. **Marine Ecology Progress Series** 67(2):105 - 126.

KAISER, M.; ATTRILL, M.; JENNINGS, S.; THOMAS, D.N.; BARNES, D.; BRIERLEY, A.; POLUNIN,; RAFFAELLI, D.; WILLIAMS, P.L.B. 2005. **Marine Ecology: Processes, Systems and Impacts**, Oxford: Oxford University Press.

LAGE, A.M.C.; JOYEUX, J.C.; GOMES, L.C. 2011. Reprodução de *Lytechinus variegatus* (Echinodermata: Echinoidea): efeito do ciclo lunar e características da população. Acta Scientiarum. **Biological Sciences Maringá**, v. 33, n. 3, p. 341-346.

LITTLE, C. 2000. **The Biology of Soft Shores and Estuaries**. Oxford University Press.

LLANSÓ, R.J.; SCOTT, L.C.; DAUER, D.M.; HYLAND, J.L.; RUSSELL, D.E. 2002. An estuarine benthic index of biotic integrity for the mid-atlantic region of the United States. I. Classification of assemblages and habitat definition. **Journal of Estuaries and Coasts**, 25: 1219-1230.

MAIA-BARBOSA, P. M.; ESKINAZI-SANT'ANNA, E. M.; VALADARES, C. F.; PESSOA, G. C. D. 2003. The resting eggs of zooplankton from a tropical, eutrophic reservoir (Pampulha Reservoir, south-east Brazil). **Lake and Reservoir Management**, 8: 269-275.

MANSO, C.L.C.; ALVES, O.F.S & MARTINS, L.R. 2008. Echinodermata da Baía de Todos os Santos e da Baía de Aratu (Bahia, Brasil). **Biota Neotropica**, 8 (3): 179-196.

MANTELATTO, F.L.M.; BARBOSA, L.R. 2005. Population structure and relative growth of freshwater prawn *Macrobrachium brasiliense* (Decapoda, Palaemonidae) from São Paulo State, Brazil. **Acta Limnologica Brasiliensia**. 17: 245-255.

MARTINS, S. T. S.; D'INCAO, F. 1996. Os Pinnotheridae de Santa Catarina e Rio Grande do Sul, Brasil (Decapoda, Brachyura). **Revista Brasileira de Zoologia**, 13 (1): 1-26.

MELO, G. A. S. 1999. **Manual de identificação dos Crustacea Decapoda do litoral brasileiro: Anomura, Thalassinidea, Palinuridea Astacidea**. Plêiade/Fadesp, São Paulo, 370-371.

MERRIL, R.J.; HOBSON, E. Field observations of *Dendraster excentricus,* a sand dollar of western North América. **American Naturalist.** v.83, p.595, 1970.

NORSE, E. A. 1978. An experimental gradient analysis: hyposalinity as an "upstress" distributional determinant for caribbean portunid crabs. **Biological Bulletin**, 155: 586-598.

OLIVEIRA, E.; MASUNARI, S. 1995. Estrutura populacional de *Petrolisthes armatus* (Gibbes, 1850) (Decapoda, Anomura, Porcellanidae) da Ilha do Farol, Cuiabá, Paraná. **Revista brasileira de Zoologia**, 12 (2): 355-371.

PEARCE, J. B. 1962. Adaptation in symbiotic crabs of the family Pinnotheridae. **Biologist**, 45:11– 15.

PEARCE, J. B. 1964. On reproduction in *Pinnotheres maculatus* (Decapoda: Pinnotheridae). **Biological Bulletin**, 127:384.

POHLE, C.; TELFORD, M. 1981. The larval development of *Dissodactylus crinitichelis* Moreira, 1901 (Brachyura, Pinnotheridae) in laboratory culture. **Bulletin of Marine Science**, 31:753–773.

POSEY, M. H.; ALPHIN, T. D.; HARWELL, H.; ALLEN, B. 2005. Importance of low salinity areas for juvenile blue crabs, *Callinectes sapidus* Rathbun, in the river-dominated estuaries of southeastern United States. **Journal of Experimental Marine Biology and Ecology**, 319:81-100.

RATHBUN, M. J. 1918. The Grapsoid crabs of America. **Bulletin of the United States National Museum**, 97: 1-445.

SCHMITT, W. L.; MCCAIN, J. C.; DAVIDSON, E. S. 1973. Decapoda I: Brachyura I: Fam. Pinnotheridae. **Crustaceorum Catalogus**, 3: 1–160.

SCHWAMBORN, R. 1997. **Influence of mangroves on community structure and nutrition of macrozooplankton in northeast Brazil.** [Ph.D. Thesis]. Bremen: University of Bremen.

SCHWAMBORN, R.; BONECKER, A.C.T. 1996. Seasonal changes in the transport and distribution of meroplankton into a Brazilian estuary with emphasis on the importance of floating mangrove leaves. **Arquivos de Biologia e Tecnologia.** 39(2): 451-462.

SMITH, R. R. 1989. **Nutritional energetics**. In Halver, J. E. (Ed). Fish Nutrition. Academic Press, San Diego. p.2-31.

TAVARES, Y.A.G. 1996. **Ecologia populacional de Mellita quinquiesperforata Leske, 1778 (Echinodermata: Echinoidea: Clypeasteroida) em diferentes praias do litoral do Paraná, Brasil**. Dissertação (Mestrado em Zoologia), Universidade Federal do Paraná, Curitiba. 191f.

TELFORD, M. 1978a. Post-larval growth in two species of *Dissodactylus* (Brachyura: Pinnotheridae). **Bulletin of Marine Science**, 28: 645–650.

TELFORD, M. 1978b. Distribution of two species of *Dissodactylus* (Brachyura: Pinnotheridae) among their echinoid host populations in Barbados. **Bulletin of Marine Science**, 28:651–658.

VENTURA, C.R.R.; PIRES, D.O. 2002. Ciclos de vida de invertebrados marinhos. In: PEREIRA, R. C.; SOARES-GOMEZ, A. (Ed.). Biologia marinha. Rio de Janeiro: **Interciência**, p. 49-67.

WEIHE, S.C.; GRAY, I.E. Observations on the biology of the sand dollar Mellita quinquiesperforata. **Journal of the Elisha Mitchell Scientific Society**, v. 84, p.315-327, 1968.

WEINSTEIN, M.P.; KREEGER, D.A. 2000. **Concepts and Controversies in Tidal Marsh Ecology**. Kluwer Academic Publishing, Dordrecht, The Netherlands, 862 pp.

WEISBERG, S.B., RANASIGHE, J.A., SCHAFFNER, L.C., DIAZ, R.J., DAUER, D.M.; FRITHSEN, J.B. 1997. An estuarine index of biological integrity (B-IBI) for Chesapeake Bay. **Estuaries**, 20, 149-158.

WIEGERT, R.G.; POMEROY, R.L. 1981. **The salt marsh ecosystems: a synthesis**. In: POMEROY, L.R.; WIEGERT, R.G. (Eds.). The Ecology of Salt Marsh. Springer, New York, pp. 219-230.

Anexo: Dados Abióticos

Tabela anexa: Média das variáveis abióticas por mês em Pernambuco litoral, tropical Atlântico Sudoeste de novembro / 2011 a outubro / 2012.

	NORTH LITTORAL			SOUTH LITTORAL		
MONTHS	TEMP. (ºC)	SALINITY	GRAN (φ)	TEMP (ºC)	SALINITY	GRAN (φ)
NOVEMBER	26.00±2.16	29.25±8.26	1.59±1.28	25.60±1.52	31.60±8.53	1.76±0.47
DECEMBER	27.50±0.58	33.25±5.19	2.08±1.45	23.80±2.17	33.20±5.22	1.74±0.46
JANUARY	27.00±0.82	38.00±0.82	2.30±1.26	25.40±1.14	36.40±5.41	1.77±0.50
FEBRUARY	25.50±1.00	40.00±0.00	2.15±1.36	26.00±1.87	38.20±3.11	1.84±0.49
MARCH	29.00±2.94	37.75±3.59	2.16±1.40	27.40±1.95	35.50±10.62	1.74±0.47
APRIL	30.25±0.96	42.50±2.08	2.09±1.36	26.80±1.30	37.20±9.73	1.76±0.49
MAY	26.63±0.48	37.25±2.06	2.17±1.12	27.80±1.10	31.40±12.80	1.76±0.48
JUNE	29.25±4.35	29.00±2.83	2.24±1.20	27.40±1.14	32.40±10.55	1.79±0.49
JULY	28.00±0.82	34.25±3.10	2.19±1.16	27.80±2.05	31.80±7.98	1.85±0.37
AUGUST	28.75±0.65	37.50±1.73	2.17±1.56	27.90±1.02	33.60±8.29	1.77±0.49
SEPTEMBER	28.75±1.26	38.75±1.50	1.95±1.76	26.80±1.30	29.60±10.53	1.74±0.50
OCTOBER	27.75±1.50	36.75±3.30	2.18±1.06	25.90±0.55	47.52±23.49	1.75±0.48