Monitoring reintroduced Lear’s macaws (*Anodorhynchus leari*) in the Raso da Catarina, Bahia (Brazil)

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**RESUMO.** Soltura monitorada de araras-azuis-de-lear (*Anodorhynchus leari*, Bonaparte, 1856) no Raso da Catarina, Bahia, Brasil. Dois indivíduos de *Anodorhynchus leari*, encontrados ainda ninhegos, caídos do ninho em março de 2003 foram devidamente tratados e submetidos a um treinamento prévio em cativeiro, visando sua recondução à natureza. O treinamento envolveu exercício da musculatura de vôo, análise da capacidade de forrageamento e de aversão a predadores naturais e à presença humana. Utilizou-se a radiotelemetria convencional (VHF) como ferramenta para avaliação e monitoramento do processo de soltura. Os resultados demonstraram que as araras foram capazes de sobreviver por pelo menos 83 dias, alimentando-se na natureza e interagindo com indivíduos selvagens. A participação de moradores locais também foi de grande importância, contribuindo com valiosas informações sobre a localização dos indivíduos soltos. Contudo, considerando as características do ambiente de ocorrência da *A. leari* e a amplitude da sua distribuição natural, consideramos a radiotelemetria via satélite a modalidade mais adequada para o acompanhamento de indivíduos desta espécie. Apesar da iniciativa de recondução de apenas duas araras não ser passível de interpretação generalizada, em espécies com populações extremamente reduzidas, cada informação nova pode ser muito valiosa para as propostas de conservação.

**PALAVRAS-CHAVE.** radiotelemetria, Psittacidae, espécie ameaçada, Caatinga, soltura.

**ABSTRACT.** Two Lear’s Macaws (*Anodorhynchus leari*), which were rescued as nestlings from a nest in March, 2003, were treated and raised in captivity. A pre-release training program was established before their reintroduction to prepare their muscles through natural flights in a large cage, while simultaneously developing avoidance behaviors towards predators and human beings. While in captivity, their foraging capability was analyzed. Conventional (VHF) radiotelemetry was used to evaluate and monitor the release process and the post-release behavior of the birds. The macaws were able to survive in the wild for at least 83 days, being able to forage successfully and interact with wild *A. leari*. Local residents provided important information on their location after release. However, the kinds of habitat used and the long distances daily typically covered by the macaw suggest satellite-based tracking technology may be more effective for the gathering of data in future reintroduction experiments. The fact that only two individuals were reintroduced limits potential extrapolations on the utility of the approach for the conservation of the species. Despite these limitations, the study may contribute to the development of effective reintroduction procedures for this highly endangered species.

**KEY WORDS.** radiotelemetry, Psittacidae, endangered species, Caatinga, release.

**INTRODUCTION**

The monitoring of captive-reared animals released into the wild is essential for the understanding of their post-release behavior and the evaluation of the effectiveness of the release procedures adopted. This is especially important in the case of endangered species. Recent technological advances, in particular the miniaturization of electronic components, have provided the means for the systematic monitoring of animals in the wild with minimal interference in their behavior, activity patterns, and movements, by using remote sensing tools such as radiotelemetry (Kenward 2000, Lopes & Mantovani 2005, Hagen et al. 2006, Bernardo et al. 2011).

Lear’s Macaw, *Anodorhynchus leari* Bonaparte, 1856, is endemic to the Caatinga of the Brazilian state of Bahia, and is considered to be a critically endangered species on a local level (MMA 2003), and as endangered on a worldwide scale (BirdLife International 2013). The wild population of Lear’s Macaw has been estimated at 1000 individuals, and the principal threats to the species are habitat loss and illegal capture and trade, both domestic and international (Lugarini et al. 2012). The loss of feeding resources, in particular the fruits of the Licuri palm (*Syagrus coronata* (Mart.) Becc.), is considered to be one of the principal factors limiting the survival of the species (Brandt & Machado, 1990, Campos et al. 2012).

The management plan for Lear’s Macaw includes a recommendation for the experimental, monitored release of individuals into the wild at selected sites, in order to develop and perfect procedures for the eventual release of animals into their habitat (IBAMA 2006). The present study analyzes the results of the captive rearing and release of two *A. leari* rescued in March, 2003. These animals were found as 2-month old nestlings that had fallen from their nest on a sandstone cliff in the southern portion of the Raso da Catarina Ecological Station in Jeremoabo, Bahia (Brazil). The nestlings were examined and
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hand-reared, and then maintained in a natural enclosure in the vicinity of the rescue site, where they were in constant visual contact with wild bands of *A. leari*. The animals were then prepared physically and behaviorally for their release into the wild.

This was the first experimental release of the species into the wild, during which the animals were monitored by conventional VHF radiotelemetry. In Brazil, similar experiments have been conducted on other threatened psittacids, such as *Anodorhynchus hyacinthinus* (Seixas et al. 2002, Antas et al. 2010) and *Amazona pretrei* (Seixas et al. 2002), and near-threatened species, including *Triclaria malachitacea* (Bencke 1998) and *Primolius maracana* (Barros et al. 1998). Similar studies have also been conducted on other New World species, such as *Ara ambiguus* in Nicaragua and Costa Rica (Chassot & Arias 2002, 2012), *Amazona vittata* in Puerto Rico (Lindsey et al. 1994), and *Amazona barbadensis* in Venezuela (Sanz & Grajal 1998).

The present study analyzed the whole process and evaluated the effectiveness of the procedures adopted for the rearing of captive animals and their release into the wild.

**METHODS**

**Initial care of the nestlings** - following initial veterinary processing, which included the collection of blood specimens for DNA sexing (using the P2 and P8 primers and PCR amplification: Griffiths et al. 1998) and fecal samples for parasitological analyses, the nestlings were weighed, measured, and housed in a enclosure at a distance of approximately 8 km from the rescue site. During the study period, wild individuals of the same species were frequently observed foraging in the vicinity of the enclosure, providing interspecific interactions with the captive specimens.

The nestlings were initially fed on a paste containing the endosperm of licuri palm nuts, coconut milk, parrot food, a vitamin supplement (Stimovit), and fruit (papaya, banana). This paste was introduced directly into the animal’s beak at three-hour intervals throughout the day, and was gradually replaced by open licuri nuts and then entire licuri nuts of varying degrees of ripeness. Eventually other fruits consumed by *A. leari* in the wild, such as umbu (*Spondias tuberosa* L.), mucunã (*Dioclea* sp.) and baraúna, *Schinopsis brasiliensis* Engl. (Sick et al. 1987), and maize, *Zea mays* L. (Brandt & Machado 1990), were offered. The weight gain of the two individuals was recorded in detail during the first 7 months following their rescue.

**Pre-release preparations** - in November, 2003, the birds were transferred to a larger enclosure at the same site for flight training. The enclosure was 15 m long, 5 m wide and 6 m high (Fig. 1). An observation cabin was constructed next to the enclosure, allowing observations keepers and researchers to watch the macaws unseen during assessment and behavioral training. Access to the enclosure was through a tunnel. The birds were marked with standard CEMA VE bands (IBAMA 1994), numbered U54901 and U54902. The bands were painted with different colored enamels, permitting the differentiation of the individuals during observations.

Figure 1. Enclosure used for flight training, showing the access tunnel.
Evaluation of foraging ability - The licuri nuts were presented in natural bunches, which were wired to a licuri tree growing within the enclosure, in an attempt to simulate the fruiting of this palm in the wild, and thereby enabling the identification of this resource after the macaws’ release. The nuts were wired to the tree before dawn, in a quantity sufficient to feed the macaws during the course of the day.

The ability of the macaws to manipulate and process the licuri nuts was evaluated during the first 16 weeks following their rescue. The time spent by the individuals during each feeding event – corresponding to a single predation attempt, following Galetti (2002) – was recorded. Each event was classified as successful or unsuccessful. The duration of successful events was measured as the time elapsed between the retrieval of the fruit and the complete consumption of the solid endosperm. This process includes the manipulation of the fruit, the rupturing of the endocarp, and the processing of the endosperm. Feeding time was also estimated during the period prior to the release of the macaws into the wild, in April, 2007.

Response to the presence of natural predators - During the study period, A. leari was observed in the field for the identification of potential predators, providing a reference for the selection of the species to be used in the experimental trials. Based on this, the behavior of the macaws was analyzed in response to playback of the Black-chested Buzzard Eagle, Geranoaetus melanoleucus (Vieillot, 1819) vocalizations. This species was chosen because it is the only known predator of Lear’s macaw, as shown in the results of the present study. These vocalizations were broadcast from alternating sides of the enclosure, in an attempt to provoke a response from the macaws. These trials were conducted using an audio apparatus linked to loudspeakers located on opposite walls of the enclosure.

Training and evaluation of flight capacity - a 3-month training scheme was devised, which consisted of broadcasting A. leari vocalizations alternately from opposite sides of the enclosure, in an attempt to provoke repeated flights. This procedure aimed to improve the physical conditioning of the macaws. The performance of the macaws during this training period was evaluated every two weeks in six 5-minute sessions, with the day being chosen randomly. The data were analyzed for the assessment of the evolution of the birds’ flight capacity. For each evaluation, the total distance flown by the animal and the duration of this activity were calculated, as well as records of any additional behavioral variables considered to be relevant.

Response to the presence of human beings - given the initial contact with human beings during the captive rearing process, conditioning the birds to avoid humans was considered to be a necessary prerequisite for release. The conditioning was based on the anti-predator training procedure developed by Griffin et al. (2000). This procedure was developed using the principles of classical conditioning (Pavlov 1927), in which a primary stimulus is replaced by a secondary one. During this procedure, an Event that is Initially Insignificant (IIE) to the subject, such as the presence of a given species, is made to provoke a response by being paired with a Biologically Significant Event (BSE), which stimulates a positive or negative reaction in the subject. These events include access to food and loud noises, which provoke salivation and preventive behaviors (avoidance, attack), respectively. The training procedure is designed to replace the BSE with the IIE, so that after an adequate number of repetitions, the subject will present the behavior provoked by the BSE when presented only with the IIE.

Both macaws had had frequent contact with their keepers from the moment they were rescued, and were thus habituated to the presence of humans and conditioned to relate their presence (IIE) with provisioning (BSE). Given this, the objective of the training procedure was to weaken the “human-food” association, which was achieved by eliminating the presence of humans at feeding time.

To achieve this, a tunnel was constructed which allowed the keepers to enter the enclosure without being seen by the macaws. Before entering the enclosure, in addition, the keeper donned clothing that disguised the human form. Two months after these procedures were adopted, the training process was initiated. The procedure consisted of the association of the presence of humans with episodes designed to induce aversion or fear in the macaws.

Three training sessions were conducted at intervals of 15 days. During each session, a person (IIE) entered the enclosure in association with three negative stimuli – A. leari alarm vocalizations (BSE1), which were broadcast over the sound system, firecrackers (BSE2), and aggressive behavior (BSE3) such as screaming at the macaws and beating on the walls of the enclosure. Whenever possible, the session was conducted when wild macaws were in the proximity of the enclosure, thereby accentuating the effects of the negative stimuli on the behavior of the captive animals through the reaction of their wild counterparts.

Medical exams - blood samples and fecal specimens were collected for examination. Hemograms and biochemical tests were conducted on the blood samples for the assessment of the general health and condition of the animals, while PCR testing was employed to detect the possible presence of the following diseases – beak-and-feather disease (Circovirus), avian polyomavirus (APPV), Pacheco’s disease (PsHV), Newcastle disease (Paramixovirus), Chlamydophila psittaci, Salmonella sp., and avian tuberculosis (Mycobacterium tuberculosis and Mycobacterium avium complex). All analyses were conducted by the UNIGEN Laboratory in São Paulo, except for the tuberculosis testing, which was run at the Microbiology Laboratory of the University of São Paulo (USP).

Release - the release of the macaws was timed to
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Overlap with the period when licuri nuts are most abundant within the study region (Brandt & Machado 1990), which also coincides with the A. leari breeding season (IBAMA 2006). During the breeding season, the species tends to aggregate in the nesting area, which is close to the enclosure. This period was thus selected due to the greater probability of encountering dietary resources and conspecific individuals. The two macaws were released simultaneously, considering the possibility that they might not be able to integrate rapidly with other individuals in the wild.

Wild macaws were typically observed in the area surrounding the enclosure during the early part of the day, when they come from their roost to forage in this area. So, the morning was considered to be the most adequate period for the release, given the long daytime period available for the birds to explore their environment and for the research team to conduct the first day of monitoring. The enclosure doors were opened at 04:00 h on December 7th, 2007, allowing the macaws to exit spontaneously at first light. A “soft release” procedure (Seixas & Mourão 2000) was adopted, in which food and water is provided during the period following the release of the animals, to maximize their chances of survival in the wild. These provisions were presented on a platform located on top of the enclosure, and were offered once a day for the first four weeks, then every two days for the subsequent three weeks, and every three days for the last two weeks, after which, provisioning was suspended. Following the release, the enclosure was left open permanently.

Monitoring – was intensive during the first few months following the release of the macaws into the wild. This monitoring aimed to guarantee the safety of the two individuals, given that it would permit rapid intervention, if necessary. The birds’ movements were monitored using standard VHF radio transmitters with circuitry based on the design of Kenward (1987) and an external whip antenna, set in self-polymerizing resin (a mixture of beeswax and paraffin). Each animal was equipped with two transmitters, one attached to the tail (tail mount) and the other around the neck (radio collar). The RX-81 VHF receiver was equipped with a five-element unidirectional YAGI antenna. The total weight of the transmitter was restricted to less than 4% of the body weight of the birds (Brandt & Cochran 1969). The transmitters are designed to last approximately 180 days.

The monitoring was based on the homing-in technique (White & Garrott 1990), in which the observer moves in the direction of the strongest signal until the animal is located and can be observed directly with binoculars. Care is taken to ensure that the observer does not approach the macaws to within a distance that would modify their behavior. Following the initial monitoring period, the birds were tracked once a week until the signal was lost.

During each sighting, the date, time of contact, and behavior of the animal when sighted (if possible) were recorded. The location of the animal when sighted was recorded as accurately as possibly using a Garmin Etrex GPS for subsequent mapping of the birds’ movements. Following the development of defects in the radio receptor, which was rendered inoperative, observations were conducted using binoculars (Bushnell 10 x 42 mm) and a telescope (Nikon 16-48 x 60 mm), focalizing on the radio collars and leg bands for the identification of the individuals. Local residents were also consulted for possible information on the released macaws.

RESULTS

The sexing of the animals revealed that one was female – marked with band number U54901 – and the other, male (band number U54902). When they were rescued, on 22/03/2003, each nestling weighed 525 g. After they were transferred to the first enclosure, manual feeding was gradually reduced in frequency, while an increasing number of whole licuri nuts were offered. During the evaluation of the birds’ foraging capacity, manipulation time for the consumption of licuri nuts decreased progressively (Fig. 2). The licuri nuts were always preferred (98%) over the other foods offered, such as parrot food and fruit, with the birds obtaining the nuts either directly from the tree or from the ground, as observed in wild A. leari.

Figure 2. Time spent processing (peeling and breaking open) and ingesting the endosperm of licuri nuts by the two captive macaws during the first 16 weeks following their rescue from the wild. (a) = female; (b) = male.
On August 10th, the female weighed 750g and the male, 725g. By April, 2007, both individuals had reached the typical body weight of wild adult *A. leari*, that is, 850g for the female and 800g for the male (Sick, 1997), and remained at this weight until their release. By the time of their release, the macaws were able to open and consume a licuri nut completely in an average of 49 seconds, and ingested 30 nuts in 30 minutes, a feeding rate 50% lower than that of wild *A. leari*. This may reflect either the lack of competition or the reduced energetic needs of the captive animals.

A number of potential predators of *A. leari* were observed during the course of the study. When they were in the enclosures, both macaws presented agonistic behavior (emitting alert vocalizations and crouching) every time they heard the calls of raptors, Burrowing Owls, *Athene unicollaris* (Molina, 1782), and domestic dogs (A. C. Menezes pers. comm.). During the 2005/2006 breeding season, a Black Vulture, *Coragyps atratus* (Bechstein, 1793), was observed entering an active *A. leari* nest in the roosting area, which was subsequently abandoned by the pair of macaws, indicating the possible competition for nest cavities or the predation of eggs and/or nestlings (A. C. A. Amaral pers. comm.). During the 2009/2010 breeding season, a Black-chested Buzzard Eagle (*G. melanoleucus*) was observed capturing a fledgling *A. leari* as it left its nest on its first flight (Lugarini et al., 2012). This is the first recorded predation of *A. leari* in the wild.

Three distinct types of vocalization were recorded during the captive study – communication between the two captive macaws (38%), communication between the captive and the wild macaws (27%), and alarm calls (41%). This confirmed the occurrence of interactions between the captive birds and the wild *A. leari* that forage and rest in the vicinity of the captive enclosure.

During the tests involving the playbacks of *G. melanoleucus* calls, the captive macaws presented typical antipredator behavior, emitting alarm calls and flying in the opposite direction from the loudspeakers. This behavior declined in intensity as the calls continued, until the macaws eventually perched in the center of the enclosure, generally after a few minutes.

The flight training did not result in any significant difference in the time spent flying over the course of the study period. The captive macaws typically perched in the center of the enclosure after a few minutes of flying, apparently used to the calls of their own species in the vicinity of the cage. The lack of progress in this activity led to its cancellation after six sessions. No stress-related behavior was observed during the study period.

During the negative conditioning towards humans, a marked change was observed in the behavior of the captive macaws, which began to act incisively when confronted with the presence of people, emitting alarm calls and flying around the enclosure.

The results of the blood tests (hemogram and biochemical analyses) were normal for psittacids, and the fecal exams were negative for all the diseases tested.

On the afternoon prior to release, the female macaw destroyed its tail-mounted transmitter, leaving only the male with a transmitter, which was mounted on a radio collar (Fig. 3). When the enclosure was opened, the two animals moved out onto the roof, where they remained for a few minutes. They then flew away in opposite directions, following different bands of wild macaws. As it was no longer possible to monitor the female, only the male was monitored subsequently by radiotelemetry. However, the female was recognized by the monitoring team through its tarsal band when it joined the male at the end of the morning. The two animals then remained together until the last sighting of the day, although they separated again the following day. The male returned to the enclosure on the following day, while the female was only seen again on the eighth day following its release, when local residents reported a macaw with tame behavior.

The male presented marked social behavior during the first few days after release (Tab. 1), when it accompanied bands of *A. leari* that approached the area of the enclosure, although it soon returned to the enclosure. This individual flew increasingly greater distances over longer periods of time, moving a distance of approximately 7 km on the tenth day of monitoring (Fig. 4). Following its morning flights, it would typically come to perch on or in the enclosure, before going on to forage with groups of wild *A. leari* within the neighboring area. This behavior continued until the 16th day after the release.

On alternating days, bunches of licuri fruits were placed in licuri palms visited frequently by wild *A. leari* in the vicinity of the enclosure. On these occasions, the wild macaws would allow the male to feed alongside them, resulting in social interactions, such as feather preening and agonistic interactions.

Prior to their release, the captive macaws presented feeding behavior similar to that of their wild counterparts, but requiring more time to process and ingest the licuri nuts. Following its release, however, the male was observed imitating the behavior of the wild animals, and presented a pattern of feeding behavior similar to that described by Brandt & Machado (1990) for wild macaws.

On the 35th day after release, the female macaw was captured by a resident of the Água Branca settlement, located approximately 10 km from the enclosure, and was returned to the enclosure by the monitoring team. This was the last occasion on which the two macaws were observed together at the enclosure – they were perched on the roof – following their release.

On February 28th, 2008, 83 days after the release, one of the local collaborators, José Reis Silva dos Santos (Seu Dedé), observed both macaws near Água Branca. The two animals were recognized by their relatively tame behavior, and the leg bands and radio collar. On the following day, the signal was lost from the male’s transmitter due to a problem with the receiver. From this moment onward, monitoring of the released macaws was based on weekly searches using binoculars and a telescope. An attempt was made to locate macaws with leg bands or a radio collar.

Local residents were also interviewed regularly in order to gather information on the possible whereabouts of the animals. On the 141st day after release, a possible sighting of the two macaws was reported from one of the local communities. However, as the report did not refer specifically to the leg bands or radio collar, it cannot be considered reliable.
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Figure 3. Male *A. leari* with radio collar used for monitoring.

Table I. Main events recorded following the release of the male macaw (monitored by radio tracking).

<table>
<thead>
<tr>
<th>Day</th>
<th>Flying</th>
<th>Minimum distance flown</th>
<th>Feeding</th>
<th>Returned to the enclosure</th>
<th>Social interaction with wild macaws</th>
<th>Radio signal received</th>
<th>Sighted by the project monitors</th>
<th>Sighted by local residents</th>
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DISCUSSION

The release of animals into the wild can be an important component of the management of populations of endangered species, despite the economic costs and the potential risks for the individuals involved (Griffin et al. 2000, Sanz & Grajal 1998, Seixas et al. 2002, Wanatal & Silveira 2000). However, psittacids are behaviorally versatile, which allows them to adapt to novel conditions, especially when they are wild-caught, and are fed adequately (Sanz & Grajal 1998, Lima & Santos 2005).

The initial care of the nestlings proved effective both in terms of their gain in body weight and their increasing ability to process and consume the endosperm of licuri nuts. The fact that these macaws were born in the wild and were able to interact with other members of their species, either during the short time they spent in the nest or the longer period they were in the enclosure, may have been important for the success of this experiment. Wanatal & Silveira (2000) concluded that reintroduction programs tend to be more successful when the birds are wild-born, in comparison with those in which the animals were born, raised or have spent some time in captivity.

The results of the study of Brandt & Machado (1990) were used to establish a threshold for the evaluation of the captive macaws’ ability to process licuri nuts prior to their release. In the wild, Lear’s macaws take a mean of 25 seconds to open a licuri nut and extract the endosperm, and consume 350 nuts per day, on average, primarily in the early morning and late afternoon. The less efficient feeding behavior of the captive macaws may be the result of the development of distinct behavioral abilities in captivity. Among other factors, captive animals have more time available to process their food, given that the resource is available continuously, and there is no competition from other macaws or any threat from potential predators. This may allow the animal to engage in alternative activities before or even during the feeding event. However, the ability of these animals to feed efficiently on licuri nuts would be expected to have increased following contact with wild macaws, when they would have to dispute access to the resource and feed quickly enough to ensure the possibility of accompanying the wild macaws as they moved on.

The agonistic reaction of the macaws towards raptor and dog vocalizations suggests that they may have learned the behavior from their parents while still in the nest, or by observing the wild macaws in the area surrounding the enclosure, when they reacted to the presence of potential predators or even an attempted attack. Adequate anti-predator behavior may be
especially important for the reintroduced macaws, particularly when they are raising their own young and need to “teach” them appropriate behaviors. However, it is hoped that, before they breed, these individuals will have developed adequate anti-predator behavior through their contact with wild macaws. While this may be an important factor, it is necessary to consider all the other behaviors that are essential to guarantee the success of the release, such as social interactions, foraging techniques, and the ability to identify adequate nesting cavities.

The dimensions of the enclosure limited the development of the birds’ flight capacity. Following their release, however, it was possible to confirm that the macaws were able to perfect their technique, flying increasingly longer distances, reaching 7 km on the tenth day after their release, although this is a relatively modest trajectory in comparison with those of wild macaws. Araújo & Scherer-Neto (1997) estimated that wild macaws travel between 25 km and 170 km a day between their nightly roost and feeding grounds. However, these macaws generally travel the longest distances during the dry season, when the flocks range widely in search of feeding resources (Lugarini et al. 2012). During the breeding season, the macaws tend to travel shorter distances, and most of the population is concentrated in the region of Serra Branca, in the municipality of Jeremoabo, where large numbers of tree holes can be found in close proximity to feeding patches (Menezes et al. 2006). In the present study, the two macaws were released during this period, when food is abundant and the animals do not have to range widely to forage.

Despite the apparent aversion to the presence of human beings observed during the training sessions, most conditioning procedures are known to be effective after only one or two sessions (Griffin et al., 2000), whereas continued trials may eventually result in habituation and thus the neutralization or reversal of the expected results. When the female was recaptured, no biometric data were collected and the general condition of the animal was not evaluated, which impedes the reliable assessment of the factors that contributed to its vulnerability to capture, whether through inadequate behavioral conditioning and/or the loss of its physical strength.

Birds destined for reintroduction should be in the best possible physical condition in order to guarantee their chances of survival in the release area (Wantal & Silveira, 2000). In the present study, the medical exams indicated that both birds were in good health prior to their release.

While conventional radiotelemetry is probably adequate for the post-release monitoring of these macaws, a number of limitations were encountered during the present study, due not only to the failure of the equipment, but also the characteristics of the study area. In particular, the region inhabited by the species, especially its roosts and breeding sites, which are often located in sandstone cliffs, is an unfavorable environment for the transmission of radio waves, and thus requires relatively powerful transmitters (Jacob & Rudran, 2006).

Given these characteristics of the species’ natural habitat and the long distances travelled each day by the macaws, satellite-based tracking technology would appear to be more appropriate for the reliable monitoring of A. leari in the wild. While conventional radiotelemetry provided some good results, the characteristics of the species and the habitats it occupies demands the careful consideration of monitoring options.

As an endangered species, the development of reliable and effective procedures for the release of captive A. leari may be a vitally important component of a long-term conservation and management program. In particular, the successful reintroduction of individuals may compensate for the eventual reduction of population numbers in the wild. The continual testing and refinement of release procedures will thus be essential for the development of a reliable conservation tool. These techniques will also be important for the recuperation of populations in other areas, such as Boqueirão da Onça, in the Bahian municipalities of Campo Formoso and Sento Sê, where the species has been driven to the point of extinction (only two macaws survive in the present day) by anthropogenic pressures (Lugarini et al. 2012).

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