

## RECORDS OF GOOSE BARNACLES (CIRRIPEDIA, LEPADIDAE) IN THE NORTHEAST BRAZILIAN REGION

Cristiane Maria Rocha Farrapeira<sup>1</sup>

<sup>1</sup>UFRPE- Dept<sup>o</sup> de Biologia- R. Dom Manoel de Medeiros, s/n<sup>o</sup>, Dois Irmãos, Recife/PE, 52.171-900 -  
email: c.farrapeira@db.ufrpe.br

### ABSTRACT

The goose barnacles are exclusively marine, with worldwide distribution in the warm temperate and tropical seas and known for its usual settlement on living organisms and artificial floating substrata conducted by sea currents. This paper reports lepadis barnacles listed in inventories carried out by several authors and collected from the northeastern coast of Brazil (only Rio Grande do Norte and Pernambuco states), including the Saint Peter and Saint Paul and Fernando de Noronha archipelagos. The samples were collected by hand and using spatula from diverse substrata drifted ashore and on hull of vessels moored in the harbor areas. The specimens had been fixed in alcohol 70%. From the literature review, the vectors of dispersal of these species were considered as shipping, rafting, and phoresy. Five species of lepadids were found: *Conchoderma auritum*, *C. virgatum*, *Lepas anatifera*, *L. anserifera*, *L. hillii*, and *L. pectinata*. All species treated in this study have been cited for the three vectors of dispersal. The first occurrence of *Lepas anatifera*, *L. anserifera*, and *L. hillii* for the Saint Peter and Saint Paul Archipelago was recorded, as well as *L. anserifera* for the Fernando de Noronha Archipelago and Rio Grande do Norte State. All these new records are linked by shipping routes of the fishing boats among the sites mentioned.

**Key-words:** *Conchoderma*, dispersion, *Lepas*, rafting, ship's hull.

### RESUMO

As cracas pedunculadas são exclusivamente marinhas, com distribuição cosmopolita em mares temperados quentes e tropicais, e conhecidos para a sua fixação comum em organismos vivos e substratos artificiais flutuantes conduzidos por correntes marinhas. Este artigo relata cracas lepadomorfas listadas em inventários realizados por diversos autores e coletados no litoral nordestino do Brasil (somente Rio Grande do Norte e Pernambuco), incluindo os arquipélagos de São Pedro e São Paulo e de Fernando de Noronha. As amostras foram coletadas manualmente e utilizando espátula em diversos substratos arribados em praias e no casco dos navios atracados nas áreas portuárias. Os espécimes foram fixados em álcool 70%. A partir da revisão de literatura, os vetores de dispersão destas espécies foram considerados como: navegação, "rafting", e foresia. Cinco espécies de lepas foram encontradas: *Conchoderma auritum*, *C. virgatum*, *Lepas anatifera*, *L. anserifera*, *L. hillii* e *L. pectinata*. Todas as espécies tratadas neste estudo foram citadas para os três vetores de dispersão. Foi registrada a primeira ocorrência de *Lepas anatifera*, *L. anserifera* e *L. hillii* no Arquipélago de São Pedro e São Paulo, bem como de *L. anserifera* no Arquipélago de Fernando de Noronha e no Rio Grande do Norte. Todos estes novos registros são ligados por rotas de navegação das embarcações de pesca entre os locais mencionados.

**Palavras-Chave:** Cascos de navio, *Conchoderma*, dispersão, *Lepas*, "rafting".

## INTRODUCTION

Goose barnacles constitute a group of sessile organisms considered pseudo-planktonic that have 'oceanic' distribution (usually worldwide) due to the fact that they usually attach themselves to mobile substrata, being able to change their positions (Darwin, 1851; Hinojosa *et al.*, 2006). The Lepadidae Family include barnacles of the genera *Conchoderma* Olfers, 1814, *Dosima* Gray, 1825, and *Lepas* Linnaeus, 1758, which are widely cited as ships' hull member (Darwin, 1851; Whoi, 1952; Weisbord, 1979, Farrapeira *et al.*, 2007), also transported on oil platforms (Foster & Willan, 1979) and inside vessels' sea-chests (intake chambers in the hulls of vessels) (Coutts & Dodgshun, 2007). They are also well adapted to the rafting style of life, being carried by ocean currents and winds on drift natural and artificial substrata, sometimes found washed ashore when an onshore wind blows for an extended period (Cheng & Lewin, 1976; Minchin, 1996; Thiel & Gutow, 2005; Hinojosa *et al.*, 2006). In addition to these vectors of dispersal, this group has also as facilitator of transport in the oceans the association with nektonic animals, as swimming crabs, fishes, sea turtles, and whales (Jones *et al.*, 1968; Gittings *et al.*, 1986; Kitsos *et al.*, 2003).

In one of the most complete inventories on Cirripedia in the southwestern Atlantic coast, Young (1990) recorded only 5 species of goose barnacles for the Lepadidae Family: *Dosima fascicularis*, *Lepas anatifera* Linnaeus, 1758, *L. anserifera* Linnaeus, 1767, *L. hilli* (Leach, 1818), and *L. pectinata* Spengler, 1792. It can be emphasized that *Conchoderma auritum* (Linnaeus, 1758), *C. virgatum* (Spengler, 1790), and *L. hilli* were not found in any sample of Brazilian collections examined by Young (1990), but they were cited by Farrapeira *et al.* (2007) from vessels arriving to the Port of Recife, Pernambuco, Northeast of Brazil. Despite its wide distribution in all oceans of tropical and temperate climate, there are scarce records of its occurrence in Northeastern region of country.

Thus, this study aimed to report the goose barnacles from the Northeast region of Brazil, listed in inventories carried out by several authors and collected from two ports and two Northeastern archipelagos, in order to upgrade

its distribution in this region and indicate their vectors of dispersal.

## MATERIAL AND METHODS

The present report provides a checklist of published and unpublished lepadid records of the Brazilian Northeast region (comprising the states of Maranhão to Bahia) and the insular environments from this region: the Saint Peter and Saint Paul (ASPSP) and Fernando de Noronha (FN) archipelagos, and the Rocas Atoll (Figure 1). Samples of goose barnacles were collected at eight locations: Rio Grande do Norte State (Port of Natal- 5°44'S, 35°12'W), Pernambuco State (Port of Recife- 08°04'S, 34°52'W - and four beaches), Saint Peter and Saint Paul (0°56'N, 29°19' W) and Fernando de Noronha (03°50'S, 32°24'W) archipelagos (Figure 1).

Field surveys were conducted between November 2004 to January 2009, by scraping samples of fouling communities with a spatula from vessel's hull and buoys and hand collecting of specimens from drift debris and algae. It was also incorporated in this review some materials sampled in earlier dates, deposited in the Cirripedia collection (Universidade Federal Rural de Pernambuco – DBUFRPE).

Samples from hulls were achieved in the ports of Recife (total period), of Natal (November 2006 and August 2007) and of Santo Antônio, Fernando de Noronha Archipelago (in February 2009). At which time, the type of the vessel and its area of operation-navigation were investigated, asking to the crew members. Part of the goose barnacles collected on vessels docked at the Port of Recife (until May 2006) was published by Farrapeira *et al.* (2007). Other collections, conducted in the same place (May 2006 to January 2009), are now published, as well as other relevant data of barnacles sampled in other locations.

In the results, the vessels were classified into four categories: 1) "Insular Boats" – IN (cargo and fishing boats), which navigate regularly from Recife and Natal to the Saint Peter and Saint Paul and Fernando de Noronha archipelagos; 2) "Fishing Boats" – FI, which fish in the North-Northeastern coastal regions; 3) "Sailboat" – SB (Götheborg, a replica of an 18th

century sailing) that came from Swedish and Spain on a journey of 72 days; and 4) "Research Boat"- RB (the vessel called Riobaldo, belonging to the Center of Fishing Resources Research and

Administration of the Northeast Littoral-ICMBIO/CEPENE), used for assessments of the pelagic resources in the Northeastern Brazilian coast.

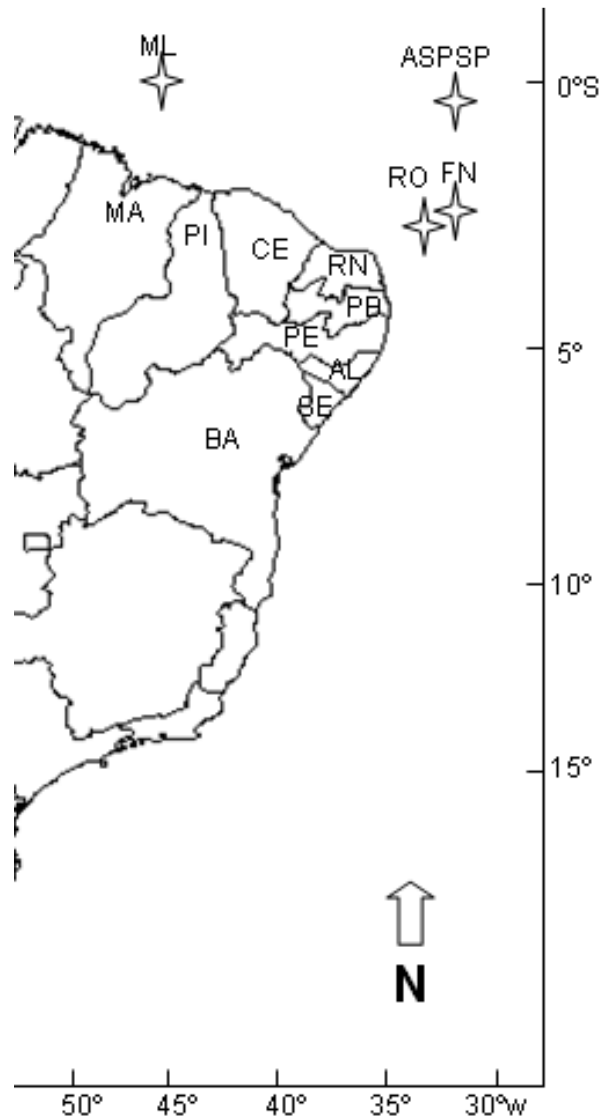


Fig. 1. Brazilian Northeastern region, including the insular environments, where: MA= Maranhão, PI= Piauí, CE= Ceará, RN= Rio Grande do Norte, PB= Paraíba, PE= Pernambuco, AL= Alagoas, BA= Bahia States, ASPSP= Saint Peter and Saint Paul Archipelago, FN= Fernando de Noronha Archipelago and RO= Rocas Atoll (RO).



Figure 2. Lepidids on hulls of vessels moored in the Port of Recife. a. FI-Chung Kuo 242. b. *Lepas anatifera* on FI-Chung Kuo 287's hull. c. *Lepas anserifera* on FI-Chung Kuo 242's hull. d. *Lepas hillii* on FI-Chung Kuo 280's hull. e. Swedish SB-Götheborg. f. detail of the SB-Götheborg's hull showing a concentration of goose barnacles (evident only *Lepas* spp.) in the dark band.

Specimens settled in other substrata were collected in six locations. In Saint Peter and Saint Paul Archipelago the specimens came from a nylon rope of the Transmar II fishing boat (boat also responsible for transporting the researchers to the archipelago) and, after, from artisanal anchor of the same boat. In Fernando de Noronha Archipelago, the barnacles were sampled on a wreck signalizing buoy in the Santo Antônio Bay. The material collected in Pernambuco State came from the following beaches and substrata: Jaguaribe (7°43'S, 34°49'W- on Nylon rope and *Sargassum* drifted ashore), Boa Viagem (8°07'S, 34°53'W- on tar pellets and plastic bottle), Itapoama (8°17'S, 34°57'W- on floating bamboos), and Gaibu (8°20'S and 34°57'W0 on floating lamp).

It was also examined a debris of the wreckage of the Air France Flight 447 (from Rio de Janeiro, Brazil, to Paris, France) crashed into the Atlantic Ocean between the Saint Peter and Saint Paul and Fernando de Noronha archipelagos. This material was submitted for consideration by the 'Bureau d'Enquêtes et d'Analyses' (BEA) by the Safety of Civil Aviation of France and were donated to the Carcinology Collection of the Oceanographic Department of the Universidade Federal de Pernambuco (DOUFPE).

Barnacles were fixed and preserved in alcohol 70%. Stereomicroscope and microscope were used for species identification. Digital images of organisms were captured using a Sony Cyber-shot DSC-W35 camera. The number of

specimens collected on the respective sample is indicated in parentheses.

All available sources of information documented in the literature regarding the geographical distribution and vectors of dispersion of the lepadids found were investigated. The retrieved data was assembled in: taxa identity, examined material, geographical distribution (from Brazil, including only the Northeastern region), and related vectors of dispersion. On this subject, it was considered: shipping (specimens carried on hulls and in sea-chests and ballast water tanks of vessels, and also gas/oil platforms dislocated throughout the oceans), rafting (transportation on drift debris and floating algae through marine currents), and phoresy (transportation associated with pelagic animals).

## RESULTS

The five species of lepadids present in the Northeast Region of Brazil, including the archipelagos can be identified according to the anatomical and morphological characteristics indicated in the following descriptive and dichotomous key (based in Darwin, 1851 and personal observation):

1. Capitulum formed of smooth membrane, with two to five reduced and remote valves; Scutum with two or three lobes, with their umbones in the middle of the occludent margin; Carina quite rudimentary or absent.....*Conchoderma* (2)
- 1' Capitulum covered with five valves, approximate; Scutum subtriangular, with their umbones at the rostral angle; Carina extending up between the *Tergum*, terminating downwards in an embedded fork.....*Lepas* (3)
2. **Capitulum** more or less spotted, often nearly uniformly purple; sometimes with five dark purple longitudinal bands confluent; slightly compressed, almost globular, membrane thick, with two flexible, tubular, and folded ear-like appendages, behind the rudimentary and often absent *tergum*. **Valves** 5 rudimentary plates, or 2 reduced or rudimentary valves widely separated from each other (in this case, carina and terga absent). **Scutum** small, V-shaped, umbo in the middle. **Tergum** small, linear and same length of the carina, or absent. **Carina** pointed-elliptical, rudimentary or absent. **Peduncle** colored as the capitulum, long (generally twice or thrice as long as the capitulum), distinctly separated from the capitulum.....*Conchoderma auritum* (Fig. 3)
- 2'. **Capitulum** grey, with a tinge of blue, with six purplish brown bands; flattened, summit square or obtusely pointed, with two small prominences; membrane thin; **Valves** 5, thin, small, remote and imbedded in membrane, very variable in shape and in proportional length. **Scutum** small, Y-shaped, with upper and lower lobe united into a straight flat disc; **Tergum** small, narrow, linear, concave internally, with apices slightly curved inwards; **Carina** narrow, moderately developed, slightly curved nearly parallel to the scutum, very slightly bowed; **Peduncle** colored as the capitulum, short (equal in length or a little longer), flattened, gradually widening as it joins the capitulum.....*Conchoderma virgatum* (Fig. 4)
3. Valves smooth, or delicately striated.....(3)
- 3'. Valves slightly to coarsely furrowed.....(4)
4. **Capitulum** with length in proportion to the breadth of the variable, which the scutum and tergum have their apices produced; edges of the orifice bright scarlet orange; interspaces between the carina and terga and scuta valves dull orange-brown colored and not wide. **Valves** white, seldom translucent and thick, with a tinge of bluish-grey from the underlying corium; smooth or with traces of very fine lines radiating from the umbones, or delicately striated on scutum and tergum; seldom with one or more diagonal lines of dark greenish-brown slightly depressed square marks across the capitulum. **Scutum** large, basal margin straight to a little concave; occludent margin curved or nearly straight; right scutum with an internal umbonal tooth. **Tergum** relatively narrow, longer than high, convex, obliquely quadrangular. **Carina** exteriorly, convex,

smooth, seldom barbed, apex more or less acuminate and sharply bifurcated near the basal umbo. **Peduncle** dark purplish-brown colored, uppermost part darker, lower part pale; smooth or wrinkled; length equal to seven times as long as the capitulum. **Filamentary appendages** never more than two.....*Lepas anatifera* (Fig. 2b, 5)

4' **Capitulum** laterally flat, length varies in proportion to the breadth; edges of the orifice bright orange-yellow, space between carina and other valves, and purplish-brown, between the scutum. **Valves** white, bluish-grey from the underlying corium, somewhat translucent, moderately thick, always very smooth but with faint traces of radiating lines. **Scutum** with upper angle little acuminate; occludent margins with wide space of corium between them; no internal umbonal teeth. **Tergum** flat, rather broad, almost triangular, with the basal angle not much acuminate. **Carina** narrow, upper part not much acuminate, separated by wide space from the scutum and Tergum; with the fork not close to the basal margin of the scutum. **Peduncle** purplish brown colored; uppermost part pale, orange or purplish-brown colored; smooth. **Filamentary appendages** three on each side.....*Lepas hillii* (Fig. 2d, 7)

5. **Capitulum** more or less elongated relatively to its breadth; both the tergum and scutum sculptured by concentric growth lines and by radial striae and furrows, generally stronger on the tergum; edges of valves bright orange; occludent border of scutum strongly arched forming wide area between the border and the ridge running from the umbo to the apex of the plate; carina not contracted just above the fork. **Valves** white, thick, closely approximate to each other - no interspaces, slightly furrowed. **Scutum** large, with occludent margin arched, protuberant; apex pointed; right valve with a strong internal umbonal tooth; left valve with small tooth, or mere ridge. **Tergum** trapezoid, equal or only

two-thirds of the length of the scutum, usually more strongly striated than scutum. **Carina** rather broad, strongly arched and pronged at the base, deeply concave within; exterior sides finely furrowed longitudinally, denticulate, with barbed margin. **Peduncle** orange-brown; uppermost part bright orange all round; usually about as long as the capitulum. **Filamentary appendages** four, five, rarely six on each side.....*Lepas anserifera* (Fig. 2c, 6)

5'. **Capitulum** conspicuously inflated; characterized by its radially striate or grooved valves, often with strong spines; length variable, compared to its breadth; edges pale purple, with very narrow area between the occludent border; with a ridge from umbo to apex of the scutum. **Valves** white to bluish thin, brittle, coarsely furrowed, often pectinated, sometimes that alone, is covered with prominent, curled, flat, calcareous spines. **Scutum** almost triangular, with prominent and curved ridge extending from the umbo to the apex, with only a very narrow space between this margin and the ridge, internal teeth, under the umbones, either sharp and prominent, or mere knobs. **Tergum** almost triangular, with a conspicuous notch to receive the apex of the scutum; occludent margins meet each other at a rectangle. **Carina** barbed, with edges sinuous, upper part wide and conspicuously contracted just above the basal fork, deeply concave within. **Peduncle** brownish, narrow, shorter than the capitulum. **Filamentary appendages** none, or only one, short.....*Lepas pectinata*

*Conchoderma auritum* (Linnaeus, 1758)

**Examined Material** (39 specimens): **PERNAMBUCO:** *Port of Recife:* FI-Chung Kuo 232: *DBUFRPE 722-* Mar 21, 2006 (7 spc); FI-Chung Kuo 242: *DBUFRPE 742-* May 07, 2006 (20 spc); FI-Chung Kuo 287: *DBUFRPE 505-* Jan 21, 2006 (3 spc) and *DBUFRPE 623-* Mar 02, 2006 (4 spc); FI-Titan: *DBUFRPE 738-* May 05, 2006 (5 spc) (Fig. 3).



Figure 3. *Conchoderma auritum* specimens. **a, b**- right specimen from FI-Chung Kuo 287's hull. **b**- left and middle specimens from FI-Chung Kuo 242's hull (middle specimen with a young *Lepas hillii* settled in basal region of peduncle).



Figure 4. *Conchoderma virgatum* specimens. **a, b**. from SB-Göteborg (**b**. with *Amphibalanus improvisus* specimens newly settled). **c**. from FI-Chung Kuo 232's hull, showing the capitulum opening. **d**. from FI-Chung Kuo 242's hull.

**Geographic Distribution:** Cosmopolitan (Weisbord, 1979). Northeast of Brazil: Pernambuco State (Farrapeira *et al.*, 2007; present study).

**Remarks:** This species was reported to inanimate substrata, as fixed seismic streamer cables in Southwest Brazil (Miranda *et al.*, 2004) and being towed by a geophysical vessel towed off eastern African coast (Harper Jr., 1995). There are few records of specimens from floating buoys (Weisbord, 1979; Gittings *et al.*, 1986; Wirtz *et al.*, 2006). Moreover, *C. auritum* is found on the three vectors of dispersion, related to shipping movements, rafting, and phoresy (Table 1).

*Conchoderma virgatum* (Spengler, 1790)

**Examined Material** (112 specimens):

**PERNAMBUCO:** *Port of Recife:* FI-Chung Kuo 232: DBUFRPE 723- Mar 21, 2006 (2 spc); FI-Chung Kuo 242: DBUFRPE 743- May 07, 2006 (20 spc); FI-Chung Kuo 287: DBUFRPE 504- Jan 21, 2006 (21 spc) and DBUFRPE 624- Mar 02, 2006 (14 spc); FI-Tontini: DBUFRPE 465- Jan 03, 2006 (1 spc); SB-Götheborg: DBUFRPE 450- Jan 03, 2006 (17 spc) and DBUFRPE 458- Jan 04, 2006 (37 spc) (Fig. 4).

**Geographic Distribution:** Cosmopolitan (Weisbord, 1979). Northeast of Brazil: Pernambuco State (Farrapeira *et al.*, 2007; present study)

**Remarks:** It shows a preference for settling below the surface of the sea rather than on it (Weisbord, 1979), being only occasionally found on floating buoys (Wirtz *et al.*, 2006). Similarly to what occurred with *C. auritum*, this species is also a fouling component of vessels (outside – on hulls, and inside – in sea-chests) and towed oil platforms, as well as being well adapted to the rafting lifestyle, transported on floating objects and algae and nektonic animals (Table 1).

*Lepas anatifera* Linnaeus, 1758

**Examined Material** (175 specimens): **ASPSP:** DBUFRPE- Nov 08, 2004- 290 (10 spc on a nylon rope of the boat of *IN-Transmar II*); DBUFRPE 916- November 11, 2008 (17 spc on artisanal anchor of *IN-Transmar II*); **PERNAMBUCO:** Jaguaribe Beach: DBUFRPE 288- May 18, 2005 (6 spc, from Nylon rope) and DBUFRPE 367- Jun 22, 2006 (8 spc, from drifted *Sargassum*); Port of Recife: FI-Arão X: DBUFRPE 908- Out 29, 2008 (2 spc); Chung Kuo 232: DBUFRPE 724- Mar 21, 2006 (2 spc); FI-Chung Kuo 242: DBUFRPE 744- May 07,

2006 (5 spc); FI-Chung Kuo 287: DBUFRPE 506- Jan 04, 2006 (31 spc) and DBUFRPE 625- Mar 02, 2006 (14 spc); FI-Gilontas: DBUFRPE 456- Jan 04, 2006 (17 spc); IN-Águas do Rio Negro: DBUFRPE 531- Jan 04, 2006 (3 spc); IN-Águas do Rio Negro: DBUFRPE 531- Jan 04, 2006 (3 spc); IN-Concórdia: DBUFRPE 1010- Jan 27, 2009 (2 spc); RB-Riobaldo: DBUFRPE 604- Feb 18, 2006 (3 spc); SB-Götheborg: DBUFRPE 454- Jan 03, 2006 (17 spc) and DBUFRPE 461- Jan 04, 2006 (10 spc); Boa Viagem Beach: DBUFRPE 293- Ago 18, 1989 (10 spc, from tar pellets); DBUFRPE 786- Nov 06, 2006 (1 spc, from plastic bottle); Itapoama Beach: DBUFRPE 292- Feb 13, 2005 (14 spc, from floating bamboo) (Fig. 2b, 5) **Geographic Distribution:** Cosmopolitan (Weisbord, 1979). Northeast of Brazil: Saint Peter and Saint Paul Archipelago (present study); Rocas Atoll (Paiva *et al.*, 2007; Young, 2007); Maranhão (Silva & Eugênio, 1998); Paraíba (Young, 1990); Pernambuco (Farrapeira *et al.*, 2007, present study); and Bahia (Weisbord, 1979; Young, 1990; Young & Serejo, 2005).

**Remarks:** *Lepas anatifera* is found on buoys (Chapman & Santler, 1955; Weisbord, 1979; Relini *et al.*, 2001; Yan *et al.*, 2006; Young, 2007); and is extremely common attached to vessels, to different types of floating substrata, and associated with pleustonic gastropod (*Janthina* sp.) and marine swimming vertebrates (Table 1).

*Lepas anserifera* Linnaeus, 1767

**Examined Material** (90 specimens): **ASPSP:** DBUFRPE 291- Nov 8, 2004 (10 spc on nylon rope of *IN-Transmar II*); DBUFRPE 917- Nov 11, 2008 (11 spc on artisanal anchor of *IN-Transmar II*); DOUFPE- Jun 18, 2009 (20 spc on metal fragment of airplane seat of the Airbus France Flight 447); **FN:** Santo Antônio Harbor: DBUFRPE 1023- Feb 12, 2009 (10 spc on signaling buoy) and *IN-Titikaka*: DBUFRPE 1024- Feb 12, 2009 (3 spc); **RIO GRANDE DO NORTE:** *IN-Transmar I*: DBUFRPE 778- Nov 11, 2006 (2 spc); **PERNAMBUCO:** *Port of Recife:* FI-Chung Kuo 287: DBUFRPE 626- Mar 03, 2006 (1 spc); FI-Titan: DBUFRPE 739- May 07, 2006 (5 spc); IN-Águas do Rio Negro: DBUFRPE 530- Jan 04, 2006 (5 spc); IN-Burra Leiteira: DBUFRPE 907 Out 29, 2008 (2 spc); IN-Concórdia: DBUFRPE 1011- Jan 27, 2009 (4 spc); *Jaguaribe Beach:* DBUFRPE 287- May 18, 2005 (12 spc on Nylon rope); *Gaibu Beach:* DBUFRPE 286- Jun 27 2005 (5 spc on floating lamp) (Fig. 2c, 6).



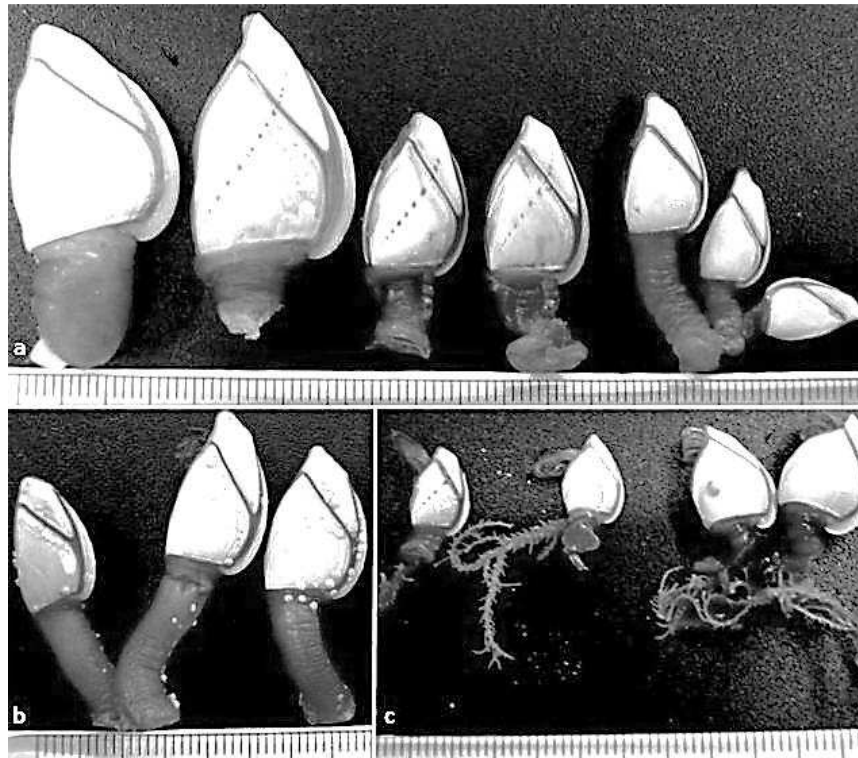


Figure 5. *Lepas anatifera* specimens. a: right specimen from a plastic bottle (Boa Viagem Beach), three specimens with diagonal line of brown quadrilateral depressions, from FI-Chung Kuo 287's hull, linked three specimens group from FI-Gilontas. b: from SB-Göteborg (with *Amphibalanus improvisus* Darwin, 1854 specimens newly settled). c: from *Sargassum* sp. (Jaguaribe Beach).

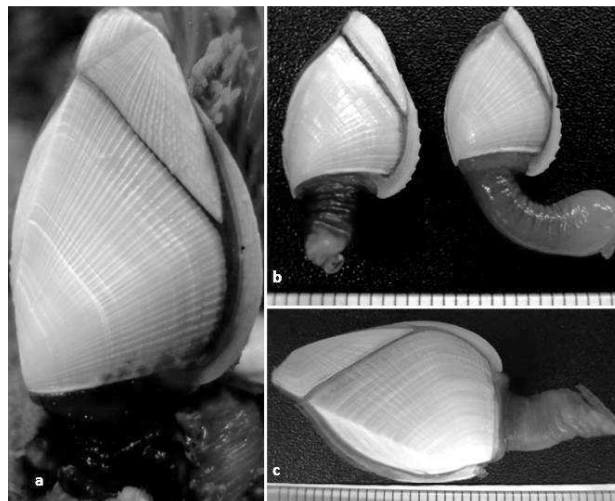


Figure 6. *Lepas anserifera* specimens. a: from a nylon rope (Jaguaribe Beach). b: from *IN-Águas do Rio Negro*. c: from artisanal anchor of *IN-Transmar II* (Saint Peter and Saint Paul Archipelago)

**Geographic Distribution:** Cosmopolitan (Weisbord, 1979). Northeast of Brazil: Saint Peter and Saint Paul Archipelago (present study); Fernando de Noronha Archipelago (present study); Maranhão (Silva & Eugênio, 1998); Rio Grande do Norte (present study); Paraíba (Young, 1990; Riul *et al.*, 2008); Pernambuco (Farrapeira *et al.*, 2007; present study); Bahia (Young, 1990; Young & Serejo, 2005).

**Remarks:** It is a pelagic barnacle present on buoys (Utinomi, 1962; Weisbord, 1979; Yan *et al.*, 2006) and preferably settled on ships and floating objects at the sea surface. Relating with nektonic host, this species is cited on turtles and, rarely, also associated with empty shells of *Spirula* sp. (Table 1).

**Lepas hillii (Leach, 1818)**

**Examined Material** (74 specimens): **ASPSP:** DBUFRPE 289- Nov 08, 2004 (7 spc on a nylon rope of *IN-Transmar II*); **PERNAMBUCO:** Port of Recife: FI-Chung Kuo 232: DBUFRPE 725- Mar 03, 2006 (2 spc); FI-Chung Kuo 242: DBUFRPE 745- May 07, 2006 (4 spc); FI-Chung Kuo 280: DBUFRPE 696- Mar 21, 2006 (2 spc) and DBUFRPE 724- Mar 21, 2006 (34 spc); FI-Chung Kuo 287: DBUFRPE 507- Jan 04, 2006 (1 spc); DBUFRPE 627- Mar 03, 2006 (11 spc); *IN-Águas do Rio*

Negro: DBUFRPE 532- Jan 04, 2006 (4 spc); SB-Göteborg: DBUFRPE 453- Jan 04, 2006 (7 spc); DBUFRPE 460- Jan 04, 2006 (2 spc) (Fig. 2d, 3b- on *Conchoderma auritum*, 7).

**Geographic Distribution:** Cosmopolitan (Weisbord, 1979). Northeast of Brazil: Saint Peter and Saint Paul Archipelago (present study); Maranhão (Silva & Eugênio, 1998); Pernambuco (Farrapeira *et al.*, 2007; present study).

**Remarks:** Extremely common attached to ships' bottoms, from all parts of the world and floating debris, although it is also recorded to other vectors of dispersion, the phoresy by turtles (Table 1).

*Lepas pectinata* Spengler, 1792

**Examined Material** (one specimen): **ASPSP:** DBUFRPE 918- November 11, 2008 (1 broken spc on artisanal anchor of *IN-Transmar II*)

**Geographic Distribution:** Cosmopolitan (Weisbord, 1979). Northeast of Brazil: Saint Peter and Saint Paul Archipelago (Weisbord, 1979; Young, 1990; present study).

**Remarks:** It is a species most commonly reported as rafter in floating debris, algae and planktonic gastropods (*Janthina* sp. and *Spirula* sp.), than in vessels and other vectors of dispersal (Table 1).



Figure 7. *Lepas hillii* specimens. **a** and **b**- first two specimens from a nylon rope (Saint Peter and Saint Paul Archipelago) (**a**. newly-fixed specimen). **b**- last two specimens from FI-Chung Kuo 287.

Table 1 Goose barnacles' vectors of dispersion. SH= ship's hull, SC= sea-chest, BW= ballast water, OP= oil platform, DD= drift debris, DA= drift algae, PH= phoresy (ga= gastropod, co= copepod, cr= swimming crab, do= dolphin, fi=fish, sn= sea snake, tu= sea turtle, wh= whales); # present study.

SPECIES	SHIPPING	RAFTING	PHORESY
<i>C. auritum</i>	SH <sup>15, 21, 22, 24, 31, 32, 33, 34, 40, 41, 45, 50, 52, 62, 66, 68, 72, 74, 80, 81, 85, 87, 88, #</sup> , SC <sup>18, 19</sup> , OP <sup>27</sup>	DD <sup>31, 78</sup> DA <sup>78</sup>	fi <sup>6</sup> , do <sup>69</sup> , wh <sup>13, 31, 37, 41, 72, 81</sup>
<i>C. virgatum</i>	SH <sup>15, 21, 24, 31, 32, 33, 34, 40, 41, 50, 62, 65, 68, 72, 73, 74, 80, 81, 87, 88, #</sup> , SC <sup>18</sup> , OP <sup>27</sup>	DD <sup>21, 55, 65, 78</sup> DA <sup>17, 21, 31, 78, 81</sup>	co <sup>16, 72, 82</sup> , cr <sup>42, 64, 81</sup> , fi <sup>5, 6, 9, 44, 81</sup> , tu <sup>4, 29, 47, 48, 53, 84</sup> , sn <sup>2</sup> , wh <sup>31</sup>
<i>L. anatifera</i>	SH <sup>7, 21, 24, 25, 33, 34, 38, 40, 41, 45, 51, 52, 55, 68, 74, 76, 80, 81, 88, #</sup> , BW <sup>38</sup> , SC <sup>19</sup> , OP <sup>27</sup>	DD <sup>3, 11, 12, 14, 21, 26, 31, 35, 39, 41, 43, 45, 47, 49, 51, 54, 55, 56, 58, 62, 63, 70, 71, 75, 77, 78, 79, 81, 83, 84, 86, #</sup> DA <sup>17, 21, 31, 36, 75, 78, 81, #</sup>	ga <sup>81</sup> , tu <sup>4, 10, 28, 29, 49, 47, 48, 53</sup>
<i>L. anserifera</i>	SH <sup>21, 24, 31, 45, 33, 34, 46, 50, 57, 79, 80, 81, #</sup> , OP <sup>20, 27</sup>	DD <sup>11, 21, 23, 26, 31, 43, 55, 59, 62, 63, 65, 67, 70, 74, 76, 78, 81, 86, #</sup> DA <sup>11, 17, 21, 31, 62, 63, 70, 76, 79, 81</sup>	ga <sup>21</sup> , tu <sup>29, 53</sup>
<i>L. hillii</i>	SH <sup>15, 20, 21, 24, 34, 40, 41, 65, 72, 73, 74, 79, 80, 81, #</sup>	DD <sup>21, 41, 55, 67, 76, 78, 81, 86</sup> DA <sup>17, 78</sup>	tu <sup>4, 29, 53, 81, 86</sup>
<i>L. pectinata</i>	SH <sup>21, 31, 50, 81, #</sup> SC <sup>19</sup>	DD <sup>1, 8, 21, 30, 31, 39, 41, 49, 54, 78, 81, 84, 86</sup> DA <sup>17, 19, 21, 31, 62, 63, 78, 79, 81</sup>	ga <sup>16</sup> , tu <sup>4, 28, 60, 61</sup>

<sup>1</sup>Aliani & Molcard (2003); <sup>2</sup>Alvarez & Celis (2004); <sup>3</sup>Amaral & Nonato (1994); <sup>4</sup>Badillo *et al.* (2003); <sup>5</sup>Balakrishnan (1969); <sup>6</sup>Barnard (1924); <sup>7</sup>Bertelsen & Ussing (1936); <sup>8</sup>Broch (1922); <sup>9</sup>Broch (1925); <sup>10</sup>Caine & Baruch (1986); <sup>11</sup>Celis *et al.* (2007); <sup>12</sup>Chace Jr. (1951); <sup>13</sup>Chapman & Santler (1955); <sup>14</sup>Cheng & Lewin (1976); <sup>15</sup>Chilton (1911); <sup>16</sup>Ciurea *et al.* (1933); <sup>17</sup>Coston-Clements *et al.* (1991); <sup>18</sup>Coutts & Dodgshun (2007); <sup>19</sup>Couture & Simard (2007); <sup>20</sup>Crainfield *et al.* (1998); <sup>21</sup>Darwin (1851); <sup>22</sup>Davidson *et al.* (2009); <sup>23</sup>deVantier (1992); <sup>24</sup>Farrapeira *et al.* (2007); <sup>25</sup>Ferreira *et al.* (2006); <sup>26</sup>Foster (1974); <sup>27</sup>Foster & Willan (1979); <sup>28</sup>Frick *et al.* (1998); <sup>29</sup>Frick *et al.* (2003); <sup>30</sup>Galil (2006); <sup>31</sup>Gittings *et al.* (1986); <sup>32</sup>Godwin (2003); <sup>33</sup>Godwin *et al.* (2004); <sup>34</sup>Gollasch (2002); <sup>35</sup>Henry (1940); <sup>36</sup>Hobday (2000); <sup>37</sup>Holthuis & Fransen (2004); <sup>38</sup>Hopkins (2002); <sup>39</sup>Horn *et al.* (1970); <sup>40</sup>Jennings (1915); <sup>41</sup>Jennings (1918); <sup>42</sup>Jerde (1970); <sup>43</sup>Jones (1994); <sup>44</sup>Jones *et al.* (1968); <sup>45</sup>Jones *et al.* (2000); <sup>46</sup>Key (1843); <sup>47</sup>Kitsos *et al.* (2003); <sup>48</sup>Kitsos *et al.* (2005); <sup>49</sup>Koukouras & Matsa (1998); <sup>50</sup>Krüger (1927); <sup>51</sup>Leung & Jones (2000); <sup>52</sup>Lewis *et al.* (2004); <sup>53</sup>Loreto & Bondioli (2008); <sup>54</sup>Minchin (1996); <sup>55</sup>Newman (1972); <sup>56</sup>Nobre (1903); <sup>57</sup>Otani *et al.* (2007); <sup>58</sup>Patel (1959); <sup>59</sup>Pettibone (1963); <sup>60</sup>Pfaller *et al.* (2006); <sup>61</sup>Pfaller *et al.* (2008); <sup>62</sup>Pilsbry (1907); <sup>63</sup>Pilsbry (1916); <sup>64</sup>Rathbun (1930); <sup>65</sup>Roskell (1969); <sup>66</sup>Ruiz *et al.* (2005); <sup>67</sup>Silva & Eugênio (1998); <sup>68</sup>Skerman (1960); <sup>69</sup>Soto (2001); <sup>70</sup>Southward (1975); <sup>71</sup>Spivak & Bas (1999); <sup>72</sup>Stebbing (1910); <sup>73</sup>Stubbings (1936); <sup>74</sup>Stubbings (1961); <sup>75</sup>Stubbings (1963); <sup>76</sup>Stubbings (1967); <sup>77</sup>Sumner *et al.* (1913); <sup>78</sup>Thiel & Gutow (2005); <sup>79</sup>Utinomi (1968); <sup>80</sup>Visscher (1928); <sup>81</sup>Weisbord (1979); <sup>82</sup>Williams Jr. & Williams (1986); <sup>83</sup>Winston *et al.* (1997); <sup>84</sup>Wirtz *et al.* (2006); <sup>85</sup>Wolff (2005); <sup>86</sup>Young (1990); <sup>87</sup>Zullo (1979); <sup>88</sup>Zvyagitsev (2000)

## DISCUSSION

All species of lepadids found in this study were mentioned in all vectors of oceanic dispersal, what is expected, because they are travelling pseudo-planktonic or pelagic species, due its settlement on any floating or moving substrate in oceanic waters. According to WHOI (1952) it occurs because they possess pelagic larvae that colonize any floating item during the early stages of succession.

Regarding the information documented in the literature in this review and also considering the examined material, *Conchoderma* spp. and *Lepas hillii* seem to be better adapted as shipborne species. Darwin (1851) mentioned an incident that happened in the survey of Beagle ship after an interval of exactly thirty-three days in sea (around Galapagos), which demonstrates the rapid colonization and growth of *Conchoderma virgatum*. Several individuals developed on the hull, some of them contained numerous ova in their lamellae, ready to burst forth.

With respect to phoretic transport by nectonic animals, species of *Conchoderma* have greater diversity of host-support, compared to species of *Lepas*, usually cited as epibionts associated with sea turtles. The association with highly mobile taxa is a factor that contributes to the spread of these goose barnacle species. According to Van Syoc (2009), this symbiotic way of life reflects the range of their potential host species. Sea turtles are platforms for the colonization of various species (Frick *et al.*, 1998). Thus, several barnacles occur fortuitously on sea turtles, and many are non-obligate commensals that can be found in a variety of epifaunal situations (ERC, 2007).

Among the pelagic species that serve as transportation for the goose-barnacles is the purple sea snail *Janthina* sp., gastropod that floats by producing a mass of mucous bubbles which harden into a bubble plastic-like float (Thiel & Gutow, 2005). *Lepas anatifera* and *L. pectinata* were found attached on this bubble float (Weisbord, 1979). Another unusual and interesting substratum is the floating *Spirula* empty shell, commonly called 'spirulae', that is a chambered shell formed by the squid that serves as its internal buoyancy system (Abbott, 1974).

This substratum was used by *Lepas anserifera* (Southward, 1975) and *L. pectinata* (Darwin, 1851)

From the compiled list of goose barnacles, in their respective vector of transport in oceanic waters, another pattern was found: the association with drift substrata. Thiel & Gutow (2005) point out that Cirripedia is, in general, one of the most typical rafting organisms; moreover, most Lepadidae are obligate rafters and their populations are entirely pelagic. A variety of substrata where they can be found range from naturally floating organisms and organic debris as well as anthropogenic solid waste carried by the ocean currents and winds.

The various floating substrata where *Lepas anatifera* is found exemplify that lack of choice about the nature, texture and origin of these debris. This species was found on driftwood (Darwin, 1851; Nobre, 1903; Pilsbry, 1907; Pilsbry, 1916; Stubbings, 1963; Newman, 1972; Foster, 1974; Southward, 1975; Gittings *et al.*, 1986; Young, 1990; Koukouras & Matsa, 1998; Jones, 1994; Minchin, 1996; Jones *et al.*, 2000; Leung & Jones, 2000; Kitsos *et al.*, 2003; Thiel & Gutow, 2005); on corks (Nobre, 1903); on plastic debris (Winston *et al.*, 1997); on floating bottles (Darwin, 1851; Young, 1990; Minchin, 1996; present study); on pelagic tar particles (Horn *et al.*, 1970; Cheng & Lewin, 1976; Weisbord, 1979; Thiel & Gutow, 2005; present study); on a piece of rope stranded on a beach (Spivak & Bas, 1999; present study); on drift buoy washed ashore (Patel, 1959). It was found also on organic debris, such as volcanic pumice (Newman, 1972; Thiel & Gutow, 2005); floating bamboo (Utinomi, 1968; Weisbord, 1979; Jones, 1994; present study); floating nut (Stubbings, 1963); and on fragments of algae and naturally floating *Sargassum* (Darwin, 1851; Stubbings, 1963; Gittings *et al.*, 1986; Coston-Clements *et al.*, 1991; Hobday 2000b; Thiel & Gutow, 2005; Weisbord, 1979; present study).

A fact worthy of note was the presence of specimens of *Lepas anserifera* on floating fragments derived from the plane wreckage of Airbus Flight 447. This air plane crashed on the night of May 31, 2009 night and wreckage samples were found in June 18, 2009, between the Saint Peter and Saint Paul and Fernando de Noronha archipelagos. Saint Peter and Saint Paul

Archipelago is one of the smallest isolated oceanic islands in the world, lying just north of the equator on the mid-Atlantic, approximately 960 km off the northeast coast of Brazil (Edwards & Lubbock, 1983). The Archipelago of Fernando de Noronha, about 545 km from Recife, capital of the State of Pernambuco, and 360 km to Natal, Rio Grande do Norte State (Farrapeira *et al.*, 2007). One solely metal fragment had 14 juveniles (maximum size ranging from 15.5 to 19.0 mm- stalk and capitulum) and six newly recruited (with a maximum length ranging from 1.8 to 3.3 mm).

Adult specimens of *L. anserifera* were collected in Saint Peter and Saint Paul Archipelago since November 2004 on nylon rope of *Transmar II* fishing boat (here classified as "insular vessel"). This boat carries researchers (Port of Natal –archipelago – Port of Natal) and stays moored on the main island for 15 days. Later (November 2008), it was found specimens of this species in the same boat's anchor, and also on two substrata (buoy and hull of fishing- "insular" boat) sampled in the Santo Antônio Bay, the harbor area of Fernando de Noronha Archipelago. The association of *L. anserifera* with hulls of vessels (mainly fishing boat- that navigate in these waters), and with raft of floating debris and algae (that are carried by ocean currents) explains their appearance in these oceanic archipelagos. The appearance of specimens in the wreckage objects floating around these areas is therefore quite understandable.

The speed with which the larvae of this goose barnacle colonized the new floating substratum available probably means that they are released into the surrounding area of these waters and it happened as soon as it rose to the surface (or sub-surface). Another interesting fact to highlight is the rapid growth of newly recruited specimens. Adult specimens from this area can measure up to 68.4 mm (of which 40.2 mm is the length of the stalk), but mature specimens, with eggs incubated in the mantle cavity, were found measuring 43.3 mm. Evans (1958) mentioned that *L. anatifera*, a similar species, can reach sexual maturity within ~30 days at temperatures of ~25°C. Adults of this last species (with 21.2 to 37.4 length) were found on the Swedish Götheborg Sailboat's hull after a voyage of 72 days, having departed from the city of

Götheborg, routed to Spain through the Channel, and passed by the Equator towards Port of Recife, where they were sampled (Farrapeira *et al.*, 2007).

Although all species treated in this study have been cited for numerous vectors of dispersal, the number of specimens found in the sampled vessels of the Northeastern harbor areas (mainly Port of Recife) justifies its occurrence in oceanic islands far from the mainland coast of Brazil. Moreover, even considered that this species has 'oceanic' and cosmopolitan distribution, this study records for the first time *Lepas anatifera*, *L. anserifera*, and *L. hillii* in the Saint Peter and Saint Paul Archipelago. It was also the recorded the first occurrence of *L. anserifera* in the Fernando de Noronha Archipelago and Rio Grande do Norte State. All these new records are linked by shipping routes of the fishing boats among the sites mentioned.

#### Acknowledgements

I thank to Fernanda Maria Duarte do Amaral and Débora Ferreira Barbosa for bringing some specimens from Pernambuco beaches, to Sílvio Felipe B. Lima and Simone Albuquerque Lira for bringing specimens from Saint Peter and Saint Paul Archipelago, and to José Oribe Rocha de Aragão and Sigrid Neumann Leitão, for making available the airbus wreckage' sample of this last nearby areas. I am also grateful to anonymous reviewers for their important suggestions.

#### REFERENCES

- Abbott, R.T. 1974. American seashells. 2<sup>nd</sup> ed. New York, Van Nostrand Reinhold Co. 663 p.
- Aliani, S. & Molcard, A. 2003. Hitch-hiking on floating marine debris: macrobenthic species in the Western Mediterranean Sea. *Hydrobiologia*, The Hague, 503: 59-67.
- Alvarez, F. & Celis, A. 2004. On the occurrence of *Conchoderma virgatum* and *Dosima fascicularis* (Cirripedia, Thoracica) on the sea snake, *Pelamis platurus* (Reptilia, Serpentes) in Jalisco, Mexico. *Crustaceana*, Leiden, 77 (6): 761-764.
- Amaral, A.C.Z. & Nonato, E.F. 1994. Anelídeos poliquetas da costa brasileira. 5. Pisionidae,

- Chrysopetalidae, Amphinomidae e Euphrosionidae. *Revista Brasileira de Zoologia*, São Paulo, 11 (2): 361-390.
- Badillo, F.J.; Aznar, F.J.; Tomás, J. & Raga, J.A. 2003. Epibiont fauna of *Caretta caretta* in the Spanish Mediterranean. p. 62-66. In: D. Margaritoulis & A. Demetropoulos (Eds.). Proceedings of the First Mediterranean Conference on Marine Turtles, Rome, 2001. Nicosia, Barcelona, Bern and Bonn Convention-CMS.
- Balakrishnan, K.P. 1969. Observations on the occurrence of *Conchoderma virgatum* (Spengler) (Cirripedia) on *Diadon hystrix* Linnaeus (Pisces). *Crustaceana*, Leiden, 16(2): 101-103.
- Barnard, K.H. 1924. Contributions to the Crustacean fauna of South Africa. 7. Cirripedia. *Annals of the South Africa Museum*, Cape Town, 20: 1-103.
- Bertelsen, E. & Ussing, H. 1936. Marine tropical animals carried to the Copenhagen Sydhavn on a ship from the Bermudas. *Videnskabelige Meddelelser fra Dansk Naturhistorisk Forening i København*, Copenhagen, 100: 237-245
- Broch, H.J. 1922. Papers from Dr. Th. Mortensen's Pacific Expedition 1914-1916. 10. Studies on Pacific cirripeds. *Videnskabelige Meddelelser fra Dansk Naturhistorisk Forening i København*, Copenhagen, 73: 215-358.
- Bugoni, L.; Krause, L.; Almeida, A.O. & Bueno, A.A.P. 2001. Commensal barnacles of sea turtles in Brazil. *Marine Turtle Newsletter*, Durham, (94): 7-8.
- Caine, E.A. & Baruch, B.W. 1986. Carapace epibionts of nesting loggerhead sea turtles: Atlantic coast of U.S.A. *Journal of Experimental Marine Biology and Ecology*, Amsterdam, 95 (1): 15-26.
- Celis, A.; Rodríguez-Almaráz, G. & Álvarez, F. 2007. Los cirripedios torácicos (Crustacea) de aguas someras de Tamaulipas, México. *Revista Mexicana de Biodiversidad*, Mexico, 78: 325- 337.
- Chace Jr, F.A. 1951. The oceanic crabs of the genera *Planes* and *Pachygrapsus*. *Proceedings of the United States National Museum*, 101: 65-103.
- Chapman, G. & Santler, J.E. 1955. Aspects of the fauna and flora of the Azores. V. Crustacea. *Annals and Magazine of Natural History*, ser. 12, London, 8: 371-376.
- Cheng, L. & Lewin, R.A. 1976. Goose barnacles (Cirripedia: Thoracica) on flotsam beach at La Jolla, California. *Fishery Bulletin*, Washington, 74: 212-217.
- Chilton, C. 1911. Crustacea. *Scientific Results New Zealand Government Trawling Expedition 1907. Records of the Canterbury Museum*, Christchurch, 1 (3): 285-312.
- Ciurea, J.; Monod, T. & Dinulesco, G. 1933. Presence d'un Cirripède operculé sur un poisson dulcequicole européen. *Bulletin de l'Institute Océanographique de Monaco*, Monaco, (615): 1-32
- Coston-Clements, L.; Settle, L.R.; Hoss D.E. & Cross, F.A. 1991. Utilization of the *Sargassum* habitat by marine invertebrates and vertebrates - a review. Springfield, NOAA Technical Memorandum NMFS-SEFSC-296. 32 p.
- Cranfield, H.J.; Gordon, D.P.; Willan, R.C.; Marshall, B.A.; Battershill, C.N.; Francis, M.P.; Nelson, W.A.; Glasby, C.J. & READ, G.B. 1998. Adventive marine species in New Zealand. National Institute of Water and Atmospheric Research- NIWA Technical Report, Wellington, (34): 1-48.
- Coutts, A.D.M. & Dodgshun, T.J. 2007. The nature and extent of organisms in vessel sea-chests: A protected mechanism for marine bioinvasions. *Marine Pollution Bulletin*, Oxford, 54: 875-886.
- Couture, J.Y. & Simard, N. 2007. Évaluation préliminaire des risques potentiels d'introduction d'espèces non indigènes dans les eaux de la côte est canadienne par l'intermédiaire des caissons de prises d'eau de mer des navires. *Mont-Joli, Rapport Manuscrit Canadien des Sciences Halieutiques et Aquatiques*, 2824. 33 p.

- Darwin, C.R. 1851. *A monograph on the Sub-Class Cirripedia, with figures of all the species. The lepadidae, or, pedunculated cirripedes*. London, Ray Society. 400p.
- Davidson, I.C.; Brown, C.W.; Systma, M.D. & Ruiz, G.M. 2009. The role of containerships as transfer mechanisms of marine biofouling species. *Biofouling*, Chur, 25 (7): 645–655.
- DeVantier, L.M. 1992. Rafting of tropical marine organisms on buoyant coralla. *Marine Ecology Progress Series*, Ameltinghausen, 86: 301-302.
- Edwards, A. & Lubbock, R. 1983. Marine zoogeography of Saint Paul's Rocks. *Journal of Biogeography*, Oxford, 10: 65-72.
- ERC. 2007. A synopsis of the literature on the turtle barnacles (Cirripedia: Balanomorpha: Coronuloidea) 1758-2007. *Epibiont Research Cooperative- ERC Special Publication*, s.l. 62 p.
- Evans, F. 1958. Growth and maturity of the barnacles *Lepas hillii* and *Lepas anatifera*. *Nature*, London, 182: 1245-1246.
- Farrapeira, C.M.R.; Melo, A.V.O.M.; Barbosa, D.F. & Silva, K.M.E. 2007. Ship hull fouling in the Port of Recife, Pernambuco. *Brazilian Journal of Oceanography*, São Paulo, 55 (3): 207-221.
- Ferreira, C.E.L.; Gonçalves, J.E.A. & Coutinho, R. 2006. Ship hulls and oil platforms as potential vectors to marine exotic introduction. *Journal of Coastal Research*, Fort Lauderdale, 39: 1340-1345.
- Foster, B.A. 1974. The barnacles of Fiji with observations on the ecology of barnacles on tropical shores. *Pacific Science*, Honolulu, 28 (1): 35-56.
- Foster, B.A. & Willan, R.C. 1979. Foreign barnacles transported to New Zealand on an oil platform. *New Zealand Journal of Marine & Freshwater Research*, Wellington, 13 (1):143-150.
- Frick, M.G.; Ross, A.; Williams, K.L.; Bolten, A.B.; Bjornal, K.A. & Martins, H.R. 2003. Epibiotic associates of oceanic-stage loggerhead turtles from the Southeastern North Atlantic. *Marine Turtle Newsletter*, Durham, (101): 18-20.
- Frick, M.G.; Williams, K.L. & Robinson, M. 1998. Epibionts associated with nesting loggerhead sea turtles (*Caretta caretta*) in Georgia, USA. *Herpetological Review*, Lawrence, 29 (4): 211-215.
- Galil, B.S. 2006. Shipping impacts on the biota of the Mediterranean Sea. p. 39–69. In: J. Davenport & J.L. Davenport (Eds.). *The ecology of transportation: Managing mobility for the environment*. The Netherlands, Springer.
- Gittings, S.R.; Dennis, G.D. & Harry, H.W. 1986. Annotated guide to the barnacles of the northern Gulf of Mexico. *Biological Oceanography*, New York, 402: 1-36.
- Godwin, L.S. 2003. Hull fouling of maritime vessels as a pathway for marine species invasions to the Hawaiian Islands. *Biofouling*, Chur, 19 (Suppl.): 123-131.
- Godwin, L.S.; Eldredge, L.G. & Gaut, K., 2004. The assessment of hull fouling as a mechanism for the introduction and dispersal of marine alien species in the main Hawaiian Islands. *Bishop Museum Technical Report*, Honolulu, (28): 1-122.
- Gollasch, S. 2002. The importance of ship hull fouling as a vector of species introductions into the North Sea. *Biofouling*, Chur, 18 (2): 105-121.
- Henry, D.P. 1940. Notes on some pedunculate barnacles from the North Pacific. *Proceedings of the United States National Museum*, Washington, 88: 225-236.
- Hinojosa, I.; Boltaña, S.; Lancellotti, D.; Macaya, E.; Ugalde, P.; Valdivia, N.; Vásquez, N.; Newman, W.A. & Thiel, M. 2006. Geographic distribution and description of four pelagic barnacles along the south east Pacific coast of Chile - a zoogeographical approximation. *Revista Chilena de Historia Natural*, Santiago, 79 (1): 13-27.
- Hobday, A.J. 2000. Persistence and transport of fauna on drifting kelp (*Macrocystis pyrifera*) (L.) C. Agardh) rafts in the southern California Bight. *Journal of Experimental Marine Biology and Ecology*, Amsterdam, 253 (1): 75-96.
- Holthuis, L.B. & Fransen, C.H.J.K. 2004. Interesting records of whale epizoic crustaceans from the Dutch North Sea coast (Cirripedia, Amphipoda).

- Nederlandse Faunistische Mededelingen, Leiden, 21: 11-16.
- Hopkins, C.C.E. 2002. Introduced marine organisms in Norwegian waters, including Svalbard. p. 240-252. In: E. Leppakoski; S. Gollasch & S. Olenin (eds.). Invasive aquatic species of Europe: Distribution, impacts and management. Dordrecht, Kluwer Academic Publishers.
- Horn, M.H.; Teal, J.M. & Backus, R.H. 1970. Petroleum lumps on the surface of the sea. Science, New York, 168: 245-246.
- Jennings, B.A. 1915. Pedunculate Cirripedia of New Zealand and neighbouring islands. Transactions and Proceedings of the Royal Society of New Zealand, Wellington, 47: 285-293.
- Jennings, B.A. 1918. Revision of the Cirripedia of New Zealand. Transactions of the Royal Society of New Zealand, Wellington, 50 (3): 56-63.
- Jerde, C.WI. 1970. Further notes on the distribution of *Portunus xantusii affinis* and *Euphyllax dovii* (Decapoda Brachyura, Portunidae) in the eastern tropical Pacific. Crustaceana, Leiden, 19 (1): 84-88.
- Jones, D.S. 1994. Barnacles (Cirripedia: Thoracica) of the Cocos (Keeling) Island. Atoll Research Bulletin, Washington, (413): 1-7.
- Jones, D.S.; Hewitt, M.A. & Sampey, A. 2000. A checklist of the Cirripedia of the South China Sea. The Raffles Bulletin of Zoology, Singapore, (Suppl. 8): 233-307.
- Jones, E.C.; Rothschild, B.J. & Shomura, R.S. 1968. Additional records of the pedunculate barnacle, *Conchoderma virgatum* (Spengler), on fishes. Crustaceana, Leiden, 14 (2): 193-196.
- Key, J.E. 1843. Zoology of the New York. Part. V. Mollusca. Albany, Carrol and Cook Printers. 378 p.
- Kitsos, M.-S.; Christodoulou, M.; Kalpakis, S.; Noidou, M. & Koukouras, A. 2003. Cirripedia Thoracica associated with *Caretta caretta* (Linnaeus, 1758) northern Aegean Sea. Crustaceana, Leiden, 76 (4): 403-409.
- Kitsos, M.-S.; Christodoulou, M.; Arvanitidis, c.; Mavidis, M.; Kirmizoglou, I. & Koukouras, A. 2005. Composition of the organismic assemblage associated with *Caretta caretta*. Journal of Experimental Marine Biology and Ecology, Cambridge, 85 (2): 257-261.
- Koukouras, A. & Matsa, A. 1998. The thoracican cirriped fauna of the Aegean Sea: New information, check list of the Mediterranean species, faunal comparisons. Senckenbergiana Maritima, Frankfurt, 28 (4/6): 133-142.
- Krüger, P. 1927. Cirripedia Thoracica der Dänischen Gewässer. Videnskabelige Meddelelser fra Dansk Naturhistorisk Forening i Kjöbenhavn, Copenhagen, 84: 11-16.
- Leung, T.Y. & Jones, D.S. 2000. Barnacles (Cirripedia: Thoracica) from epibenthic substrata in the shallow offshore waters of Hong Kong. p. 105-127. In: B. Morton (Ed.). The marine flora and fauna of Hong Kong and Southern China V. Hong Kong, Hong Kong University Press.
- Lewis, P.N.; Riddle, M.J. & Hewitt, C.L. 2004. Management of exogenous threats to Antarctica and the sub-Antarctic Islands: balancing risks from TBT and non-indigenous marine organisms. Marine Pollution Bulletin, Oxford, 49: 999-1005.
- Loreto, B.O. & Bondioli, A.C.V. 2008. Epibionts associated with green sea turtles (*Chelonia mydas*) from Cananéia, Southeast Brazil. Marine Turtle Newsletter, Durham, (122): 5-8.
- Minchin, D. 1996. Tar pellets and plastics as attachment surfaces for lepadid cirripeds in the North Atlantic Ocean. Marine Pollution Bulletin, Oxford, 32 (12): 855-859.
- Miranda, C.M.; Silva-Ribeiro, C.C. & Soto, J.M.R. 2004. Associação da lepa-de-orelha *Conchoderma auritum* (Linnaeus, 1767) (Crustacea, Cirripedia) com cabos de recepção, durante atividades de prospecção sísmica 3D. Associação Brasileira de Oceanografia, I Congresso Brasileiro de Oceanografia, Resumos. Itajaí. p. 150.
- Newman, W.A. 1972. Lepadids from the Caroline Islands (Cirripedia, Thoracica). Crustaceana, Leiden, 22 (1): 31-38.



- Nobre, A. 1903. Subsídios para o estudo da fauna marinha do Norte de Portugal. *Annaes de Sciencias Naturaes*, Porto, 8: 37-94.
- Otani, M.; Oumi, T.; Uwai, S.; Hanyuda, T.; Prabowo, R.E.; Yamaguchi, T. & Kawai, H. 2007. Occurrence and diversity of barnacles on international ships visiting Osaka Bay, Japan, and the risk of their introduction. *Biofouling*, Chur, 23: 277-286.
- Paiva, P.C.; Young, P.S. & Echeverría, C.A. 2007. Rocas Atoll, Brazil: A preliminary survey of the Crustacea and Polychaete fauna. *Arquivos do Museu Nacional*, Rio de Janeiro, 65 (3): 241-250.
- Patel, B. 1959. The influence of the temperature on the reproduction and moulting of *Lepas anatifera* L. under laboratory conditions. *Journal of the Marine Biological Association of the United Kingdom*, Cambridge, 38: 589-597.
- Pettibone, M.H. 1963. Marine polychaete worms of the New England region. 1. Families Aphroditidae through Trochochaetidae. *Bulletin of the United States National Museum*, Washington, 227: 1-356.
- Pfaller, J.B.; Bjorndal, K.A.; Reich, K.J.; Williams, K.L. & Frick, M.G. 2006. Distribution patterns of epibionts on the carapace of loggerhead turtles, *Caretta caretta*. *JMBA2 - Biodiversity Records*, Cambridge, 1 (e36): 1-4.
- Pfaller, J.B.; Frick, M.G.; Reich, K.J.; Williams, K.L. & Bjorndal, K.A. 2008. Carapace epibionts of loggerhead turtles (*Caretta caretta*) nesting at Canaveral National Seashore, Florida. *Journal of Natural History*, London, 42 (13-14): 1095-1102.
- Pilsbry, H.A. 1907. Cirripedia from the Pacific coast of North America. *Bulletin of the Bureau of Fisheries*, Washington, 26: 193-204.
- Pilsbry, H.A. 1916. The sessile barnacles (Cirripedia) contained in the collections of the U.S. National Museum; including a monograph of the American species. *Bulletin of the United States National Museum*, Washington, 93: 1-366.
- Rathbun, M.J. 1930. The cancrioid crabs of America of the families Euryalidae, Ponunidae, Atelecyclidae, Cancridae, and Xanthidae. *Bulletin of the United States National Museum*, Washington, 152: 1-609.
- Relini, G.; Montanari, M.; Mochella, P. & Siccardi, A. 2001. Macrofouling of an oceanographic buoy in the Ligurian Sea (Western Mediterranean). *University of Melbourne, X International Congress on Marine Corrosion and Fouling, Proceedings*. Melbourne, pp. 33-58.
- Riul, P.; Rodrigues, F.M.A.; Xavier-Filho, E.S.; Leonel, R.M.V. & Christoffersen, M.L. 2008. Macrocrustaceans from Ponta do Cabo Branco, João Pessoa, Paraíba, Brazil, the Easternmost point of South America. *Revista Nordestina de Biologia*, João Pessoa, 19 (1): 3-13.
- Roskell, J. 1969. A note on the ecology of *Conchoderma virgatum* (Spengler, 1790) (Cirripedia, Lepadomorpha). *Crustaceana*, Leiden, 16: 103-104.
- Ruiz, G.M.; Brown, C.; Smith, G.; Morrison, B.; Ockrassa, D. & Nekinaken, K. 2005. Analysis of biofouling organisms associated with the hulls of containerships arriving to the Port of Oakland: A pilot study. p.138-155. In: G. Ruiz & G. Smith (Eds.). *Biological study of container vessels at the Port of Oakland*. Oakland, The Port of Oakland.
- Silva, E.R. & Eugênio, W.S. 1998. Taxonomia e distribuição dos cirripédios da Ilha de São Luís - MA. *Universidade Federal do Maranhão*. São Luís, Monografia, 52 f.
- Skerman, T.M. 1960. Ship-fouling in New Zealand waters: a survey of marine fouling organisms of vessels of the coast and over-seas trade. *New Zealand Journal of Science*, Wellington, 3(4):620-648.
- Southward, A.J. 1975. Intertidal and shallow water Cirripedia of the Caribbean. *Studies on the Fauna of Curaçao and other Caribbean Islands*, Utrecht, 46 (150): 1-53.
- Soto, J.M.R. 2001. First record of a rabbit-eared barnacle, *Conchoderma auritum* (Linnaeus, 1767) (Crustacea, Cirripedia), on the teeth of the La Plata dolphin, *Pontoporia blainvillei* (Gervais & D'Orbigny, 1844) (Cetacea, Platanistoidea). *Mare Magnum, Balneário Camboriú*, 1 (2): 172-172.

- Spivak, E.D. & Bas, M.C. 1999. First finding of the pelagic crab *Planes marinus* (Decapoda: Grapsidae) in the southwestern Atlantic. *Journal of Crustacean Biology*, Woods Hole, 19 (1): 72-76.
- Stebbing, T.R.R. 1910. General catalogue of South African Crustacea. *Annals of the South Africa Museum, Cape Town*, 6 (4): 563-575.
- Stubbings, H.G. 1961. Campagne de La Calypso dans le Golfe de Guinée et aux îles Princes, São Tomé, Annobon (1956). II Cirripedia. *Annales de l'Institut Océanographique, Paris*, 39 (5): 179-192.
- Stubbings, H.G. 1963. Cirripedia of the tropical South Atlantic coast of Africa. In: *Expédition Océanographique Belge dans les eaux côtières Africaines de l'Atlantique Sud (1948-1949)-Résultats scientifiques*. Bruxelles: Institut Royal de Sciences Naturelles de Belgique, 3 (10): 3-39.
- Stubbings, H.G. 1967. The cirriped fauna of tropical West Africa. *Bulletin of the British Museum (Natural History)*, London, 15 (6): 229-319.
- Sumner, F.B.; Osburn, R.C. & Cole, L.J. 1913. A biological survey of the waters of Woods Hole and vicinity. Physical and zoological. *Bulletin of the Bureau of Fisheries, Washington*, 31: 11-218.
- Thiel, M. & Gutow, L. 2005. The ecology of rafting in the marine environment. II. The rafting organisms and community. *Oceanography and Marine Biology: An Annual Review, Aberdeen*, 43: 279-418.
- Utinomi, H. 1962. Studies on the Cirripedian fauna of Japan. VII. Thoracic cirripeds from Western Kyusyu. *Publications of the Seto Marine Biological Laboratory, Sirahama*, 10 (2): 211-239.
- Utinomi, H. 1968. Pelagic, shelf and shallow-water Cirripedia from the Indo-west Pacific. *Videnskabelige Meddelelser fra Dansk Naturhistorisk Forening I Kjöbenhavn, Copenhagen*, (131): 161-186.
- Van Syoc, R. 2009. Barnacles. p. 283-289. In: I.S. Wehrmann & J. Cortés (Eds.). *Marine biodiversity of Costa Rica, Central America*. New York, Springer.
- Visscher, J.P. 1928. Nature and extent of fouling on ships bottoms. *Bulletin of the United States Bureau of Fisheries, Washington*, 43: 193-252.
- Weisbord, N.E. 1979. Lepadomorph and Verrucomorph barnacles (Cirripedia) of Florida and adjacent waters, with an addendum on the Rhizocephala. *Bulletins of American Paleontology, Ithaca*, 76 (306): 1-156.
- Williams Jr., E.H. & Williams, L.B. 1986. The first association of *Conchoderma virgatum* (Spengler) (Cirripedia, Thoracica) with a eurypodid copepod in the mouth of a fish. *Galaxea, Nishihara*, 5 (2): 209-212.
- WHOI. 1952. Species recorded from fouling. p. 165-207. In: WHOI. *Marine fouling and its prevention*. Annapolis, Woods Hole Oceanographic Institution- WHOI.
- Winston, J.E.; Gregory, M.R. & Stevens, L.M. 1997. Encrusters, epibionts, and other biota associated with pelagic plastics: a review of biogeographical, environmental, and conservation issues. p. 81-97. In: J.M. Coe & D.B. Rogers (Eds.). *Marine debris: sources, impacts, and solutions*. New York, Springer.
- Wirtz, P.; Araújo, R. & Southward, A.J. 2006. Cirripedia of Madeira. *Helgoland Marine Research, Berlin*, 60 (3): 207-212.
- Wolff, W.J. 2005. Non-indigenous marine and estuarine species in The Netherlands. *Zoologische Mededeelingen, Leiden*, 79 (1): 1-116.
- Yamato, S.; Yusa Y. & Tanase, H. 1996. Distribution of two species of *Conchoderma* (Cirripedia: Thoracica) over the body of a sea snake, *Laticauda semifasciata* (Reinwardt), from the Kii Peninsula, southwestern Japan. *Publications of the Seto Marine Biological Laboratory, Sirahama*, 37 (3/6): 25-31.
- Yan, T.; Yan, W.-X.; Dong, Y.; Wang, H.-J.; Yan, Y. & Liang, G.-H. 2006. Marine fouling of offshore installations in the northern Beibu Gulf of China. *International Biodeterioration & Biodegradation, Barking*, 58 (2): 99-105.

- Young, P.S. 1990. Lepadomorph cirripeds from Brazilian coast. I: Families Lepadidae, Poecilasmatidae and Heteralepadidae. *Bulletin of Marine Science*, Miami, 47 (3): 641-655.
- Young, P.S. 2007. Cirripedia (Crustacea) from Rocas Atoll. *Arquivos do Museu Nacional*, Rio de Janeiro, 65(3): 251-257.
- Young, P.S. & Serejo, C. 2005. List of crustacean species recorded from the Abrolhos region (including the nearby coast) indicating habitat, range within Brazil, and general distribution. p. 137-156. In: G.F Dutra; G.R. Allen; T. Werner & S.A. McKenna (Ed.). *A rapid marine biodiversity assessment of the Abrolhos Bank, Bahia, Brazil*. Washington, Conservation International.
- Zullo, V.A. 1979. Marine flora and fauna of the northeastern United States, Arthropoda: Cirripedia. Silver Spring, NOAA Technical Report NMFS Circular 425. 29 p.
- Zvyagintsev, A.Y. 2000. Fouling of ocean-going shipping and its role in the spread of exotic species in the seas of the Far East. *Sessile Organisms*, Kitasato, 17 (1): 31-43