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The Golden lion tamarin *Leontopithecus rosalia*: a conservation success story

M. C. M. KIERULFF[1,2], C. R. RUIZ-MIRANDA[3], P. PROCÓPIO DE OLIVEIRA[2], B. B. BECK[4], A. MARTINS[5], J. M. DIETZ[6], D. M. RAMBALDI[7] & A. J. BAKER[8]

[1]*Departamento de Ciências Agrárias e Biológicas, Centro Universitário Norte do Espírito Santo, Universidade Federal do Espírito Santo, Rodovia BR 101, São Mateus, ES, 29932-540, Brazil,* [2]*Instituto Pri-Matas para a Conservação da Biodiversidade, Rua Guanhães 565 Apto 301, Colégio Batista, Belo Horizonte, MG, 31.110-160, Brazil,* [3]*Laboratório de Ciências Ambientais, Universidade Estadual do Norte Fluminense, Av. Alberto Lamego 2000, Campos dos Goytacazes, R.J. 28103-602, Brazil,* [4]*Great Ape Trust of Iowa, 4200 S.E. 44th Avenue, Des Moines, Iowa 50320, USA,* [5]*Associação-Mico-Leão-Dourado, Caixa Postal 109.968, Casimiro de Abreu, RJ, 28960-970, Brazil,* [6]*Department of Biology, University of Maryland, College Park, Maryland 20742, USA,* [7]*Instituto Estadual do Ambiente – RJ, Avenida Venezuela 110, Centro, RJ, 20081-312, Brazil, and* [8]*Philadelphia Zoo, 3400 West Girard Avenue, Philadelphia, Pennsylvania 19104-1196, USA*
E-mail: kierulff@terra.com.br

In 1960, the Golden lion tamarin *Leontopithecus rosalia* was almost extinct in the wild and the captive population, with poor reproduction and survival, was not well established. In the 1970s, after many improvements, the captive population began to grow and the Poço das Antas Biological Reserve was created to protect the species. In the 1980s, long-term research was begun on the demography and socio-ecology of the Golden lion tamarins, along with community environmental education and a reintroduction programme of captive-born animals (initially in the reserve, later in neighbouring private forests). About 30 zoos contributed the 146 captive-born reintroduced tamarins, and provided information on social behaviour, nutrition and health that was critical to developing reintroduction strategies. In 1994, threatened groups isolated in small fragments were rescued and translocated to a protected forest. Both programmes have been successful as measured by survival and reproduction after release, and both techniques have established growing populations. Although new threats (introduction of exotic primates) continue to challenge our efforts to preserve the species, there is no doubt of the success of almost 30 years of the Golden Lion Tamarin Conservation Programme.

Key-words: conservation; ecology; Golden lion tamarin; Golden Lion Tamarin Conservation Programme history; management.

HISTORY

The Golden lion tamarin *Leontopithecus rosalia* is endemic to the lowland Atlantic Forest of the state of Rio de Janeiro, the second most populous state of Brazil. Since the arrival of the first Portuguese in the 16th century, the Atlantic Forest has been destroyed and converted to urban centres, cattle pasture, farmland and plantation forestry, and the Golden lion tamarin now survives only in small forest fragments in a fraction of its original range.

Adelmar F. Coimbra-Filho (1965, 1969) was the first to call attention to the dramatic situation of the Golden lion tamarin. In the early 1960s, he travelled to many of the municipalities of the state of Guanabara (now Rio de Janeiro) in search of remnant populations, and witnessed the destruction of the forests and the drastic reduction of the habitat for the species (Rylands *et al*., 2002). Hunting also contributed to the near extinction of the species in the wild, and between

1960 and 1965 *c.* 300 Golden lion tamarins were captured for trade each year (Coimbra-Filho & Mittermeier, 1977).

In 1964, Alceo Magnanini and A. F. Coimbra-Filho outlined the threatened status of numerous vertebrate species in Brazil, and their work formed the basis for Brazil's first list of threatened species, which included the lion tamarins (Coimbra-Filho, 1972). The Brazilian Fauna Protection Law of 1967, along with the Brazilian Official List of Species Threatened with Extinction, forbade the capture, hunting, purchase, sale and exportation of threatened species and any products made from them. In 1969, the US Rare and Endangered Species Act effectively prevented the acquisition of lion tamarins by zoos in the United States, helping to end the importation of this species.

Until 1970, the reproductive trends of the captive Golden lion tamarin population were dismal – population growth was minimal and the survivorship of adults and young remained poor (Ballou *et al*., 2002). In 1972, a conference entitled 'Saving the Lion Marmoset' was held at the Smithsonian National Zoological Park, Washington, DC, USA (Bridgwater, 1972). It brought together 28 European, American and Brazilian biologists, who reviewed the available data on lion tamarins and other callitrichids. Long-term recommendations for research and conservation activities resulted, including studies of breeding biology, protocols for captive husbandry and management, and medical programmes, and a studbook and data bank were set up to record all aspects of the captive propagation of the species. At that time, Devra Kleiman of the Smithsonian National Zoo assumed the coordination of the captive Golden lion tamarin population, and the numbers rapidly increased from *c.* 70 to a controlled 500 (Kleiman, 1977a,b; Ballou *et al*., 2002). The factor that probably contributed most to this success was the finding that the mating system of Golden lion tamarin was unlike that of other primates: monogamy with cooperative breeding and reproductive suppression of subordinate ♀♀ (Kleiman, 1977c).

Through the efforts of Magnanini and Coimbra-Filho, in 1974 the Poço das Antas Biological Reserve was created, the first Biological Reserve in Brazil and the first protected area for Golden lion tamarins. In 1982, Green (unpubl.) estimated that 2000 ha of the then 5500 ha Poço das Antas reserve was forested, with only *c.* 500 ha of mature forest. In 1981, the Golden Lion Tamarin Conservation Programme (GLTCP), established by Devra Kleiman and colleagues, held its first negotiations with the Brazilian Forestry Development Institute [Instituto Brasileiro de Desenvolvimento Florestal (IBDF), now the Instituto Chico Mendes (ICMBio)] to initiate long-term research and conservation measures in the reserve. Research on the demography and socio-ecology of the Golden lion tamarins, a reintroduction programme (for captive-born animals from about 30 zoos in North America and Europe as well as the Rio de Janeiro Primate Center or wild-born animals that had spent part of their lives in captivity), initially in the reserve but later in neighbouring private forests, and a community environmental-education programme began in 1983.

The International Committee for Conservation and Management of the Lion Tamarins (ICCM) was created in 1981. The ICCM comprises Brazilian and international researchers and institutions involved with lion tamarin biology and conservation, including representatives of non-governmental organizations (NGOs), zoos and Brazilian environmental agencies. The Committee reviews proposals, assesses progress and makes recommendations to Brazilian managers from the Brazilian Environment Institute [Instituto Brasileiro do Meio Ambiente (IBAMA); successor to IBDF] and ICMBio (which has ultimate decision-making authority) regarding research and conservation activities for captive and wild populations (Rambaldi *et al*., 2002). This was the first time that such a committee was implemented to deal with Brazilian fauna. The success of the ICCM led to the implementation by IBAMA of committees for other threatened primates (*Cebus* and *Brachyteles*), carnivores and birds.

A survey of the forests throughout the original known range of the species was carried out in 1991 (Kierulff & Oliveira, 1996; Kierulff & Rylands, 2003). In all, 272 Golden lion tamarins in 55 groups were found outside the reserve, occupying 77 km^2. Of these, 213 (78%) were in four areas of 5–45 km^2, and the remaining 60 were in 12 groups in small secondary forest fragments of 0.2–2 km^2. In 1994, six of the threatened groups found were captured and translocated to a forest of 240 km^2 on the Fazenda União, just north of Poço das Antas. In 1998, União was transformed into a Biological Reserve.

In 1992, the Golden Lion Tamarin Association [Associação Mico-Leão-Dourado (AMLD)] was created to administer the GLTCP. The AMLD had the stated aim of protecting biodiversity in the Atlantic Forest of the lowlands in northern Rio de Janeiro, with the Golden lion tamarin as the flagship species (Rambaldi *et al*., 2002). The NGO has been instrumental in developing conservation awareness in the region, mainstreaming the conservation agenda in watershed management, recruiting local landowners for the lion tamarin reintroductions, maintaining conservation-education programmes and developing a model landscape approach to connect the lion tamarin populations. The AMLD also deals with threat reduction; for example, reducing poaching and hunting and habitat destruction, and controlling invasive introduced marmosets.

ECOLOGY

The Golden lion tamarin weighs 500–700 g (Hershkovitz, 1977). The pelage is long and silky, and the face is almost bare, surrounded by a mane derived from long hairs on the crown, cheeks and throat that obscure the ears. Its original distribution was the lowland coastal region of the state of Rio de Janeiro below 300 m altitude (Coimbra-Filho, 1969). It inhabits swamp and lowland forest, and uses hillside forest less (Kierulff, Raboy *et al*., 2002). Today, wild populations are restricted to forest fragments in four municipalities (Kierulff & Rylands, 2003; Ruiz-Miranda *et al*., 2008). The largest population (estimated at 385 individuals; Ruiz-Miranda *et al*., 2008) is in Poço das Antas Biological Reserve (68.4 km^2) in the municipality of Silva Jardim.

Lion tamarins live in groups typically composed of a breeding pair and their offspring of up to 3 years old. In Poço das Antas, group size varies from two to 11 (average 5.4 ± 2.0: Dietz & Baker, 1993). The groups defend territories of 0.45–2.29 km^2 using calls and agonistic behaviour. Their sleeping sites consist primarily of tree holes that are often reused, and occasionally vine tangles, palm crowns and bamboo thickets. Reproduction is seasonal, with births from September through March, peaking in October and February (Coimbra-Filho & Maia, 1979; Dietz *et al*., 1994). In Poço das Antas, ten of the 32 reproductive ♀♀ recorded over a 10 year period produced two litters per year at least once, and in 128 documented parturitions, 27 were singletons, 100 were twins and one litter had triplets (Dietz *et al*., 1994).

All group members help to carry and care for the offspring. The predominant system is monogamy, with alpha ♀♀ suppressing ovulation in subordinate daughters (Abbott *et al*., 1993; French & Schaffner, 2000). Polyandry and polygyny have also been documented in the wild (Baker *et al*., 2002). Males and ♀♀ disperse, and most Golden lion tamarins emigrate from their natal groups in young adulthood; ♂♂ tend to disperse with a ♂ relative, usually a sibling, while ♀♀ tend to disperse alone (Baker *et al*., 2002).

Lion tamarins are fauni-frugivores (Kierulff, Raboy *et al*., 2002) and have long, slender arms and elongated fingers to exploit microhabitats when searching for animal prey (Coimbra-Filho, 1981). Their diet includes ripe fruits, nectar and animal prey. Fruits eaten are typically small, soft and sweet, with a lot of pulp, but large fruits are also eaten occasionally (Kleiman *et al*., 1988; Dietz *et al*., 1997). Melastomataceae is one of the main families providing fruits for *L. rosalia*, ripe fruits are preferred over unripe, and nectar is an important seasonal

resource when fruit is scarce (Kierulff, Raboy *et al*., 2002). The most frequent microhabitats for foraging for prey are tree bark, bases of palm leaves, wood crevices, dead leaves, vine tangles, and bromeliads and other epiphytes (Kierulff, Raboy *et al*., 2002). Small vertebrates, arthropods and snails constitute the majority of prey eaten. Capture of mobile prey or flying insects is relatively rare compared to sedentary and cryptic prey, such as adult orthopterans, Coleoptera larvae and Lepidoptera (Dietz *et al*., 1997).

MANAGEMENT

Coimbra-Filho (1969) estimated that only 900 km^2 of lion tamarin habitat remained, with *c.* 600 surviving in small forest patches. By 1975, estimates suggested that only 100–200 individuals might survive (Coimbra-Filho & Mittermeier, 1977; Magnanini, 1978). In 1983, there was an urgent need to increase the numbers and the genetic diversity of the wild population. The emergence of a self-sustaining captive population, the establishment of Poço das Antas and the beginning of a long-term study of the behavioural ecology of the wild population were factors that allowed for the reintroduction of captive-born animals into native Brazilian forest (Kleiman *et al*., 1986; Beck *et al*., 1991, 2002; Kierulff, Oliveira *et al*., 2002; Ruiz-Miranda *et al*., 2010). The conservation goal of the GLTCP [defined in 1984, and modified in successive Population and Habitat Viability Assessment workshops in 1991, 1997 and 2005] is a minimum of 2000 Golden lion tamarins in a minimum of 250 km^2 of viable, connected and protected habitat by 2025. Those numbers represent a population with 95% chances of survival for 100 years, maintaining 98% of the genetic diversity.

Zoos contributed most of the Golden lion tamarins that were reintroduced. In all, 146 reintroduced captive-born tamarins were born in or had lived at about 30 zoos in North America and Europe. Critical research on social behaviour, nutrition and disease was carried out in zoos, and virtually all of the funding for reintroduction and post-release monitoring came from the Smithsonian National Zoological Park and the Frankfurt Zoological Society, Germany. For the last 5 years most of the funding for field monitoring has come from the Lion Tamarins of Brazil Fund, Frankfurt Zoological Society and Copenhagen Zoo, Denmark. An interesting aspect of zoo involvement was the establishment of 'gateway zoos', institutions that would channel the captive-born animals to be reintroduced giving them somewhat standardized free-ranging experience before reintroduction (Stoinski *et al*., 1997)

Lion tamarins were reintroduced from 1984 to 2000 (153 animals: 146 captive-born and seven wild-born) and a group of five wild-born animals was reintroduced in 2005 (Ruiz-Miranda *et al*., 2010). The first were introduced into Poço das Antas but subsequent releases were in privately owned forests. The reintroduction of the captive-born animals involved post-release provisioning (soft release), along with management and veterinary support to maximize survival and reproduction. The involvement of local landowners was determinant for the success of the reintroduction. Today, over 40 properties have descendants of reintroduced lion tamarins, and more than ten have been formally designated as Permanent Private Reserves (Reservas Particulares do Patrimônio Natural: RPPNs). Another key factor for the success of these conservation efforts has been the multi-institutional commitment to both *in situ* and *ex situ* conservation. The involvement of zoos (>100) was crucial for maintaining a well-managed captive population and for supporting the *in situ* efforts.

The reintroduction project was designed as a research programme to test the effect of release techniques (pre-release experience and post-release conditions) on survival and reproduction, and behavioural studies were conducted to elucidate the mechanisms related to the success of captive-born animals. The main single cause of loss in the reintroduced population was theft and vandalism (21%). Problems with adaptation to the new environment, readily noticeable after the

release of captive-born animals (e.g. inability to find food, and problems with locomotion and orientation), likely caused the majority of losses if considered together (starvation 13%; lethargy/diarrhoea/anorexia/dehydration 10%; hypothermia/exposure 10%; injuries 3%). Other causes of death were natural predation (15%), wounds from social conflict (8%), a bee sting, eating toxic fruit, snakebite and haemorrhage following miscarriage (21%). Tests with pre-release training showed no differences in group survival. Monitoring indicated the effects of post-release management and origin (wild vs captive) on survival to 2 years after release or birth in the wild. Survival was higher for those under intense post-release management and for the wild-born offspring of the reintroduced adults (Beck *et al*., 1991, 2002; Kleiman *et al*., 1991).

Infants born to reintroduced parents seem to be less affected by these deficiencies and survived better than the reintroduced captive-born individuals. Behavioural studies revealed differences between captive-born animals and their wild-born offspring for behaviours related to survival and reproduction (Ruiz-Miranda *et al*., 1999; Ruiz-Miranda & Kleiman, 2002; Stoinski *et al*., 2003; Stoinski & Beck, 2004).

Management of the reintroduced population changed adaptively as the population changed in the wild. Provisioning was gradually reduced as reintroduced Golden lion tamarins began to eat natural foods and move through their territories. The time necessary for a group to become fully independent varied but all groups were independent 5 years after reintroduction (Kierulff, Oliveira *et al*., 2002). In 2005, provisioning was discontinued in all groups; by this time there were fewer than 15 captive-born animals in the reintroduced population. After 21 years, the population formed by the reintroduced captive-born lion tamarins and their descendants was 589 in 87 groups (Procópio-de-Oliveira *et al*., 2008).

Conservation management of the Golden lion tamarins also included translocation to rescue small populations under a high risk of extinction. During the survey of the populations in 1991–1992, 12 groups were found isolated in secondary forest fragments, none larger than 2.0 km^2. The risk of demographic and/or genetic problems because of small population size, the threats to these areas and the high costs of preserving these forests, made translocation the only viable option to save these groups. In 1994–1998, 42 tamarins in six groups (entire families) were captured in these forest fragments and taken to the Fazenda União (today the União Biological Reserve). União was large enough to take in all the groups (240 km^2 of forest), contained adequate habitat and lacked other resident groups. The lion tamarin groups were captured and immediately released there. They were not provisioned (hard release).

Social disruption following translocation was common, with the replacement of breeding ♂♂ in established groups by immigrant ♂♂. Emigration and immigration and considerable movements were more frequent when groups were released between established territories. The amount of unoccupied habitat and the low population density increased the opportunities for the establishment of new groups by individuals dispersing from the original (translocated) groups. We learned that groups should be released as far apart as possible from each other to minimize the inter-group movements after translocation. However, even when contact between translocated groups occurred and resulted in social disruption, the effects were temporary and stable groups emerged soon afterwards.

The translocated population showed similar survivorship and reproduction to the native population in Poço das Antas. The lion tamarins were self-sustaining immediately after release, being totally independent of provisioning or additional management. Their diet included more than 120 plant species. In 2006, the translocated population comprised more than 220 individuals in 30 groups, including only eight of the individuals translocated. More than 200 births have been registered in 12 years (Procópio-de-Oliveira *et al*., 2008).

The adaptive management strategy for conservation includes periodically revising the status of the population and how close we are to achieving the conservation goals. The most recent estimate is of 1600 Golden lion tamarins in *c.* 150 km^2 of forest (Holst *et al*., 2006; Ruiz-Miranda *et al*., 2008). Three of the six existing, potentially viable populations were the result of reintroduction ($n > 600$ individuals) and one the result of translocation ($n > 300$), more than 50% of the Golden lion tamarins and available habitat. Both reintroduction and translocation programmes have been major contributors to the protection of habitat for the species. These populations are also contributing to the retention of overall genetic diversity, reduction of the effects of genetic drift and inbreeding, and in adding new genetic diversity from captivity and from the isolated coastal populations (Dietz *et al*., 2000; Grativol *et al*., 2001; Kierulff, Oliveira *et al*., 2002; Fernandes *et al*., 2008). The other two populations are Poço das Antas and Serra dos Gaviões (Ruiz-Miranda *et al*., 2008).

Reintroduction of captive-born Golden lion tamarins was used to increase the size and genetic diversity of the wild population, whereas translocation was used to rescue threatened wild groups undoubtedly representing significant genetic diversity for the species. Both programmes have been successful as measured by survival and reproduction after release, and both techniques have established growing populations (Kierulff, Oliveira *et al*., 2002; Ruiz-Miranda *et al*., 2010).

The GLTCP is now using the knowledge obtained and the database created over 25 years to manage the wild populations as a meta-population (Holst *et al*., 2006; Grativol *et al*., 2008). The meta-population management includes establishing connectivity among isolated populations through forest corridors and translocations, and will require new techniques; for example, where, when and how animals should be moved so as to optimize the impact on demography, gene flow and spatial distribution over the landscape (Ruiz-Miranda *et al*., 2010).

NEW THREATS

Besides the omnipresent deforestation and habitat reduction, at the time of writing the introduction of exotic primates in its area of occurrence represents a major threat to the survival of the Golden lion tamarin populations. Two species, the Common marmoset *Callithrix jacchus* and the Black-tufted marmoset *Callithrix penicillata* (and their hybrids), have been released on different occasions and are present in all of the private forests where groups of Golden lion tamarins were reintroduced and in one region of foothills with a wild population. The exotic primates are not yet present in the biological reserves of União and Poço das Antas (Ruiz-Miranda *et al*., 2000; de Morais *et al*., 2008). The occupancy of other forests in the region may increase as the conservation programme for Golden lion tamarins increases the connectivity of the landscape. These introductions are intimately tied to the illegal wildlife trade in Brazil and are a nationwide problem (Ruiz-Miranda *et al*., 2011). In most cases the marmoset density is higher than that of the Golden lion tamarins in the same fragment.

The marmosets are a threat to the lion tamarins because they compete for food resources and could be the vector of anthropogenic infectious diseases (Ballou *et al*., 1998; Holst *et al*., 2006; de Morais *et al*., 2008). Field studies show that marmosets interact frequently with reintroduced Golden lion tamarins, especially around the food supplementation platforms before provisioning was suspended and more recently during capture to change radio collars and conduct periodical examination (weighing, health checks, new tattoos, etc.) and at other key food resources, and more so during the dry season (Ruiz-Miranda *et al*., 2006). The responses of lion tamarins to the presence of marmosets vary from agonism to tolerance (Ruiz-Miranda *et al*., 2006), and in some groups lion tamarin young play frequently with marmoset juveniles (Oliveira *et al*., 2003). The threat of disease is assumed from the fact that marmosets released in the area have been handled and transported by

humans under conditions that promote disease: confined in high density and under poor care. Studies of the body condition and health status of the marmosets are just beginning (Sales *et al*., 2010). The first findings suggest that *C. jacchus* × *C. penicillata* hybrids found in the fragments in which Golden lion tamarins were reintroduced may be more prone to helminth infections than non-hybrids (Sales *et al*., 2010). These concerns have prompted the development of a management strategy for these introduced marmosets.

In 2002, Golden-headed lion tamarins *Leontopithecus chrysomelas* were observed in a forest fragment in the Serra da Tiririca in the city limits of Niterói, Rio de Janeiro. Golden-headed lion tamarins – native to Bahia state, not Rio de Janeiro – were released by a private collector. We conducted a survey in 2009 to gauge the extent of the problem and found 15 groups (107 individuals). Adults carrying infants were observed at the end of April (in the wild, the birth season ends in March). The local residents feed the Golden-headed lion tamarins in the forests near their houses, which may account for the large size of the groups.

At the time of writing, these introduced Golden-headed lion tamarins are restricted to the municipalities of Niterói, Maricá and São Gonçalo, isolated in a forest fragment of >300 km^2. The nearest population of Golden lion tamarins, however, is located in Fazenda Rio Vermelho, municipality of Rio Bonito, <50 km from Niterói. If the introduced species reaches that locality either by dispersal or by people transporting them, there is a high probability that the two species will hybridize, with foreseeable negative consequences for the Golden lion tamarin. The Rio Vermelho region is already experiencing illegal wildlife trade as evidenced by the presence of introduced Common marmosets. Moreover, the Golden-headed lion is also at risk of extinction and the translocation of the population in Niterói to the native range of the species in Bahia would contribute to increasing the numbers in the wild.

CONCLUSION

It is almost impossible to write in just one chapter on the work and achievements of almost 30 years of the GLTCP. There is no doubt of its success, and the Golden lion tamarin that was almost extinct in the wild before 1983, in 2003 had its IUCN Red List category changed from Critically Endangered to Endangered (IUCN, 2011). The Golden lion tamarin remains threatened but the effort over these years has helped to increase the number of individuals in the wild and the area protected for the species. Many people and many institutions have played crucial roles, and it is impossible to list all. We would like to thank all the institutions and people who made everything described here possible. One person, however, made it all happen – Devra G. Kleiman – who sadly is with us no longer to see the ongoing success of her programme but to whom this volume on New World Primates is dedicated.

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