

## LOSSES AND REPRODUCTION IN REINTRODUCED GOLDEN LION TAMARINS *Leontopithecus rosalia*

By BENJAMIN B. BECK<sup>1</sup>, DEVRA G. KLEIMAN<sup>2</sup>, JAMES M. DIETZ<sup>3</sup>, INES CASTRO<sup>4</sup>, CIBELE CARVALHO<sup>4</sup>, ANDREIA MARTINS<sup>4</sup> AND BEATE RETTBERG-BECK<sup>5</sup>

<sup>1</sup>Associate Director for Biological Programs, National Zoological Park, Smithsonian Institution; <sup>2</sup>Assistant Director for Research, National Zoological Park, Smithsonian Institution; <sup>3</sup>Assistant Professor, Dept. of Zoology, University of Maryland; <sup>4</sup>Field Coordinator - Golden Lion Tamarin Conservation Program; <sup>5</sup>National Air and Space Museum; Smithsonian Institution.

**ABSTRACT:** We have reintroduced 91 golden lion tamarins (*Leontopithecus rosalia*) since 1984. Thirty-three survive (as of 1st June 1991). Fifty-seven infants have been born to reintroduced parents, of which 38 survive. Theft by humans, predators, starvation, apparent disease, and exposure accounted for most known losses. Deficits in food-finding, locomotion and orientation were readily noticeable after the release of captive-born tamarins, and ultimately caused most losses. Infants born to reintroduced parents seem less affected by these deficits, and they survive better. These results suggest that the best reintroduction strategy for this species is intensive support of the reintroduced animals to maximize their chances of survival and reproduction, and reliance on their wild-born offspring to become truly independent.

**KEY WORDS:** golden lion tamarins, *Leontopithecus rosalia*, reintroduction, foraging, locomotion, orientation

### Introduction

The emergence of a self-sustaining captive population of golden lion tamarins *Leontopithecus rosalia* (Kleiman *et al.*, 1982), the establishment of the Poço das Antas Biological Reserve for the species (Coimbra-Filho and Mittermeier, 1978) and the beginning of a long-term study of the behavioural ecology of the wild tamarin population in Poço das Antas (Kleiman *et al.*, 1986) converged in 1983 to make possible the reintroduction of captive-born tamarins into native Brazilian forest. The goals of the reintroduction were to increase the size and genetic diversity of the wild population, to increase available habitat within the species' historic range, to augment public conservation education programmes, and to contribute to the science of reintroduction.

### Methods

We altered our methods with experience (see Beck *et al.*, in press, for details).

**1984:** While they were still living in cages at the National Zoological Park in Washington, DC in 1983, we began to train tamarins scheduled for the first reintroduction (in 1984). Training continued at the Rio de Janeiro Primate Centre (CPRJ-FEEMA) where the first cohort of tamarins was quarantined for six months after shipment to Brazil. Training included inducing the tamarins actively to search for food that was distributed at several sites in the cage and hidden from immediate view. We hid food under bark, in cavities in rotted wood, in rolled leaves and in other "embedded sites" to stimulate extractive foraging. We presented uncut and unpeeled fruits, and a wide variety of invertebrate and vertebrate prey. We provided water in bromeliads and wood cavities rather than bowls. To promote strength and locomotor ability, we placed food at sites that required the tamarins to hang, climb and jump on the milled lumber climbing frames of their cages. Large birds flew over tamarins' cages at the Zoo and the Primate Centre, and chickens and dogs approached cages at the Centre; these opportunities allowed us to start assessing predator detection and avoidance abilities without exposing the tamarins to harm.

For two to four weeks before release we kept the tamarin groups (families or pairs) in large acclimatisation cages built over and around natural vegetation at the release sites. Formal training continued in these cages, and we offered natural fruits eaten by wild tamarins. The different potential prey (e.g., butterflies) and predators (e.g., snakes) that approached and entered these forest cages provided additional experience. A nest box, in some cases the one used at the Primate Centre, was provided in the cage.



PLATE 1

JESSIE COHEN, *National Zoological Park,  
Smithsonian Institution*

As part of their training at the National Zoological Park (N.Z.P.) in 1984, captive born golden lion tamarins *Leontopithecus rosalia* learn how to peel bananas because normally keepers peel and cut up their food, but wild fruits often have hard exteriors.

The release itself consisted of opening the cage door. We continued to provide food and water in bowls near the tamarins. Whole bananas were sometimes fed instead of bowls of cut food. We determined quantities by consensus of the field team, trying to balance nutritional adequacy with sufficient hunger to maintain motivation to forage. We searched for lost tamarins and baited them back to familiar areas. Sick or injured animals were rescued, treated, and re-released if possible.

1985: We reintroduced two family groups in 1985. We trained one group for three months in a large (112 m<sup>3</sup>) cage at the National Zoo. The protocol was similar to that used in 1983/84. Additionally, a dense network of slender natural branches and vines replaced the lumber climbing frame to attempt to reduce locomotor deficits seen in the first reintroduction. The network was dismantled and reassembled several times each week to preclude habitual use of travel routes and foster spatial orientation. We presented a stuffed owl and a caged snake to assess response to potential predators. After shipment to Brazil the group lived and was further trained in a large acclimatisation cage at the release site as in the previous year.

The other family group in the 1985 cohort served as a "control" and received no formal training, being held for three months in a small (13 m<sup>3</sup>) cage with standard cage furniture at the National Zoo. After shipment to Brazil the control group lived in a large acclimatisation cage before release but was fed and watered conventionally in bowls and received no training.

Since both groups were reluctant to leave the acclimatisation cages, reintroduction consisted of simply dismantling the cages. We fed and managed the "experimental" group as in 1984, except that we presented some structured food-finding tests in the first two post-release weeks. The control group was similarly tested but needed intense food provisioning. To discourage the control group's continued use of bowls we built a feeding platform of lengths of bamboo notched with holes. Food was loaded inside the hollow bamboo requiring the tamarins to extract it through the holes. This was meant to foster foraging skills, and protected the food from birds and other mammals. After several days the bowls were discontinued, and the platform was moved further from the tamarins and hung from slender branches. This prompted the tamarins to locomote further and on more challenging substrates, and forced them to orient to the platform and back to the provided nest box.

1987: The third reintroduction cohort (1987) received no formal training or acclimatisation in cages before release. Rather we released each family group directly into the forest from a nest box or transport cages within several days of their arrival in Brazil. We then trained the tamarins after release, using the platform technique developed with the 1985 control group. We also baited and presented rolled leaves, hollow logs, and bromeliads to stimulate foraging. When the tamarins learned to use the platform, we hung whole bananas on branches up to 50 m away to stimulate movement and exploration.

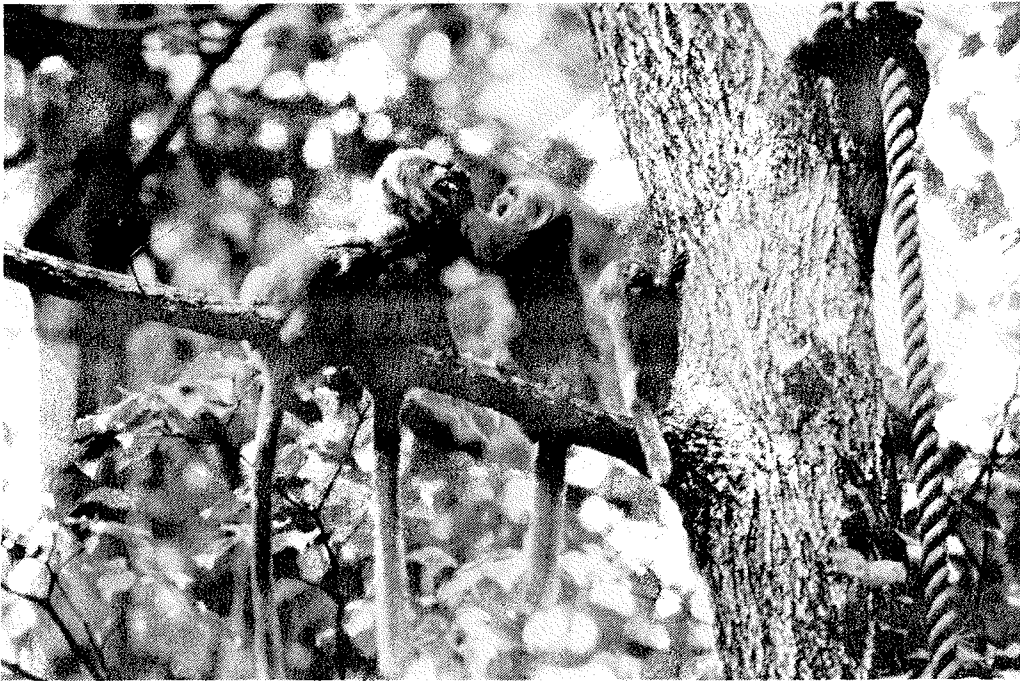


PLATE 2

JESSIE COHEN, National Zoological Park,  
Smithsonian Institution

Free ranging golden lion tamarins *Leontopithecus rosalia* on N.Z.P. grounds provided proof that they can be trained after release as long as they have food and a nest box in which to sleep.

We provided food frequently and abundantly at sites that allowed easy access by the group member least proficient in locomotion. We trapped and returned tamarins that left the release site and got lost, or we lured them back. If a whole group got lost and the weather was cold and rainy, we moved the box to the group. In good weather we allowed the lost group to choose its own sleeping site.

1988, 1989, 1990: Members of the fourth, fifth and sixth reintroduction cohorts received the same post-release training but additionally spent one to three months living at liberty in a beech and oak copse in the grounds of the National Zoo before shipment to Brazil (Bronikowski *et al.*, 1989). The nest box (a modified plastic picnic cooler) provided to each group during initial quarantine at the Zoo was also used while the group was free-ranging in the Zoo and again when the group was released into Brazilian forest. The box was a familiar, secure point from which the tamarins could slowly begin to explore and expand their range. We exposed the animals in Washington to feeding devices like the feeding platform used in Brazil, and in 1990 to special experiments that tested spatial orientation ability (C. Menzel, unpubl.).



PLATE 3

JESSIE COHEN, National Zoological Park,  
Smithsonian Institution

Drs. J. Dietz (right) and D. Kleiman, assisted by A. Baker, measuring golden lion tamarins *Leontopithecus rosalia* as a part of an examination given to every individual prior to release (Brazil, 1985).

We took every measure to minimize threat to the wild tamarin population and other animals and plants of the Atlantic Coastal Forest. Reintroduction candidates in all cohorts were strictly quarantined after arrival at the National Zoo. They were screened



PLATE 4

JESSIE COHEN, National Zoological Park,  
Smithsonian Institution

Dr. J. Dietz positions his radio tracking antenna to locate and plot the direction of the radio collared golden lion tamarins *Leontopithecus rosalia*.



PLATE 5

JESSIE COHEN, National Zoological Park,  
Smithsonian Institution

Golden lion tamarin *Leontopithecus rosalia* with radio collar and transmitter at Poço das Antas Biological Reserve.

for parasites, communicable diseases, possible genetically-based defects, injuries, and diaphragmatic thinning (Bush *et al.*, 1980). Tamarins with untreatable conditions were disqualified from reintroduction (Bush *et al.*, in press).

We radio-collared one or two tamarins in each group (Telonics, Inc.; Wildlife Materials, Inc.). All were tattooed for permanent identification, and dye-marked for rapid field identification. We trapped and anaesthetized the animals every four to six months to replace radio-collars and renew dye marks. Members of a salaried all-Brazilian observation team visited groups daily for 6 to 18 months after reintroduction. They provided food, accounted for all group members, reported to the field coordinator if animals were lost, injured or ill, participated in any subsequent searches or intervention, and collected systematic observations on behaviour. As the tamarins began to eat natural foods and to move through their territories, the feeding/observation visits were progressively reduced from daily to three days a week, once a week, and finally once a month. Provisioning was ultimately discontinued except for bait used to trap animals to replace radio-collars and dye marks.

## Results

*Survivors:* Of the 91 tamarins reintroduced by 1st June 1991, 85 were captive-born and 6 were wild-born. The wild-born tamarins had presumably been taken by poachers and lived for some time in Brazilian homes. They were later confiscated by Brazilian authorities and given to us for reintroduction. As of 1st June 1991, 29 (34%) of the reintroduced captive-born tamarins and 4 (67%) of the reintroduced wild-born tamarins survive. The captive-born animals have lived in the wild for between 1 and 83 months. Some are totally independent of provisioning and daily management; others require daily provisioning and daily monitoring. The wild-born animals have lived in the wild for between 43 and 75 months since we released them; all of them and their groups are independent.

There have been 57 infants born to reintroduced parents, of which 38 (67%) survive as of 1st June 1991. The parents of six of these surviving infants were themselves born in the wild to reintroduced parents, *i.e.* there have been "second generation" births. We have intentionally tried to prevent interbreeding between reintroduced and truly wild tamarins (to avoid disturbance of the wild population), but one reintroduced male did pair and produce offspring with a wild female. The male was lost (probably to a predator) and the female and offspring disappeared.

The 71 survivors live in 3 groups in the Poço das Antas Reserve and 15 groups on nine privately owned ranches near the Reserve. None of the ranches that currently have reintroduced tamarins adjoins the Reserve but several of the ranches connect with each other, thereby allowing the groups to have contact and to exchange members without our intervention. The three groups that live within the Reserve have frequent territorial encounters and have exchanged members. These groups also have contact with wild groups that we have translocated into the Reserve, and they exchange vocalizations with resident Reserve groups. Four of the 18 groups are totally independent of provisioning and management and three other groups are provisioned only once per week.

*Losses of Reintroduced Tamarins:* Losses were due to death (evidenced by our recovery of all or part of the body, or a radio-collar with bite marks or tamarin hair); disappearance (evidenced by our failure to find them despite intensive efforts); or rescue to prevent certain death due to injury, illness, starvation or exposure. The date of loss is listed as the last day the animal was observed, thus the number of days survived slightly underestimates the time of post-release survival. Animals that disappeared are counted as lost, even though in some cases they may very well have survived. Animals that

disappeared due to theft, and animals that were rescued, are counted as lost even if they were recovered and re-released. Animals that were re-released and subsequently lost a second time appear twice in the analyses of losses.

In all there have been 66 losses of reintroduced tamarins: 25 deaths, 32 disappearances and 9 rescues. One of the rescued tamarins survives and is reproducing at the Rio de Janeiro Primate Centre. Five other rescued tamarins were re-released; three of these survive. At least six of the disappearances of captive-born reintroduced tamarins were due to theft, three of these animals were recovered and re-reintroduced. Two of these three survive.

TABLE I. PROBABILITY OF LOSS OF REINTRODUCED TAMARINS AS A FUNCTION OF TIME SINCE REINTRODUCTION. STOLEN AND RESCUED ANIMALS THAT WERE RE-RELEASED ARE COUNTED TWICE.

Year Post Release	Number Lost During Year	Number at Risk for All or Part of Year	Percentage Lost for Year
1	41	99	41%
2	14	45	31%
3	9	25	26%
4	1	11	9%
4+	1	3	33%

Table I shows the distribution of losses as a function of time since reintroduction for all reintroduced tamarins. The probability of loss is high in the first year, declines somewhat in the second and third years, and then declines dramatically in the fourth year. Although the probability of loss is similar in the second and third years, the third-year tamarins get far less provisioning and support. The overall trend, therefore, probably reflects gradually increasing competence in foraging, locomotion, orientation and avoiding predators. After four years the probability of loss increases, but the sample size is small for comparison. A rise in the probability of loss after four years might simply reflect the increased probability of dying with increased age.

TABLE II. PROBABILITY OF LOSS OF TAMARINS BORN IN THE WILD TO REINTRODUCED PARENTS AS A FUNCTION OF OFFSPRING AGE. ONE STOLEN TAMARIN THAT WAS RE-RELEASED IS COUNTED TWICE.

Year Post Release	Number Lost During Year	Number at Risk for All or Part of Year	Percentage Lost for Year
1	16	58	28%
2	4	23	17%
3	0	8	0%
4	0	4	0%
4+	0	3	0%

*Losses of Wild-born Tamarins:* There have been 20 losses of tamarins born in the wild to reintroduced parents: one death and 19 disappearances. There have additionally been six documented stillbirths/abortions. Many of the disappearances occurred in the first few weeks of life when the infants could not have survived independently, but several

occurred after a year of age; some of these juveniles may survive. Two of the wild-born animals that disappeared were stolen; one was recovered, re-released, and is still alive. First-year mortality in these wild-born tamarins is relatively high (Table II) and, adding loss due to stillbirth and abortion, approximates that of the captive population (35%, Ballou and Kleiman, in press). Mortality among these wild-born young declines markedly after the first year, and is considerably less in all year-classes than that for the captive-born reintroduced tamarins. This difference might be mediated by age, since the average age of the wild-born subsample is less than the age of the reintroduced subsample, and among reintroduced tamarins age is inversely related to post-reintroduction survivorship ( $r = -0.428$  using age of captive-born tamarins at reintroduction, and days survived until first loss, for animals at risk for at least one year;  $n = 73$ ,  $p < 0.01$ ). We have previously suggested (Kleiman *et al.*, 1986; Kleiman *et al.*, 1991) that this relationship among reintroduced tamarins reflects the greater vitality and adaptability of younger animals, or simply their smaller body weights which would confer locomotor advantage. Age-related differences in vitality, adaptability, or body weight, or non-age-related factors unique to being wild-born, may explain the difference in survivorship between reintroduced tamarins and their wild-born offspring. Sample sizes will soon be large enough to permit comparison of the behaviours of age-matched reintroduced and wild-born tamarins.

TABLE III. KNOWN CAUSES OF LOSS OF REINTRODUCED TAMARINS AND THEIR WILD-BORN OFFSPRING.

Cause	Reintroduced	Wild-Born
Theft	6	2
Mammalian or Avian Predator	6	0
Starvation	5	0
Lethargy, Diarrhoea, Anorexia, Dehydration	4	0
Hypothermia/Exposure	4	0
Wounded in Social Conflict	3	0
Bee Sting	2	1
Eating Toxic Fruit	2	0
Snakebite	2	0
Haemorrhage following Abortion	1	0
Head Injury (fall)	1	0

*Causes of Loss:* Table III shows the causes of loss where known. The leading cause is theft by humans. Six captive-born reintroduced tamarins and two wild-born offspring were stolen. Four of these eight were later recovered by Brazilian authorities from two different wealthy Brazilians. Two of the thefts occurred in September, four in December and two in February, all coinciding with long daylength when poachers can operate easily after our observers have finished work. Known predators include ocelots (*Felis pardalis*) and a feral hunting dog (*Canis familiaris*). One tamarin lost to starvation was found dead, head-down in a tree hole where he apparently became wedged while foraging. Two of the tamarins lost to exposure were actually rescued and re-released. They were found on the ground, totally wet with body temperatures of 30°C, after cold rainy nights. We warmed them gradually and gave fluids subcutaneously until they were able to ingest diluted fruit juice and then food. Both recovered within 24 hours. The synchrony of three further losses, with all animals having combined symptoms of lethargy, diarrhoea, dehydration and anorexia, suggests disease. The tamarins killed by snakebite were not victims of



predation; the first appeared to have simply stepped on the snake while running on the ground during an intergroup encounter, and the second was apparently bitten while eating the snake (a coral snake, *Micrurus fulvius*). Africanized bees (*Apis mellifera scutellata*) attacked a tamarin pair with a young infant. The female died shortly after discovery and the infant was found dead in the nest box. We found the male on the ground with diffuse, marked swelling from at least 27 bee stings. After treatment with steroids and fluids, he recovered and was re-released. Africanized bees are common in the reintroduction area and build hives in nest boxes and natural tree holes. Tamarins usually abandon colonized nest sites and avoid the bees, but this group apparently tried to enter its newly colonized nest box.

The tamarins that died of ingesting toxic fruit all were found with many large seeds of the fruit of the woody vine *Hyperbaena domingensis* in their stomachs. The second was found dead six weeks after the first, and two others of the same group disappeared on the same day as the second death. This group was feeding deep in an inundated swamp during this period and we therefore have no direct observations of these incidents. This particular plant species has not been determined to have toxic alkaloids, but toxins are widespread in the fruits of the family Menispermaceae. Closely related genera are used in the production of curare (C. Gunn; R. Barneby; M. Mathias, pers. comm.).

The bodies of five additional tamarins were found within two days of death but post-mortem changes and damage from scavengers precluded a conclusive necropsy.

TABLE IV. ANNUAL PATTERN OF LOSSES OF REINTRODUCED TAMARINS WITH REFERENCE TO THE MONTHS OF REINTRODUCTION, AND OF LOSSES OF WILD-BORN TAMARINS BORN TO REINTRODUCED PARENTS WITH REFERENCE TO THE MONTHS OF BIRTH.

Month	Number Reintroduced	Reintroduced Losses	Number Born	Wild-Born Losses
January	14	2	6	3
February	3	9	8	4
March	1	4	2	2
April	2	7	3	4
May	11	5	0	0
June	3	7	0	0
July	13	8	0	0
August	0	4	0	0
September	21	1	7	3
October	0	5	12	0
November	20	4	3	3
December	3	10	16	1

While thefts tended to occur in the Brazilian summer, there was no clear relationship between the frequency of other losses of reintroduced tamarins and rainfall, temperature or other seasonal variables. Although most reintroduced tamarins are lost in the first year after reintroduction (Table I) there was no apparent relationship to the exact months in which we have reintroduced the tamarins over the past eight years (Table IV). The timing of losses of young born to reintroduced parents is related to the month of birth. All of the 57 births occurred in September through February, with an apparent peak between October and December as is the case with births among truly wild tamarins

in Poço das Antas (Dietz and Baker, in prep.). All of the losses of young born to reintroduced tamarins were in September through February (Table IV). Seven occurred within 30 days of birth, a common pattern of early mortality that helps to explain the association between month of birth and month of loss seen in Table IV.

### Discussion

The reintroductions of the North American red wolf (*Canis rufus*) in North Carolina, and the Arabian oryx (*Oryx leucoryx*) in Oman are the best-documented mammal reintroduction projects and allow comparisons with the tamarin project. Since red wolves and oryx were extinct in the wild, only captive-born animals were reintroduced. Thus for comparison of survivorship we use only captive-born reintroduced tamarins, of which 29 of 85 (34%) survive. Thirteen of 29 red wolves (45%) survived after three years of reintroductions (Phillips, 1990a) while 10 of 14 (71%) reintroduced oryx survived after four years (Stanley Price, 1989). Direct comparisons are complicated by differences in the ages and life history patterns of the reintroducees, and in the extent of pre-release training and post-release support. But these survivorships correlate strikingly with the results of a survey (Griffith *et al.*, 1989) that shows that translocations of wild- and captive-born vertebrates are more likely to be successful for herbivores, e.g., oryx, than for carnivores, e.g., wolves, and for carnivores than for omnivores, e.g., tamarins.

The most common cause of loss of reintroduced red wolves was automobile accidents. Combined with one accidental trapping, human activities accounted for 6 of 16 (38%) wolf losses (Phillips, 1990a). For tamarins, 8 of 38 (21%) losses of known cause were due to human activity. The activity, theft, was intentional for the tamarins whereas it was accidental for the wolves. However, it is not surprising that anthropogenic factors are the leading cause of death of reintroducees since each of these species was imperiled by human activity in the first place. While the oryx were similarly eliminated originally by human activity (sport hunting), the remoteness of the reintroduction site, degree of post-release monitoring, and personal support for the project by Oman's monarchy have insulated the reintroducees from human harm. All three reintroductions have education and community relations programmes to build local support (Phillips, 1990b, Parker and Phillips, 1991 for wolves; Stanley Price, 1989 for oryx; Kleiman *et al.*, 1986 for tamarins). The tamarin and oryx projects additionally employ many local citizens; the wolf project utilizes local volunteers who receive a stipend. These activities doubtless reduce losses and interference by humans.

Intraspecific social conflict was another cause of loss common to reintroduced tamarins (three) and red wolves (two). Spalton (1991) notes that social conflict has recently caused deaths among reintroduced oryx and their offspring.

At least six pups were born to reintroduced red wolves, all of which appear to survive (Phillips, 1990a). Twenty-nine oryx were born through 1986, of which 22 (76%) survived (Stanley Price, 1989). Spalton (1991) reports that the Oman oryx population had grown to 109 by 1990, largely through reproduction since 1987. Calf survival was 95%, 96% and 81% for 1988, 1989 and 1990 respectively. Thirty-eight of 57 (67%) tamarins born through May, 1991 survive. Thus reintroducees have reproduced in each programme, and the survivorship of wild-born offspring in each exceeds that of the reintroducees themselves. Wild-born offspring of reintroduced oryx and tamarins have themselves reproduced.

Each of these programmes involved some pre-release preparation and acclimatisation in large enclosures or semi-naturalistic settings, but each also featured intensive long-term post-release monitoring, provisioning, veterinary care, and retrieval of lost animals. Reintroduced golden lion tamarins clearly require extensive post-release provisioning,

management and veterinary support if they are to survive long enough to reproduce. Intense, prolonged pre-release training and acclimatisation in relatively small cages had no lasting effect on survivorship (Beck *et al.*, in press), but living at liberty for several months in a large wooded area on the National Zoo grounds seemed to confer an enduring advantage. We now combine pre-release free-ranging experience in the Zoo with extensive post-release support and post-release training to keep the reintroducees alive long enough to reproduce. Their wild-born young show better survivorship and earlier independence, and appear to be the beginnings of a truly self-sustaining population. Thus if reintroduction is to add significantly to the wild population of this species (and most likely others), we must be committed to a long-term, labour-intensive, costly effort (Kleiman *et al.*, 1991).

Nearly all of the founders of the tamarin, red wolf and oryx reintroductions were born and raised in zoos. Each species had an inter-zoo cooperative breeding programme with pioneering genetic management to guide reproduction and selection for reintroduction. Each programme exposed the zoo-born founders and their wild-born offspring to zoo veterinary medicine and curatorial management before and after reintroduction. Zoo registrars have arranged for complicated international shipping permits and flights for the tamarins and oryx. Zoos have made substantial contributions in personnel, facilities and direct funding to these reintroductions. The results of the reintroductions have in turn been applied to improve the educational value of zoo exhibits and the quality of life for zoo animals (Bronikowski *et al.*, 1989; Price *et al.*, 1989). These reintroductions clearly demonstrate the integral rôle of modern zoos in conservation.

### *Acknowledgements*

Funding specific for reintroduction came from the Wildlife Preservation Trust International, Friends of the National Zoo, Frankfurt Zoological Society — Help for Threatened Wildlife, and the Woodland Park Zoo. Other funding for the Golden Lion Tamarin Conservation Program came from the Smithsonian Institution (International Environmental Sciences Program, Educational Outreach Program, Office of Fellowships and Grants), National Zoological Park, Friends of the National Zoo, World Wildlife Fund, National Science Foundation, National Geographic Society, U.S. Fish and Wildlife Service and Canadian Embassy, Brazil.

The Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA, formerly IBDF) authorized and supported our work in Brazil. The staff of the Centro de Primatologia do Rio de Janeiro (FEEMA) provided medical care, necropsy service and invaluable advice; we are especially grateful to Adelmar Coimbra-Filho and Alcides Pissinatti. The Fundação para a Conservação de Natureza (FBCN) has helped in many ways. Numerous zoo staff members, volunteers, and our Brazilian field coordinators and observers have made the work possible.

### *References*

- BALLOU, J. D. AND KLEIMAN, D. G. (in press): Population biology and management of the golden lion tamarin captive population. In: *A Case Study in Conservation: The Golden Lion Tamarin*, Kleiman, D. G. and Rosenberger, A. L. (Eds.). Smithsonian Institution Press, Washington, D.C.
- BECK, B. B., KLEIMAN, D. G., CASTRO, I., RETTBERG-BECK, B. AND CARVALHO, C. (in press): Preparation of captive-born golden lion tamarins for release into the wild. In: *A Case Study in Conservation: The Golden Lion Tamarin*, Kleiman, D. G. and Rosenberger, A. L. (Eds.). Smithsonian Institution Press, Washington, D.C.

- BRONIKOWSKI, E. J., BECK, B. B. AND POWER, M. (1989): Innovation, exhibition and conservation: free-ranging tamarins at the National Zoological Park. *AAZPA Ann. Conf. Proc.* **1989**: 540-546.
- BUSH, M., BECK, B. B. AND MONTALI, R. J. (in press): Medical considerations in reintroduction. In: *Zoo and Wild Animal Medicine III*, Fowler, M. E. (Ed.). Saunders, New York.
- BUSH, M., MONTALI, R. J., KLEIMAN, D. G., RANDOLPH, J., ABRAMOVITZ, M. D. AND EVANS, R. F. (1980): Diagnosis and repair of familial diaphragmatic defects in golden lion tamarins. *J. Am. Vet. Med. Assoc.* **177**: 858-862.
- COIMBRA-FILHO, A. F. AND MITTERMEIER, R. A. (1978): Reintroduction and translocation of lion tamarins: A realistic appraisal. In: *Biology and Behavior of Marmosets*, Rothe, H., Wolters, H. J. and Hearn, J. P. (Eds.). Eigenverlag Hartmut Rothe, Göttingen. pp. 41-46.
- DIETZ, J. M. AND BAKER, A. J. (in prep.): Polygyny and female reproductive success in golden lion tamarins, (*Leontopithecus rosalia*).
- GRIFFITH, B., SCOTT, J. M., CARPENTER, J. W. AND REED, C. (1989): Translocation as a species conservation tool: Status and strategy. *Science* **245**: 477-480.
- KLEIMAN, D. G., BALLOU, J. D. AND EVANS, R. F. (1982): An analysis of recent reproductive trends in captive golden lion tamarins *Leontopithecus r. rosalia* with comments on their future demographic management. *Int. Zoo Yb* **22**: 94-101.
- KLEIMAN, D. G., BECK, B. B., DIETZ, J. M., DIETZ, L. A., BALLOU, J. D. AND COIMBRA-FILHO, A. F. (1986): Conservation program for the golden lion tamarin: Captive research and management, ecological studies, educational strategies, and reintroduction. In: *Primates: The Road To Self-Sustaining Populations*, Benirschke, K. (Ed.). Springer Verlag, New York. pp. 960-979.
- KLEIMAN, D. G., BECK, B. B., DIETZ, J. D. AND DIETZ, L. A. (1991): Costs of reintroduction and criteria for success: Accounting and accountability in the golden lion tamarin conservation program. In: *Beyond Captive Breeding: Reintroducing Endangered Species to the Wild*, Gipps, J. H. W. (Ed.). Oxford University Press, Oxford. pp. 125-142.
- PARKER, W. T. AND PHILLIPS, M. K. (1991): Application of the experimental population designation to recovery of endangered red wolves. *Wildl. Soc. Bull.* **19**: 73-79.
- PHILLIPS, M. K. (1990a): The red wolf: Recovery of an endangered species. *Endangered Species Update* **8**: 79-81.
- PHILLIPS, M. K. (1990b): Measures of the value and success of a reintroduction project: Red wolf reintroduction in Alligator River National Wildlife Refuge. *Endangered Species Update* **8**: 24-26.
- PRICE, E. C., FEISTNER, A. T. C., CARROLL, J. B. AND YOUNG, J. A. (1989): Establishment of a free-ranging group of cotton-top tamarins *Saguinus oedipus* at the Jersey Wildlife Preservation Trust. *Dodo, J. Jersey Wildl. Preserv. Trust* **26**: 60-69.
- SPALTON, A. (1991): Recent developments in the reintroduction of the Arabian oryx (*Oryx leucoryx*) to Oman. *Captive Breeding Specialist Group News* **2**: 8-10.
- STANLEY PRICE, M. R. (1989): *Animal Re-introductions: the Arabian Oryx in Oman*. Cambridge University Press, Cambridge.