

## Reproductive Behavior in a Captive-Released Manatee (*Trichechus manatus manatus*) along the Northeastern Coast of Brazil and the Life History of Her First Calf Born in the Wild

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### Abstract

The West Indian manatee (*Trichechus manatus*) is an exclusively herbivorous aquatic mammal. Recently, the stranding of live-orphaned calves has been the main threat to the species in northeastern Brazil. Since 1989, the Brazilian Manatee Project (PPB) has recovered 52 calf carcasses, of which 44 were alive. In 1994, “Lua” and “Astro” were the first manatees released from captivity in Brazil, and they have been tracked using radio telemetry methods. During daily tracking bouts, Lua’s behavior and movement patterns were recorded, including reproductive behavior. On 17 December 2003, while she was in the Maracáipe Estuary, Lua gave birth to her first calf. Beginning on 18 December 2003, the mother/calf pair began repeated, tidally determined moves from the estuary used during high tides to the sandstone reefs used during low tides. Four days after the birth, an increase in motorized boat traffic in Maracáipe Estuary was observed. On 22 December, Lua and her calf moved to Serrambi Beach and remained outside the estuary in the reef area. On 25 December, the ninth day after the birth, Lua was sighted alone. On 26 December, the calf was found dead at Serrambi Beach. The place of birth supports the hypothesis that estuaries are birthing areas for manatees. The fact that Lua established her main fidelity site and gave birth in an area where manatees had previously been extirpated indicates a potential for reestablishing the species in its historical range via the rescue, rehabilitation, and reintroduction program developed by PPB. The calf’s death confirms the fragility of the species’ conservation. The last 44 live-orphaned calves seem to have been caused by habitat destruction and/or human disturbances within their habitat. The lack of effective coastal management programs, despite being mandated within the federal Environmental Protection Areas

established in the region, are factors that severely impair conservation of the Antillean manatee in Brazil.

**Key Words:** manatee, *Trichechus manatus manatus*, wild birth, reintroduction, radio-tracking, northeastern Brazil

### Introduction

The mammalian order Sirenia (sea cows) consists of two extant families: Dugongidae and Trichechidae, and only four extant species: the dugong (*Dugong dugon*) and three manatees (*Trichechus* spp.) (Husar, 1977, 1978a, 1978b, 1978c); all are listed as vulnerable to extinction by IUCN – The World Conservation Union (IUCN, 2003), and many populations are locally listed as threatened or endangered (Lefebvre et al., 2001). Dugongs inhabit the shallow coastal and island waters of the tropical and subtropical Indo-Pacific region (Marsh & Lefebvre, 1994). The family Trichechidae has three species: the African manatee (*Trichechus senegalensis*), which inhabits coastal and riverine waters of the African continent between Senegal and Angola; the Amazonian manatee (*Trichechus inunguis*), which is distributed within the river systems of the Amazonian basin, including Colombia, Peru, and Brazil; and the West Indian manatee (*Trichechus manatus*), which is the most widely distributed of the three trichechids and occurs in coastal marine habitats and river estuaries of Florida, Greater Antilles, Eastern Mexico, Central America, and northern and northeastern South America to the northeastern coast of Brazil (Reynolds & Odell, 1991; Domning, 1996; Sirenia Specialist Group, 1996; Berta & Sumich, 1999).

The West Indian manatee is a large, long-lived, and completely aquatic herbivorous mammal

(Lefebvre et al., 2001). It has been subdivided into two morphologically and geographically distinct populations, constituting two subspecies: the Florida manatee (*T. m. latirostris*) and the Antillean manatee (*T. m. manatus*) (Domning & Hayek, 1986).

Both subspecies are listed as vulnerable by the IUCN (Sirenia Specialist Group, 1996) due to estimated reduction of individuals and degradation of their habitat in areas where they are found (IUCN, 2004). Antillean manatees in Brazil have been listed in the *Official List of Endangered Species in Brazil* since 1989 (IBAMA, 1989; MMA, 2003). The Action Plan for the Aquatic Mammals of Brazil classifies the Antillean manatee as the most endangered aquatic mammal in the country (IBAMA, 1997a, 2001). Information that helped to establish this classification came mostly from the Brazilian Manatee Project/Projeto Peixe-Boi/IBAMA-FMA (PPB), which was established in 1980 by the Brazilian government.

The current population of the Antillean manatee in Brazil is estimated at less than 500 animals. The present distribution is discontinuous, with no manatees found in Espírito Santo, Bahia, nor the Sergipe States<sup>1</sup> (Lima et al., 1992; Lima, 1997; Luna, 2001). The first geographic gap in manatee occurrence covers some 200 km of coastline between Camaragibe Estuary/Alagoas and Recife Beach/Pernambuco, where no sightings have been recorded in more than 60 years (Lima, 1997).

After an extensive interview survey, which was conducted along the northern and northeastern coast of Brazil, the stranding of live-orphaned calves<sup>2</sup> was identified as the main threat to the species in northeastern Brazil, affecting their life cycle (Lima et al., 1992; Lima, 1997; Parente et al., 2004). Between 1981 and 2002, 74 manatee strandings were reported along the northeastern coast of Brazil, with 58% ( $n = 43$ ) live-stranded animals (Parente et al., 2004). During this period, all the live-stranded manatees were very young, typically newborn, dependent calves (Parente et al., 2004).

The high numbers of live-stranded dependent calves suggest that the main reason for manatee strandings along the northeastern Brazilian coast might be the result of the separation of the mothers from their calves. The degradation of estuarine areas due to the installation of shrimp and salt farms and the increase of anthropogenic activities (e.g., net fishing, tourism) may contribute to the stranding of orphaned calves by causing mother/calf pair separations and/or by the reduction of available sheltered habitats for calving and nursing (Lima, 1997; Parente et al., 2004).

In response to this threat and as a part of the Brazilian Manatee Recovery Plan, the Manatee Rescue and Rehabilitation Facility of the National Aquatic Mammals Center (CMA) was created. This facility is a specialized unit of IBAMA (Brazilian

Institute for the Environment and Renewable Natural Resources) and is located in Itamaracá Island, State of Pernambuco. Between 1989 and 2004, 44 live-orphaned calves were rescued between Maranhão (2.545° S, 44.316° W) and Alagoas (10.116° S, 36.000° W) States and transported to the Itamaracá facility. Rescued calves, after having been maintained in captivity for a minimum of two years, were prepared to be released back to the wild. Of all the orphaned calves rescued, 14 animals died, 19 are currently in captivity for rehabilitation, and 11 were released between 1994 and 2004 along the northeastern Brazilian coast.

The first release was undertaken in 1994 when two manatees, "Astro" and "Lua," were released at Paripueira Beach (9.466° S, 35.535° W) in Alagoas State (Lima & Castro, 1998). Both animals were radio-tagged during the release procedure and monitored through a tracking system composed of a satellite-monitored platform transmitter terminal (PTT) tag, very high frequency (VHF) radio-transmitter tags, and field observations made by trackers linked to a mobile-tracking unit (Lima et al., 1996, 2000).

The objectives of the paper were to (1) review the movement, reproductive behavior, and adaptation of the captive-released manatee Lua and (2) to present details on her first birthing, which occurred nine years after her release.

## Materials and Methods

### Animal Information

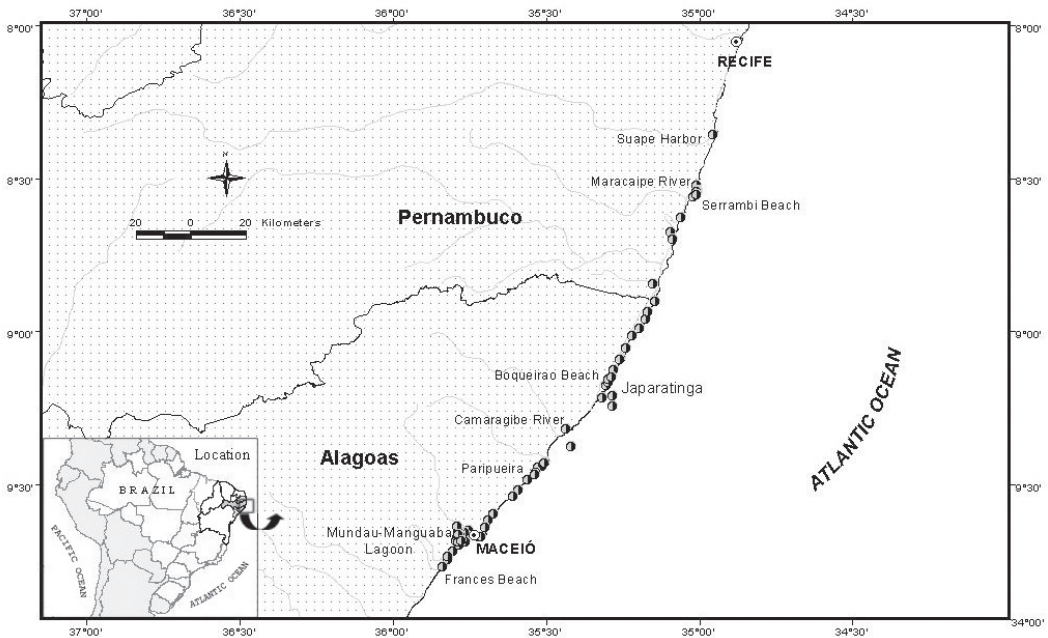
In February 1991, the female Antillean manatee, later named "Lua" (identification number 01S0112/4), stranded as an orphaned dependent calf (120 cm in length; 38.5 kg in weight) on the shores at Morro Branco (4.158° S, 38.125° W) on the eastern coast of Ceara State, Brazil. She had satisfactory rehabilitation and growth and was released at Paripueira Beach (Figure 1) after 3.5 years in captivity at 234 cm length and 293 kg weight. She has been tracked in the wild since December 1994. Nine years after her release, at 12 years of age, Lua gave birth to her first calf in the wild.

### Radio-Tag and Attachment System

Lua was radio-tagged on December 1994 at her release and was tracked along the northeastern coast

<sup>1</sup> The distribution and population estimation of the Antillean manatee in Brazil were determined through an extensive interview and survey along 5,000 km of coastal Brazil. Current stranding and sighting data collected by PPB have confirmed this information.

<sup>2</sup> *Orphaned* were defined as dependent calves that were stranded (mean of 155.7 cm in length; range of 109 to 245 cm in length) (Parente et al., 2004).



**Figure 1.** Locations of the female Lua between 1994 and 2003 along the northeastern coast of Brazil

of Brazil nearly continuously over a nine-year period (Lima et al., 2000, 2004). The tag assembly consisted of a floating housing containing the transmitter that was attached with a flexible nylon tether to an adjustable belt around the manatee's caudal peduncle.

Two types of radio tags were used during Lua's tracking. A satellite-monitored PTT, which permitted remote tracking through Service ARGOS, was used in the first year after her release. This radio-tag assembly consisted of a UHF (ultra-high frequency) ARGOS transmitter and an incorporated VHF transmitter, installed in a buoyant PVC housing. The most frequently used tag type, however, consisted of a floating housing, which contained only a conventional VHF radio-transmitter (Telonics, Inc., MOD 550) that emitted pulsed signals at specific frequencies in the 148-MHz band. With both tag designs, signals from the VHF radio-transmitter were used by trackers to locate and observe Lua in the field. The manatee's radio-tag and belt assembly system were adapted from the Florida manatee tag design (Reid et al., 1995; Deutsch et al., 1998, 2003; Lander et al., 2001), with some design changes in the floating housings for the VHF tags made by PPB.

#### *Radio-Tracking Methods and Behavior Monitoring*

Standard radio-tracking methods (Kenward, 1987; White & Garrot, 1990) were used to locate Lua and her calf in the field. Trackers homed in on the VHF signal using portable radio-receivers (Telonics, Inc., TR-4, 148/152 MHz) and directional "H" antennas

(Telonics, Inc., RA-2AK). Tracking was conducted from vehicles, boats, or bicycles. The daily tracking effort lasted a median of 7.2 h/day (max = 17.5 h). Field observations provided information on Lua's behavior, geographic position, reproductive status, human interactions, environmental conditions, tag condition, and other variables.

Behavior observations were recorded through focal animal sampling (Martin & Bateson, 1986) during time samplings of 15 min every hour. Behaviors were recorded continuously when social behavior or human interaction were observed; measurements included frequencies, durations, and times at which behavior patterns started or stopped. The social behaviors were assigned to one of three general categories: (1) socialize (nursing, "kissing," rubbing), (2) courtship activities (mounting, embracing, rolling, mating, penis exposing), and (3) agonistic contact (Hartman, 1979).

Lua was tracked before and after parturition. Two trained observers made focal followings every day after the calf was born and several days prior to parturition, during which they recorded aspects of her behavior, daily movements, human activities, and other information.

## **Results**

#### *Radio-Tracking Effort*

From 1994 through 2003, a total of 2,387 tracking days were recorded for Lua, with 17,253

observation hours. The median following effort was 75.1% of the days after the release (264 days/year), with a tracking efficiency of 84.8% (Lima et al., 2004). After the birth, Lua and her calf were sighted every day for eight days. On 25 December, nine days after the birth, Lua was seen alone, and the calf was not observed.

#### *Reproductive History*

Through this tracking system, it was possible to record Lua's movements while she travelled along 220 km of the coast (Figure 1), such as the social and reproductive behaviors between Lua and other manatees.

The first and longest interaction period occurred between December 1994 and October 1996 when Lua was accompanied by "Astro," a male manatee also released in 1994 (Lima & Castro, 1998). Also during this period, interactions with wild manatees were recorded in socialized behaviors. In May 1998, after two years apart, Astro and Lua met each other again in the Mundaú-Manguaba Lagoon, Maceió (Figure 1) and remained together for two months. During this time, trackers recorded socializing and courtship behaviors, which included copulation, but this did not result in pregnancy or calf production.

In August 2001, two male manatees were released in the proximity of Lua's main fidelity site, Japaratinga (Alvite et al., 2003). Over the next four months, Lua was seen socializing with these animals at Boqueirão Beach/Alagoas (9.146° S, 35.286° W), during which 24 social events were recorded, of which 70.8% ( $n = 17$ ) were courtship activities.

Between December 2002 and January 2003, Lua moved from her primary use area in Alagoas State to the southern coast of Pernambuco State. She made this move accompanied by an untagged manatee. During these movements, the PPB team recorded socializing behavior during four days at Suape Harbor/Pernambuco (8.355° S, 34.955° W) and Boqueirão Beach/Alagoas (Figure 1). They recorded 15 social events of which 86.6% ( $n = 13$ ) were courtship activities. After February 2003, the tracking team began observing different behaviors by Lua, who started to use preferentially calm and freshwater habitats in addition to avoiding human contact.

#### *Life History of the Calf*

In October 2003, PPB staff evidenced Lua's pregnancy by observation of the increasing girth and size of her vulva. Lua was sighted alone on 14 December and then on 17 December 2003 with her calf. The birth was not observed, but based on observations, we believe the birth occurred between 15 and 16 December 2003. This was the first calf

of a female Antillean manatee released into the wild in Brazil.<sup>3</sup> The calf was born inside a shallow lagoon at the small estuary of Maracaípe River/Pernambuco (8.525° S, 34.996° W) (Figure 1). This is a discontinuous area of the species distribution (Lima, 1997). This mother and calf pair was sighted every day for the next seven days. The calf was named "Maraca."

The tracking team observed maternal behaviors from Lua to the calf, including close bonding/contact between female and calf, synchronous surfacings, and apparent avoidance of human contact. Between 18 and 19 December 2003, the mother and calf pair began moving repeatedly from the Maracaípe Estuary during high tides to the sandstone reefs area in front of the river mouth during low tides.

On 20 December 2003, four days after the birth, the Maracaípe Estuary began receiving an increased flow of tourism due to the beginning of the summer season on the Brazilian northeastern coast. An increase in motorized boat traffic in Maracaípe Estuary was observed, going from zero on 17 December 2003 to 32 motorboats on 20 December 2003. Also, on 21 December, a huge party was recorded in the estuarine margins, with an increase of noise and music, which was not present before the birth.

On 22 December 2003, Lua and her calf moved to Serrambi Beach/Pernambuco (8.065° S, 35.00° W) and remained outside the estuary in the reef area.

On 25 December 2003, the ninth day after the birth, the calf was not seen, and Lua was sighted alone on Serrambi Beach (Figure 1), performing unusual behavior, traveling fast all day, and avoiding any human interaction.

On the morning of 26 December 2003, ten days after the birth, Maraca was found dead at Serrambi Beach and was immediately transported to the Aquatic Mammal Laboratory of CMA/IBAMA for necropsy procedures. Lua was sighted 300 m away from this beach in the reef area.

The calf was a female, 120 cm in length and 34 kg in weight, with several superficial scars scattered along the dorsal region, probably caused by contact with the reefs and some sunburn. In relation to the necropsy, it was not possible to define

<sup>3</sup> The PPB developed a Release Manatee Program as part of the Antillean Manatee Conservation Action Plan in Brazil. Between 1994 and 2004, 13 animals were released, and all of them were radio-tracked in the wild. Of these animals, four females were released: one female died; two lost their tracking assemblies; and Lua, the only female that has been monitored since her release, is still alive. For these reasons, Maraca was considered the first calf of a released female Antillean manatee in Brazil.



the cause of death due to the high autolysis state of the calf carcass.

### Discussion

The current population count of the Antillean manatee in Brazil is less than 500 animals, and the present distribution is discontinuous (Lima et al., 1992; Lima, 1997; Luna, 2001). The first gap in manatee distribution covers some 200 km of coastline between Camaragibe Estuary/Alagoas and Recife Beach/Pernambuco, where no sightings have been recorded in more than 60 years (Lima, 1997). This gap was chosen as the main manatee release site by PPB due to the critical status of the species in this area, and it is encompassed by the Federal Marine Protected Area Costa dos Corais (APA Costa dos Corais) (IBAMA, 1997b).

The rescue, rehabilitation, and reintroduction program of orphaned manatee calves has been carried out in agreement with IUCN guidelines for reintroductions and, thus, aims to reestablish the species in an area that was once part of its historical range but from which it has been extirpated (IUCN, 1998).

Since 1994, Lua has ranged along 220 km of the coast between Suape Harbor/Pernambuco and Francês Beach/Alagoas. She established three main fidelity sites: Paripueira, Mundaú-Manguaba Lagoon, and Japaratinga (Lima et al., 2004). Japaratinga had been used since 1997, and it is encompassed by the first gap in manatee distribution and by the protected area APA Costa dos Corais (IBAMA, 1997b). The fact that Lua resided here and was using habitat where manatees had previously been extirpated is a great result for the reintroduction program developed by PPB that aims to reestablish the species in this coast of Alagoas State and create a travel corridor between the isolated remaining groups.

In relation to the conservation status of the species in this coastal area of the country, an important result in connection with the success of the rescue, rehabilitation, and reintroduction program was obtained, reaching the maximum of response—the reproduction history of the first female released to the wild in Brazil and the production of a living calf in the wild. Although this occurred nine years after the female was released in the wild, acclimation of released manatees to natural habitats is critical and represents an adaptation learned after release.

The calf's birth inside the Maracápe Estuary confirms that estuaries are nurseries for the species (Hartman, 1979; Lima, 1997) and that reef areas and marine sea grass beds are associated environments that have importance to manatees in northeastern Brazil.

As mentioned, the stranding of live-orphaned calves has been identified as the main threat to the Antillean manatee in northeastern Brazil (Lima et al., 1992; Lima, 1997; Parente et al., 2004) and might be the result of the separation of mothers from their calves caused by loss of the manatees' estuarine habitats and human disturbances (IBAMA, 2001; Parente et al., 2004).

The calf's death confirms the fragility of this species' conservation along the northeastern coast of Brazil given that there have been 44 strandings of live-dependent calves in the last 15 years. This is the first information in Brazil associating manatee calves' mortality from mother/calf pair separation with loss of environmental manatee habitats. This result is particularly significant when it is considered that the southern limit of the Antillean manatee range appears to be determined by the loss of suitable habitats (Lefebvre et al., 2001) and that the south of Alagoas State in Brazil is the current southern limit of the species' range (Lima, 1997).

The absence of established coastal management programs by environmental state institutions, as well as the absence of the management plans of Federal Environmental Protection Areas established in Paraíba (IBAMA, 1993) and Alagoas/Pernambuco (IBAMA, 1997b) States to guarantee the accessibility of females and their calves to estuaries, makes the conservation efforts for the Antillean manatee even more arduous in the northeastern coastal area of Brazil. Implementation of such programs and conservation measures is vital to ensure the success of any further efforts to save the species from extinction.

Regarding proposed conservation action for Antillean manatees along the coastal areas of Brazil, we recommend the establishment of protected areas and restrictions on human activities within the Federal Environmental Protection Areas where it is known that manatees have a high rate of occurrence. Also, it is important to guarantee the radio-tracking effort of released females to monitor their reproductive behavior in the wild, which enables us to evaluate the success of the manatee reintroduction program.

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### Literature Cited

- Alvite, C. M. C., Lima, R. P., & Castro, D. F. (2003). Reintrodução dos Peixes-Bois “Araqueto” e “Boi-Voador” no litoral norte de Alagoas. In *Abstracts of the 14th Encontro de Zoologia do Nordeste* (p. 382).
- Berta, A., & Sumich, J. L. (1999). *Marine mammals: Evolutionary biology*. New York: Academic Press. 494 pp.
- Deutsch, C. J., Bonde, R. K., & Reid, J. P. (1998). Radio-tracking manatees from land and space: Tag design, implementation, and lessons learned from long-term study. *Marine Technology Society Journal*, 32(1), 18-29.
- Deutsch, C. J., Reid, J. P., Bonde, R. K., Easton, D. E., Kochman, H. I., & O’Shea, T. J. (2003). *Seasonal movements, migratory behavior, and site fidelity of West Indian manatees along the Atlantic coast of the United States* (Wildlife Monographs, No. 151). Bethesda, MD: The Wildlife Society. 77 pp.
- Domning, D. P. (1996). *Bibliography and index of the sirenia and desmotilylia: Smithsonian contributions to paleobiology* (No. 80). Washington, DC: Smithsonian Institution Press. 611 pp.
- Domning, D. P., & Hayek, L. A. C. (1986). Interspecific and intraspecific morphological variation in manatees (Sirenia: *Trichechus*). *Marine Mammal Science*, 2, 87-144.
- Hartman, D. S. (1979). *Ecology and behavior of the manatee (Trichechus manatus) in Florida* (America Society of Mammalogists Special Publication No. 5). Lawrence, KS: American Society of Mammalogists. 155 pp.
- Husar, S. L. (1977). *Trichechus inunguis*. *Mammalian Species*, 72, 1-4.
- Husar, S. L. (1978a). *Dugong dugon*. *Mammalian Species*, 88, 1-7.
- Husar, S. L. (1978b). *Trichechus senegalensis*. *Mammalian Species*, 89, 1-3.
- Husar, S. L. (1978c). *Trichechus manatus*. *Mammalian Species*, 93, 1-5.
- Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA). (1989). *Lista oficial das espécies da fauna Brasileira ameaçadas de extinção* (Portaria No. 1552, 19 December 1989). Available online: [www.ibama.gov.br/cma/legislacao.php?id\\_legislacao=31](http://www.ibama.gov.br/cma/legislacao.php?id_legislacao=31). Accessed: 9 August 2004.
- IBAMA. (1993). *Criação da Área de Proteção Ambiental da Barra do Rio Mamanguape no estado da Paraíba* (Decreto No. 924, 10 September 1993). Available online: [www.ibama.gov.br/cma/legislacao.php?id\\_legislacao=33](http://www.ibama.gov.br/cma/legislacao.php?id_legislacao=33). Accessed: 9 August 2004.
- IBAMA. (1997a). *Mamíferos aquáticos do Brasil: Plano de ação*. Brasil: Edições IBAMA. 79 pp.
- IBAMA. (1997b). *Criação da Área de Proteção Ambiental da Costa dos Corais nos estados de Alagoas e Pernambuco*. (Decreto de 23 October 1997). Available online: [www.ibama.gov.br/cma/legislacao.php?id\\_legislacao=35](http://www.ibama.gov.br/cma/legislacao.php?id_legislacao=35). Accessed: 9 August 2004.
- IBAMA. (2001). *Mamíferos aquáticos do Brasil: Plano de ação (Versão II)*. Brasil: Edições IBAMA. 96 pp.
- IUCN – The World Conservation Union. (1998). *Guidelines for re-introductions* (Prepared by the World Conservation Union – Species Survival Commission, Re-introduction Specialist Group). Gland, Switzerland and Cambridge, UK: Author. 10 pp.
- IUCN. (2003). *2003 IUCN red list of threatened species*. Available online: [www.redlist.org](http://www.redlist.org). Accessed: 13 July 2004.
- IUCN. (2004). *2004 IUCN red list of threatened species*. Available online: [www.redlist.org](http://www.redlist.org). Accessed: 4 May 2005.
- Kenward, R. (1987). Radio tracking. In *Wildlife radio tagging: Equipment, field techniques and data analysis* (pp. 115-150). London: Academic Press.
- Lander, M. E., Westgate, A. J., Bonde, R. K., & Murray, M. J. (2001). Tagging and tracking. In L. A. Dierauf & F. M. D. Gulland (Eds.), *CRC handbook of marine mammal medicine* (pp. 851-880). Boca Raton, FL: CRC Press.
- Lefebvre, L. W., Marmontel, M., Reid, J. P., Rathbun, G. B., & Domning, D. P. (2001). Status and biogeography of the West Indian manatee. In C. A. Woods & F. E. Sergile (Eds.), *Biogeography of the West Indies: Patterns and perspectives* (pp. 425-474). Boca Raton, FL: CRC Press.
- Lima, R. P. (1997). *Peixe-Boi marinho (Trichechus manatus): Distribuição, status de conservação e aspectos tradicionais ao longo do litoral nordeste do Brasil*. Master’s of Science thesis, Universidade Federal de Pernambuco, Recife.
- Lima, R. P., & Castro, D. F. (1998). Análise preliminar dos três anos da reintrodução de Astro e Lua (*Trichechus manatus*) no litoral do Brasil. In *Abstracts of the 8th Reunión de Trabajo de Especialistas en Mamíferos Acuáticos de América del Sur e 2nd Congreso da SOLAMAC* (p. 109).
- Lima, R. P., Reid, J., & Soavinski, R. (1996). Análise preliminar da utilização de radiotelemetria e telemetria satelital para conservação e manejo de sirênios no litoral nordeste do Brasil. In *Abstracts of the 7th Reunión de Trabajo de Especialistas en Mamíferos Acuáticos de América del Sur e 1st Congreso SOLAMAC* (p. 116).

- Lima, R. P., Castro, D. C., Vergara, J. E., & Alvite, C. M. C. (2000). Avaliação do sistema de monitoramento de Peixes-Bois marinhos (*Trichechus manatus*) reintroduzidos no litoral nordeste do Brasil. In *Abstracts of the 9th Reunión de Trabajo de Especialistas en Mamíferos Acuáticos de América del Sur e 3rd Congreso SOLAMAC* (pp. 72-73).
- Lima, R. P., Alvite, C. M. C., Castro, D. F., & Reid, J. P. (2004). Monitoring of the first manatees (*Trichechus manatus manatus*) released in the northeast coast of Brazil (1994-2003). In *Abstracts of the 11th Reunión de Trabajo de Especialistas en Mamíferos Acuáticos de América del Sur e 5th Congreso de la Sociedad Latinoamericana de Especialistas en Mamíferos Acuáticos* (pp. 81-85).
- Lima, R. P., Paludo, D., Silva, K. G., Soavinsk, R. J., & Oliveira, E. M. A. (1992). Distribuição, ocorrência e status de conservação do Peixe-Boi marinho (*Trichechus manatus*, Linnaeus, 1758) ao longo do litoral nordeste do Brasil. *Peixe-Boi: Coletânea de Trabalhos de Conservação e Pesquisa de Sirênios no Brasil, 1*, 47-72.
- Luna, F. O. (2001). *Distribuição, status de conservação e aspectos tradicionais do Peixe-Boi marinho (Trichechus manatus manatus) no litoral norte do Brasil*. Master's of Science thesis, Universidade Federal de Pernambuco, Recife.
- Marsh, H., & Lefebvre, L. W. (1994). Sirenian status and conservation efforts. *Aquatic Mammals*, 20(3), 155-170.
- Martin, P., & Bateson, P. F. (1986). Recording methods. In *Measuring behavior: An introductory guide* (pp. 48-69). Cambridge, UK: Cambridge University Press. 200 pp.
- Ministério do Meio Ambiente (MMA). (2003). *Lista oficial das espécies da fauna Brasileira ameaçadas de extinção* (Instrução Normativa No. 3, 27 May 2003). Available online: [www.ibama.gov.br/fauna/in\\_03MMA.doc](http://www.ibama.gov.br/fauna/in_03MMA.doc). Accessed: 3 May 2005.
- Parente, C. L., Vergara-Parente, J. E., & Lima, R. P. (2004). Strandings of Antillean manatees, *Trichechus manatus manatus*, in northeastern Brazil. *Latin American Journal of Aquatic Mammals*, 3(1), 69-75.
- Reid, J. P., Bonde, R. K., & O'Shea, T. J. (1995). Reproduction and mortality of radio-tagged and recognizable manatees on the Atlantic coast of Florida. In T. J. O'Shea, B. B. Ackerman, & H. F. Percival (Eds.), *Population biology of the Florida manatee* (Information and Technology Report 1) (pp. 171-191). Washington, DC: U.S. Department of the Interior, National Biological Service.
- Reynolds, J. E., III, & Odell, D. K. (1991). *Facts on file: Manatees and dugongs*. New York: Facts on File. 192 pp.
- Sirenia Specialist Group. (1996). *Trichechus manatus*. In IUCN (Ed.), *2003 IUCN red list of threatened species*. Available online: [www.redlist.org](http://www.redlist.org). Accessed: 13 July 2004.
- White, G. C., & Garrot, R. A. (1990). *Analysis of wildlife radio-tracking data*. San Diego: Academic Press. 383 pp.