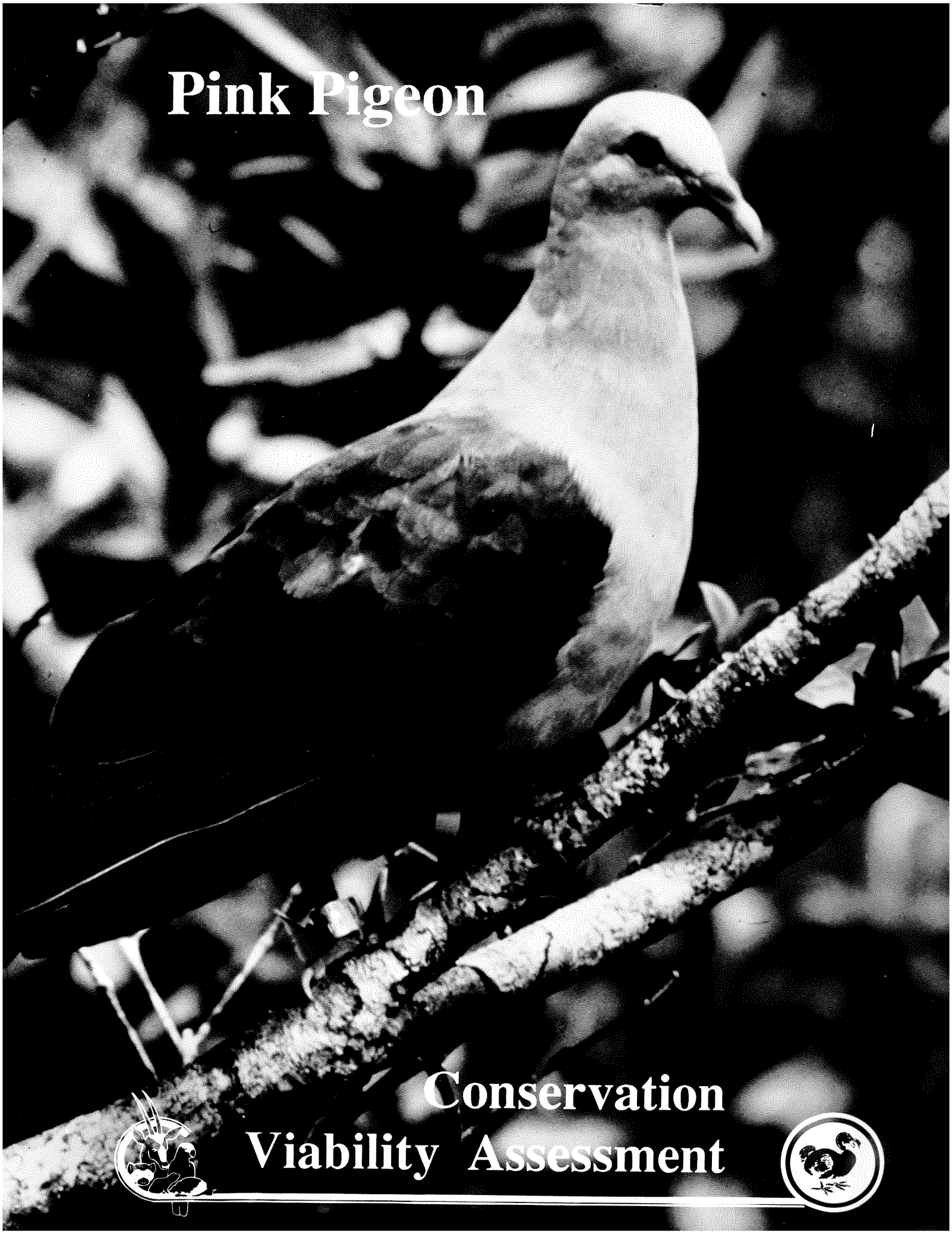
Pink Pigeon



Conservation Viability Assessment

COLUMBA (NESOENAS) MAYERI

PINK PIGEON

CONSERVATION VIABILITY ASSESSMENT WORKSHOP

REPORT

Prepared By

U. S. Seal and M. W. Bruford

A Publication of the

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SPECIES SURVIVAL COMMISSION

COLUMBA (NESOENAS) MAYERI

PINK PIGEON

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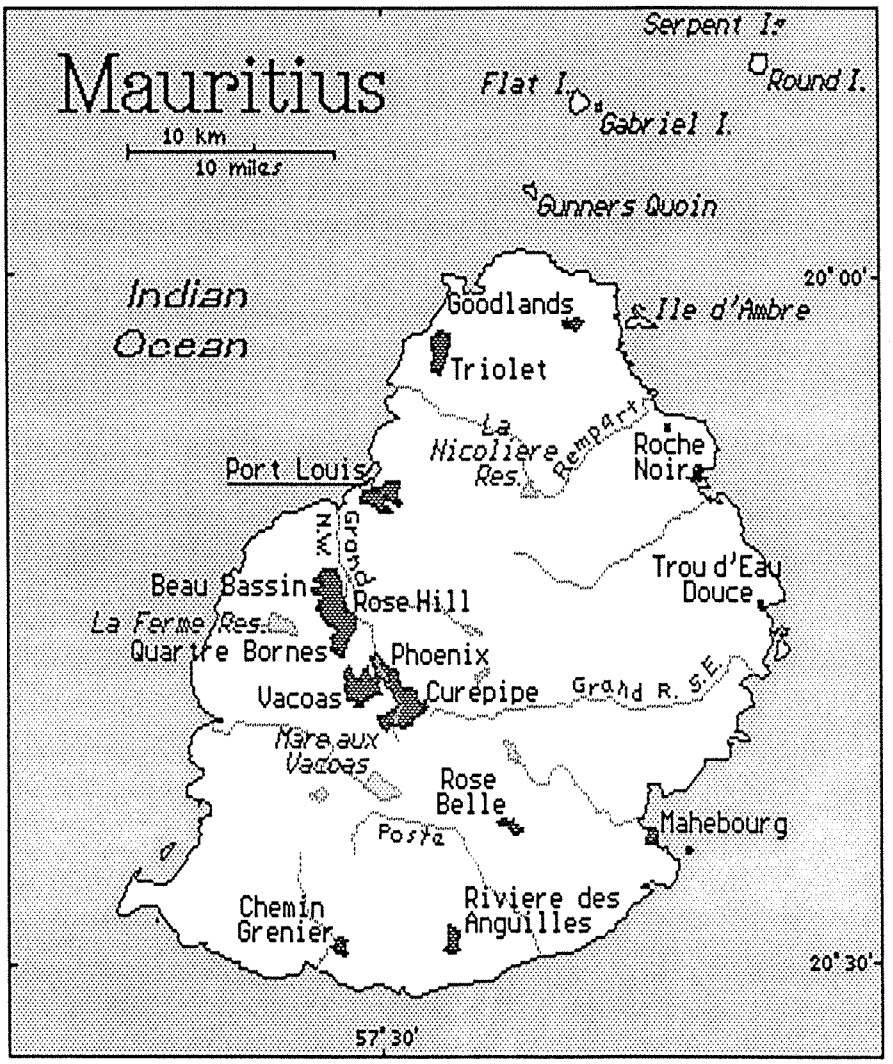
EXECUTIVE SUMMARY

The Pink Pigeon is an extremely endangered species. The wild population has been in low numbers during this century with fewer than 60 birds since 1950 and a further decline to about 20 individuals. A separate free-ranging population of approximately 10 birds has been established by release of captive bred birds into a part of the historical range on Mauritius. The studbook captive population of approximately 150 individuals is derived from 11 individuals representing about 7 effective founders. This population is distributed over facilities in Mauritius, Jersey, England, and North America. Habitat loss and introduced animal and plant species are the major factors that have caused the decline of this species. Habitat loss due to forest removal and invasion of exotic plants is still occurring. Birds are also occasionally being killed by people.

This workshop was conducted as part of a course at Jersey WPT on Wildlife Economics and Management attended by wildlife managers from 25 countries including the Chief Wildlife Officer of Mauritius. It was intended to provide an unrehearsed training experience and to accomplish a useful analysis and assessment on a critically endangered species. This approach was successful as a teaching method and in conducting the assessment process. This report provides a basis for further organization of the captive breeding programs and to indicate that the continuing constraints operating on the wild population will require an active interventionist management program for many decades. We are very appreciative of the support that has been provided by the Jersey WPT and the British Council which made this possible.

The recovery of the Pink Pigeon to viable population levels in the wild is constrained by a lack of habitat (K estimated at 100 in the present habitat) and the sustained predation by the introduced exotic crab-eating macaque which now numbers 60,000. It has not been possible as yet to develop an effective control program for this primate in the habitat of the pigeon. Survival of the wild population will require continuing supplementation until this is accomplished. The reduction in habitat occurred in the last century and the pigeon has been in low numbers since that time. This has certainly resulted in a decline in genetic diversity in the population and there is evidence of inbreeding depression in the captive population. The molecular studies suggest that careful genetic management could ameliorate this effect. The pigeon is also vulnerable to the periodic hurricanes (about every 15 years) with about 50% mortality occurring. This effect at low population numbers further increases the risk of extinction. It is possible that successful establishment of a wild population on another island may reduce the risk of extinction. However this is likely to be a long term program (more than 20 years) if a suitable location is identified. The continued survival of this species is clearly dependent upon the captive propagation program. This captive program needs to plan on at least a 100 year time scale. The development of a genetic resource banking program (sperm cryopreservation at least) for this species would be a great benefit for such a long term program and should be actively explored in collaboration with the Genetic resource Banking Working Group of CBSG.

It was the recommendation of the workshop that a follow up Habitat Viability Assessment Workshop, emphasizing the available and potential habitat for this and other endemic species, be conducted on Mauritius. This workshop will benefit from the participation of a botanist knowledgeable about possible management of the exotic plant species taking over the disturbed habitat and of a person who could advise on management and possible control of the crab-eating macaque population which appears to the major nest predator of the pigeon and other endemic bird species.


Mauritius
10 km
10 miles
Serpent I.
Round I.
Flat I.
Gabriel I.
Gunners Quoin
Indian Ocean
20°00'
Goodlands
Ile d'Ambre
Triolet
La Nicoliere Res.
Rempart
Roche Noire
Port Louis
N.W. Grand
Trou d'Eau Douce
Beau Bassin
Rose Hill
La Ferme Res.
Quartre Bornes
Phoenix
Vacoas
Curepipe
Grand R. S.E.
Mare aux Vacoas
Rose Belle
Mahebourg
Posta
Chemin Grenier
Riviere des Anguilles
20°30'
57°30'

POINTS OF AGREEMENT AND RECOMMENDATIONS

1. Conservation of the Pink Pigeon Columba mayeri in the wild is a high priority for Mauritius and for the international conservation community.

2. The commitment of the Mauritius Government in collaboration with the Jersey Wildlife Preservation Trust to the conservation of the Mauritian fauna has greatly increased our knowledge of this species and has prevented its extinction.

3. This species is an indicator of the decline of other species endemic to Mauritius as a result of forest loss and degradation, and the introduction of exotic animal and plant species.

4. The Pink Pigeon has declined in numbers in the wild from between 25-38 in the early seventies to 16-22 birds in a single population. Continued failure of recruitment to the wild population even with current releasing management carries a risk of extinction of 95% within 80 years. Extinction will likely occur in 10 years without management.

5. The establishment and the operational support of the Black River Gorge's National Park is of the highest conservation priority for Mauritius.

6. Sixty to eighty per cent of females must produce one or more offspring which is recruited into the wild population per year in order to maintain sufficient population growth to survive.

   This productivity must be reached despite high levels of nest predation due to the introduced macaque Macaca fascicularis and can only be achieved with considerable supplementary feeding (particularly during the dry season) to raise the carrying capacity to at least 75, but preferably up to 200 birds.

7. It is therefore recommended that as a matter of urgency the monkey population should be eliminated or drastically reduced in all nature reserves where there are endemic animals and plants.

   As a matter of highest priority for the survival of the Pink Pigeon in the wild there should be an elimination or reduction of the monkey populations in the area Pigeon Wood and the area surrounding Pink Pigeon release site, Plaine Lievre.

   It is recommended as a matter of urgency that there should be a study of the status and activities of the monkeys in these, and other, protected areas.

   It is recommended that a feasibility study should be made on methods of reducing, eliminating or excluding the monkey populations.

8. There is also a need to find a means of controlling nest predation and competition for the supplemented food by Black Rats Rattus rattus.

CAPTIVE POPULATION

1. The projection for the survival of the wild population predicts its extinction within 80 years. The captive population, therefore, may be vital to the survival of the species.

2. The captive population needs to preserve 90% of genetic diversity in the current population for a minimum of 100 years.

3. A genetically and demographically stable captive population needs to be secured outside Mauritius in various regional populations in North America, British Isles and Europe. This would allow Mauritius maximum flexibility to manage its captive and wild population without danger of further loss of genetic diversity.

4. Overall, the current captive population is static with a decrease of 3%/year for males and an increase of 4%/year for females.

5. Priority must be to increase the reproductive rate. 60% growth has been achieved in the Jersey population in the last three years (1988-1990).

   Review and updating of husbandry techniques in non-productive collections should increase the rate of reproduction realistically to a minimum of 15%.

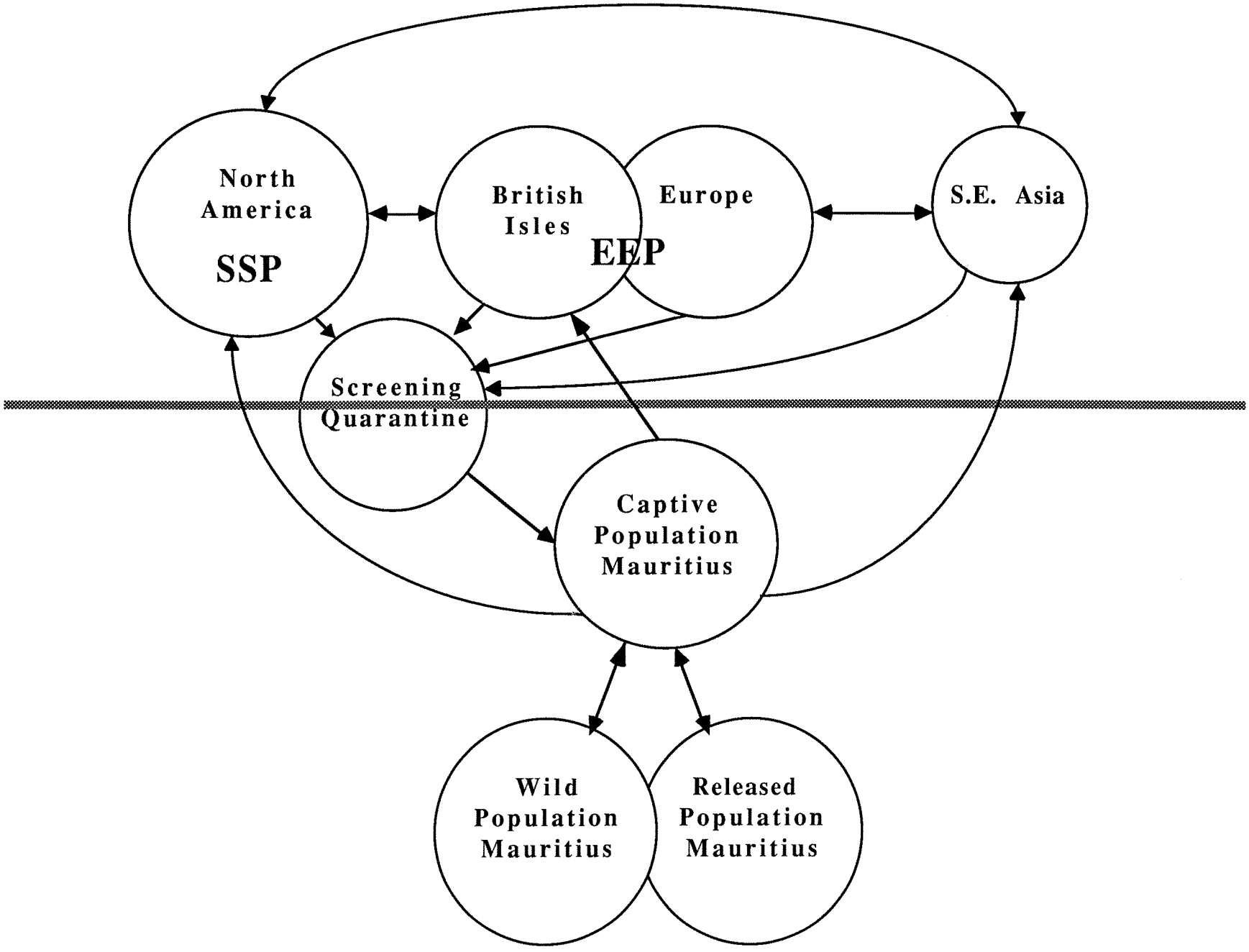
6. The target population for the captive population outside Mauritius needs to be 400.
   Requires generation time 3.7 years.
   Growth per year 1.15 (15%).
   N_e 65. Effective Founder - 60.

7. Founder representation is unbalanced. Three of the 11 founders are likely to be lost from the population unless immediate action is taken.

8. To achieve a more balanced founder representation, priority birds from which to breed have been identified. It is recommended that a number of these are moved to different locations where intensive efforts will be made to produce viable offspring from them. These include the movement of a number of birds from Mauritius to Jersey. One bird from Jurong-Jersey and several specimens within the U.S.A.

9. Irrespective of genetic importance all living individuals which have no surviving offspring should be bred from to increase the number of individuals contributing to the population.

Global Management Strategy



Captive Breeding Specialist Group

Species Survival Commission
IUCN -- The World Conservation Union
U. S. Seal, CBSG Chairman

PINK PIGEON
PVA AND CONSERVATION PLAN
WORKSHOP

16-18 April 1991

DRAFT

Problem Statement:

The pink pigeon (*Columba (Nesoenas) mayeri*) of Mauritius is an extremely endangered species, that may also represent a monotypic genus. The surviving wild population is thought to number fewer than 20 individuals. A separate free-ranging population of approximately 10 individuals has been established by release of birds into the historical range on Mauritius. The studbook captive population of approximately 100 animals is derived from a very small number 11 founders and is distributed over facilities in Mauritius, Europe and North America. Habitat loss, the major factor that has caused the decline of this species in the wild, is still occurring. Birds are also still being killed. The major issues for this species are (1) how to develop a larger and more viable captive population that can be used as a sustainable source for reintroduction programs and (2) how to develop a successful recovery program for this species in the wild, especially what needs to be done to secure adequate protected habitat for a viable population.

Goals:

(1) Prepare a Population Viability Assessment for the pink pigeon.

(2) Formulate a quantitative strategy with risk assessments to prevent extinction of the pink pigeon, to establish goals for the captive population, to propose how reproduction can be increased and management improved for the captive population, to delineate a strategy for providing animals for release to the wild, to enhance the genetic diversity of the current captive population, and to achieve the objective of developing viable, self-sustaining populations within the historic range of the pigeon.

(3) Prepare a report of the analyses, of the results of the meeting, and of recommendations for achieving the goals in (2).

12101 Johnny Cake Ridge Road, Apple Valley, MN 55124, USA tel. 612-431-9325 fax 612-432-2757
(home) 9801 Pillsbury Ave. S., Bloomington, MN 55420, USA tel. 612-888-7267 fax 612-888-5550

Objectives:

(1) Determine numbers of pink pigeons and subpopulations required for various probabilities of survival and preservation of genetic diversity for 25 - 200 years.

(2) Consider the habitat requirements needed to meet the goal of a 'viable' population in the wild.

(3) Outline metapopulation structures that could be used to achieve the goals of survival and a 'viable' wild population.

(4) Formulate the role of the captive population as a component of the metapopulation to prevent the extinction of the pink pigeon and as a source for animals for release into the wild. Develop scenarios for the size of captive population needed now and as the wild population is established and grows.

(5) Evaluate the genetic status and variability of the current captive population and the effects of additional founder material on its representation of the original wild population.

(6) Evaluate the current status of the pink pigeon in the wild, the effects on different management scenarios on the wild population, and its potential contribution to the captive population as a part of a strategy for conservation of the pink pigeon.

(7) Identify problems and issues that need continuing research and analysis.

(8) Recommend scenarios and a course of action.

Workshop Goals:

The overall purpose of the workshop is to develop a Conservation Strategy that will assure, with high probability, the continued survival and adaptive evolution of the pink pigeon (*Columba (Nesoenas) mayeri*) in the wild.

The Conservation Strategy will include specific recommendations and priorities for research and management of both captive and wild populations. The Conservation Strategy will be developed by detailed examination of the natural history, biogeography, life-history characteristics, status in the wild and captivity and threats to the subspecies continued existence. Computer models will be used to assist in evaluating the vulnerability of these populations to extinction.

PINK PIGEON P.V.A. PARTICIPANTS

DR. ULYSSES SEAL
CHAIRMAN (C.B.S.G.)
CAPTIVE BREEDING SPECIALIST GROUP
SSC; IUCN
12101 JOHNNY CAKE RIDGE ROAD
APPLE VALLEY, MN 55124
TEL: 612-431-9325
FAX: 612-432-2757

MR. CARL G. JONES
PROJECT DIRECTOR
BLACK RIVER AVIARIES
RIVIERE NOIRE
MAURITIUS
TEL: 230-683-6331
FAX: 230-683-6143

MR. YOUSSEF MUNGROO
CONSERVATION OFFICER (WILDLIFE)
MINISTRY OF AGRICULTURE
FISHERIES & NATURAL RESOURCES
CONSERVATION UNIT
4TH FLOOR
GOVERNMENT HOUSE
PORT LOUIS, MAURITIUS
TEL: 230-201-2529
FAX: 230-212-4427

MR. PETER OLNEY
EDITOR
INTERNATIONAL ZOO YEARBOOK/
CURATOR OF BIRDS
ZOOLOGICAL SOCIETY OF LONDON
REGENT'S PARK
LONDON NW1 4RY
UNITED KINGDOM
TEL: 44-71-722-3333
FAX: 44-71-483-4436

MR. MIKE BRUFORD
INSTITUTE OF ZOOLOGY
REGENT'S PARK
LONDON NW1 4RY
UNITED KINGDOM
TEL: 44-71-722-3333 EXT 831
FAX: 44-71-483 4436

DR. ROY POWELL
BIOLOGIST/RECORDS OFFICER
PAIGNTON ZOOLOGICAL &
BOTANICAL GARDENS
TOTNES ROAD, PAIGNTON
DEVON TQ4 7EU
UNITED KINGDOM
TEL: 44-803-557479
FAX: 44-803-523457

MR. MARK PILGRIM
AVICULTURAL DEPUTY
NORTH OF ENGLAND ZOOL. SOC
CHESTER ZOO
UPTON BY CHESTER
CHESHIRE CH2 1LD
UNITED KINGDOM
TEL: 44-244-380280
FAX: 44-244-371273

MR. JOHN E. COOPER
ROYAL COLLEGE OF SURGEONS
OF ENGLAND
35-43 LINCOLN'S INN FIELDS
LONDON WC2A 3PN
UNITED KINGDOM

MR. NIGEL HEWSTON
AVICULTURAL COORDINATOR
WILDFOWL & WETLAND TRUST
SLIMBRIDGE
GLOUCESTER GL2 7BT
UNITED KINGDOM
TEL: 44-453-890333
FAX: 44-453-890827

DR. ANDREW GREEN
THREATENED SPECIES OFFICER
WILDFOWL & WETLANDS TRUST
SLIMBRIDGE
GLOUCESTER GL2 7BT
UNITED KINGDOM
TEL: 44-453-890333
FAX: 44-453-890827

MR. KURT HUNGDEN
NEW YORK ZOOLOGICAL PARK
185TH STREET & SOUTHERN BLVD
BRONX, NY 10460
USA
TEL: 212-220-5070
FAX: 212-220-7114

DAVID WAUGH	TRAINING OFFICER
JEREMY J.C. MALLINSON	ZOOLOGICAL DIRECTOR
DAVID JEGGO	CURATOR OF BIRDS
KATE TAYNTON	JOINT STUDBOOK COMPILER
REESE LIND	JOINT STUDBOOK COMPILER/BIRD SECTION
KAREN HAYES	ANIMAL RECORDS COORDINATOR
JOHN HARTLEY	PERSONAL ASSISTANT TO GERALD DURRELL/MASCARENE ISLANDS COORDINATOR
ANNA C. FEISTNER	RESEARCH OFFICER
TONY ALLCHURCH	GENERAL ADMINISTRATOR/ZOO VET
SIMON HICKS	TRUST SECRETARY
GLYNN YOUNG	SECTION HEAD - BIRD SECTION

COLUMBA (NESOENAS) MAYERI

PINK PIGEON

CONSERVATION VIABILITY ASSESSMENT

REPORT

SECTION 2

OVERVIEW OF BIOLOGY AND PROGRAMS

EXTRACTED FROM JONES, C.G. & OWADALLY, A.W. (1988)
PROC. ROYAL SOC. ARTS. AND SCI. MAURITIUS 5 PART 1: 79-127

PINK PIGEON *Columba mayeri*

Brief Description and Taxonomy

The Pink Pigeon is a medium-sized pigeon, the males average about 315g and the females about 290g. There is, however, much overlap between the sexes. The tail is relatively long and broad and the wings short and rounded, while the legs are slightly elongated as is the beak. The back and wings are predominantly a dark brown, and the tail is russet. The ventral surface is a pale pink, paler on the head and neck. The male's head is often almost white.

The taxonomic position of this pigeon has been the subject of much debate. Most agree that it is a member of the genus *Columba* or is derived from it (GOODWIN, 1959, 1970; JONES, 1987). Some have felt it is distinct enough to warrant its own genus *Nesoenas* (SALVADORI, 1893; STAUB, 1973, 1976; MCKELVEY, 1976, 1977). In the most recent taxonomic review of the pigeons, Goodwin(1983) placed in it *Nesoenas* based on McKelvey's observations, noting that it shows similarities with *Streptopelia* doves. We feel its affinities are with *Columba* pigeons.

Its closest living relative may be the White-headed Pigeon *C. leucomela* of Australia, with which it shares many similarities in behaviour and ecology (see FRITH, 1982, for a good account of *C. leucomela*.)

Past and Present Distribution and Population.

Pink Pigeons were probably once widely distributed over Mauritius. They were found in the lowlands, since sub-fossil bones have been found in the Mare aux Songes (NEWTON AND GADOW, 1983). Some early accounts describe what were probably Pink Pigeons near the coast. By the 19th century the pigeons were probably restricted to the upland plateau wherever good forest persisted.

In the 1930s and 1940s the pigeon's distribution would have still extended across the central plateau.

In the early 1970s, the Pink Pigeon was found on the ridges around the Black River Gorges, including Macchabee, Brise Fer, Mare Longue and the northern slopes of Black River Peak. The pigeon was present on the crown lands to the south and west of Mare aux Vacoas, Les Mares, Plaine Paul, Plaine Champagne and along the south-facing scarp as far as Bel Ombre forest, and area of about 80 sq km. Habitat destruction in the 1970s deprived the Pink Pigeon of the important areas of Les Mares and the crown lands south of Mare aux Vacoas. This destruction also effectively cut the pigeon's route to and from the still suitable forests of Macchabee, Brise Fer and Mare Longue and no pigeons have been seen there since 1978.
In the early 1980s, the pigeon's range extended from their breeding site on the south-facing scarp between Mt. Savanne and Bassin Blanc west along the scarp into the upper reaches of Bel

Ombre forest and on to the north slopes of Black River Peak, an area of only about 25 sq km (figure 2).

Little is recorded about the early population of Pink Pigeons but by the late 19th century it was regarded as a rare bird. The population at this time would, at the most, have been in the low hundreds. By the 1950s there were thought to be about 40-60 birds (JONES, 1987). Cyclone Carol in 1960 probably halved the population, but by 1956 pigeons could be easily seen again, but they probably did not achieve their pre-cyclone status. During the 1960s and 1970s the number of pigeons declined as their habitat was destroyed, though by the early 1980s the number had apparently stabilised at about 20 birds. In 1986, 10-12 pigeons could be identified at their main roost and breeding site and the total population was thought to be around 20 individuals (D.M. Todd, pers. comm.)

Habitat Requirements

On pristine Mauritius Pink Pigeons may have been found in all vegetation types. During the last century they frequented all the native vegetation communities found above 300m in the south-west of the island. The most favoured area was the cloud forest of Montagne Cocotte and Les Mares and Plaine Paul. Today, Pink Pigeon habitat is roughly circumscribed by the 4m isohyet (see PADYA, 1972)

Feeding Ecology

The Pink Pigeon feeds upon the buds, leaves, flowers, fruits and seeds of both native and exotic plants (JONES, 1987). Fruits and seeds are more nutritions food than are leaves, buds and flowers. We suspect that "Bois Maigre" Nuxia verticillata, "Bois Manioc" Erythrospermum monticolum and "Fandamane" Aphloia theiformis are the three most frequently eaten plants.

The Pink Pigeon prefers to feed among branches of trees and bushes, although it will readily descend to the ground to feed on fallen seeds and fruits when necessary. There are seasonal changes in the availability of different foods. Flowers are abundant during the summer, though fruit and seeds gain increasing importance as the summer progresses. In late autumn and winter food becomes harder to find and the pigeons are forced to forage more and to search out fallen fruits and seeds. It is speculated that there may be food shortages at the end of winter (JONES, 1987).

Breeding Biology

Virtually nothing was known about the breeding biology of this species until the pioneering papers of McKelvey (1976, 1977). We know of only one clutch of wild collected eggs in any museum, that at the Mauritius Institute, Port Louis. Pink Pigeons have a long breeding season, extending from December or January to September. Most eggs are apparently laid between April and June (JONES,1987).

At the start of the breeding season the male establishes a territory around a suitable nest tree, which he vigorously defends from intruding pigeons. The nest is made by both birds. The male usually delivers twigs which the female makes into the nest, an untidy platform. A clutch of one or two white eggs is laid and these are incubated by both sexes. The female incubates from late afternoon to early morning and the male for the rest of the day. The incubation period is 13-15 days. The young are very poorly developed at hatching and are fed by the parents on regurgitated "crop milk". After the first four days leaves and seeds are included in the crop milk and form an increasing part of the squab's food.

The young squabs are at first covered with a sparse off-white down, but the feathers start to emerge when a week old. By ten days the squab is covered with fringing feathers. The fledgling pigeon leaves the nest at 18-22 days old, though it still remains dependent upon the parents. It probably follows the adults, occasionally being fed by them, for a week or two after fledging.

Breeding success is very poor. Only about one attempt in ten results in young being reared, and usually only one young bird is fledged (JONES, 1987). During 1986, only five nesting attempts where eggs were laid, were recorded. All of these nests were carefully watched, but all failed due to egg predation. One bird did, however, fledge from an undetected nest and was first seen on 24 September (D.M. Todd, pers. comm.) Since 1979, it is unlikely that more than three young a year have been fledged.

Habitat Destruction

The main cause of the decline has been the loss of habitat. The pigeon is largely dependent upon native forest, and as the forest has been destroyed and fragmented it has been forced to live in smaller and smaller areas.

Accounts of the destruction of native forest are given by Vaughan and Wiehe (1937), Brouard (1963) and Cheke (1978a). Vaughan and Wiehe also give a useful series of maps showing the rate of forest destruction (these maps are copied in Jones and Owadally (1985)).

Here it is sufficient to summarise the main periods of forest destruction. Mauritius was settled by the Dutch in the 17th century for the exploitation of hardwood trees, but this direct impact upon the forest would not have been great. As the population increased in the 18th and 19th centuries so the demand upon the forest grew, and areas of forest were chopped down to make way for agricultural land. In the 1830s, 65% of the island, mainly upland areas, remained under intact forest. However in 1835, the slaves were given their freedom. Many of the freed slaves went into the forest and cleared land for basic agriculture. To take their place on the sugar estates indentured labourers were brought from India. The human population had

doubled by 1850 and tripled by 1869. Between 1835 and 1846 more than half the remaining forests were felled and by 1880 only about 3.6% of the island's area remained under virgin forest (figure 4).

This century has seen a gradual eroding of the remaining areas of native forest. Relatively large tracts of native bird habitat have been cleared. The upland plateau stretching from Piton du Milieu to Black River Peak, including the forests of Bel Ombre and the Black River Gorges provided contiguous areas of native forest until the 1940s. Within this area the Midlands and Kanaka-Grand Bassin forests had been selectively logged in the 19th century. Vaughan and Wiehe (1937) provided and excellent vegetation map of the island in 1930s.

The tea industry developed in the 1940s and 1950s and upland areas centred on Midlands were cleared of native scrub for tea plantations (ROY, 1969). This development continued up into the early 1970s and by 1972 the area under tea totalled 54.6 sq km,. Most of this area had formerly been Pink Pigeon and Echo Parakeet habitat.

During the 1950s the upland pole forests and native scrub around Quartier Militaire and the Midland range were cleared primarily to plant pines, as were large areas south of Curepipe in the 1960s. Between 1967 and 1971 efforts were concentrated on clearing, and planting with softwoods, the area around Mare aux Vacoas, reservoir, Grand Bassin, Petrin, Mare Longue and Riviere du Poste - all areas utilised by Pink Pigeons, Echo Parakeets and other endemic birds. In the early 1970s destruction in this area was extended to Les Mares and Plaine Paul under the auspices and financing of the World Bank, and 30.6 sq km of key native bird habitat was cleared and planted with softwoods, between 1973 and 1981.

The clearing of Les Mares, Plaine Paul and surrounding areas resulted in precipitous declines in the populations of Pink Pigeon, Echo Parakeet, Mauritius Fody Foudia rubra and Olive White-eye Zosterops chloronothos.

In the 1980s the large scale destruction of native forest has stopped, but illegal felling of forest trees for timber and firewood still goes on unchecked.

Habitat Degradation

It is not possible to preserve the remaining native forests for the birds simply by designating nature reserves since the forests are being degraded by exotic plants. As the native trees die or are destroyed by cyclones they are replaced by exotic species which form dense thickets unsuitable for the native birds. Some of the invasive plant species are guava Psidium cattleianum and privet Ligustrum sobustum var walkeri in the uplands and tecoma Tabebuia pallida and the strangling creeper "Liane Cerf" Hiptage benghalensis in the lowlands. Many areas in the Black River Gorges are almost completely degraded and the few remaining native

trees emerge from a bed of exotic scrub. Degraded forest usually comprises a few plant species and lacks the number and diversity of invertebrates, reptiles and birds to be found in native forest. It is less suitable for Pink Pigeons because there are fewer native flowers and fruits for them to eat. Forest degradation is hastened by the rats and monkeys which destroy the seeds and fruits of native trees and by the introduced herbivores which browse any seedlings that grow.

The Impact of Exotic Herbivores on Forest Regeneration

Pigs Sus scrofa and deer Cervus timorensis hasten the degradation of the forest by trampling and browsing the slow growing native seedlings. The damage caused by deer farmers and hunters who cut down native forest for grazing areas and to provide clearings around shooting platforms is far more obvious. The whole problem of deer and their management becomes an important consideration when contemplating the conservation of the native vegetation and its dependent fauna. Careful studies of the effect of deer and deer management on the native forest are long overdue.

Since the early 1970s, there has been a conscious effort to increase the number of deer for the production of venison. This has been endorsed by Government. In a Government White Paper on agricultural diversification (ANON. 1983) it was stated, "The present legislation on Crown forest lands provides that not more than 10% of total land should be converted into pastures. Consideration will be given to relax conditions for creation of grazing grounds on Crown Lands in order to increase the number of deer per arpent". The crown lands used for deer hunting in 1985 totalled 35,000 arpents (14,773 ha). Those most affecting the kestrel, pigeon and parakeet are the crown lands in and around the Black River Gorges. Within the gorges 1,224 ha are rented for deer hunting, though intensive management of this area only started in 1972, when the deer population was 40-75 (3.3-6.1sq km). In 1984, 42 ha of forest was cleared in some of the best kestrel areas, and more clearing is proposed. By 1980, the population of deer had risen to about 400 (32.7/sq km) and in 1984, it was estimated to be about 500-700 (40.8 - 57.2/sq km). It is hoped to raise the number to 1,000 (81.7/sq km)

The other herbivore pest, the feral pig, is common in the native forests. They are most frequently encountered in areas where hunting pressure is low. In the Black River Gorges the highest densities are up small side valleys, along the Grandes Gorges river valley, on Crown Land Le Bouton and on Montagne Brise Fer. Densities are possibly 5-10/sq km within the Black River Gorge complex. The presence of deer and pigs at such high densities augurs very badly for the future of the native animal and plant communities in this area.

Food Shortages

The Pink Pigeon is probably short of food at the end of winter when the fruit stocks in the forest are largely exhausted and when

few trees are flowering, then Pink Pigeons may stop breeding, even though in captivity they can if well fed, breed in any month (JONES ET AL, 1983)

Most of the forests of Mauritius are badly degraded by exotic plants and the native plants that the pigeons feed on are now scarcer than ever before. Furthermore the introduced and adaptable Common Mynah Acridotheres tristis, Red-whiskered Bulbul Pycnonotus jocosus, monkey and Black Rat Rattus rattus all eat native flowers and fruit which may lead to the premature exhaustion of the food supply before the end of winter.

Human Persecution

It seems likely that historically human persecution of the pigeon could have had a marked influence on local populations. Since the early 1970s, however, there have only been incidental cases of birds being shot. Although these may not have had any lasting effect upon the population (JONES, 1987), it needs to be stressed that with the population at such low level any form of human persecution could be disastrous.

Nest Predation

The pigeon shows breeding success which is considerably poorer than expected. Predation upon the eggs, and to a lesser extent the young, seems to be one of the main causes.

Mopnkeys have been identified as the main nest predators. McKelvey (1976, 1977) noted that monkeys destroyed 40 out of 48 nests during 1976. Although there is no direct evidence, Black Rats probably destroy clutches as well. Come birds are also nest predators. The Mauritius Cuckoo-shrike Coracina typica was reported to have preyed upon four out of 48 clutches of Pink Pigeon eggs in 1976 (MCKELVEY, 1977). The Common Mynah was also considered a potential nest predator by McKelvey (1976), and they are believed to have stolen the eggs from as many as three to five of the nine nesting attempts at the Pamplemousses Botanical Gardens (TODD, 1985 pers. comm.)

Predation upon Adults and Fledglings

The most dangerous mammalian predators to the adult and fledgling birds are the feral cat and the mongoose Herpestes auropunctatus. Pigeons forced to feed on the ground by seasonal food shortages would be easy prey. McKelvey (1976) reported an attack on a Pink Pigeon by a Peregrine Falcon Falco peregrinus, but this must be a very rare occurrence as migrant falcons seldom visit Mauritius.

Effect of Cyclones

Pink Pigeons are very badly affected by cyclones and may be killed in the storm or suffer from post-cyclone food shortages. Severe cyclones strip trees of their flowers, fruit and leaves. All fruit-eating species are affected, and after cyclones Pink

Pigeons have been seen obviously weak or sick (JONES, 1987)

Inbreeding Depression and Disease

The data from the Pink Pigeon show the influence of inbreeding depression. The genealogies of all the captive-bred birds are known and inbreeding coefficients have been calculated (with the assumption that all the founders of the captive population were unrelated). When we compare the breeding results of unrelated pairs to brother and sister matings, or their equivalent (kinship coefficient = 0.25) we find significant differences. The percentage of fertile eggs that hatch, squabs that fledge and fledglings that survive to one year old are all significantly lower for the inbred eggs (JONES, TODD AND MUNGROO, in press). Poor breeding results are also seen in nominally unrelated pairs so it is probable that some, if not all, of the Pink Pigeons taken from the wild were closely related.
In the captive populations of Pink Pigeons on Mauritius and Jersey, mortality has followed a pattern common to many species of birds, both wild and captive. However, the percentage of individuals dying at each stage of the breeding cycle, has been higher than in most studies of other species. The incidence of infertile eggs (44.4%) has been greater than expected, parental behaviour is often poor and the pigeons have shown an increased susceptibility to a wide range of apparently unrelated diseases, both infectious and non-infectious. Further to this, a number of young develop deformities and 18 out of 152 (11.8%) fledglings reared on Mauritius have had a condition homologous to club foot in humans (JONES AND TODD, in press).

CONSERVATION RECOMMENDATIONS

Habitat Preservation and Management

Nature reserves were first set up on Mauritius in 1951. They were established in representative areas of native vegetation, based on the botanical work of R.E. Vaughan and P.O. Wiehe (1937). In 1974 some of these reserves were extended, and the Macchabee and Bel Ombre reserves were linked across Plaine Champagne to create a continuous area of protected native vegetation extending over 3,611 ha. On the mainland, nature reserves cover 4,018 ha (2% of the land) and there are another 4,842 ha of crown land, mainly mountain reserves and rough land not suitable for development. In private hands there are 3,800 ha of mountain reserve where the vegetation is protected by law. Most of these areas are classed as native vegetation, although the large trees have been logged out over much of this and large areas are badly degraded.

The long-term management of these areas poses many daunting problems due to the continued degradation of native forest. The rehabilitation of the Mauritian forests is not an easy task and at the moment the weeding out of exotic plants is the only practical approach. This unfortunately is at present only possible for relatively small areas because of the time and expense involved (JONES AND OWADALLY, 1985; STRAHM, 1988).

Legislation

The Mauritian Kestrel, Pink Pigeon and Echo Parakeet are all fully protected by law under Wildlife Act of 1983. Unfortunately this alone, without active management, is not sufficient to conserve the species.

Conservation of the Pink Pigeon

The extreme rarity of the Pink Pigeon prompted the captive breeding project which started on Mauritius in 1976. Captive breeding has been the main emphasis in the conservation of this species, although other approaches have been attempted and yet others can be applied.

Captive Breeding

The captive breeding of the Pink Pigeon has been a success. Between 1976 and the end of 1986 a total of 165 pigeons were hatched and reared at the captive breeding centre on Mauritius. Other captive colonies have been set up in Mauritius, Britain, North America, West Germany and Singapore. The main colony outside of Mauritius is at the Jersey Wildlife Preservation Trust on the Channel Islands in Britain (Table 7)

The captive breeding has not been straightforward. Fertility on Mauritius has only averaged 55.6%, this is very low and fertility rates of 85% or more would be expected from a healthy population. Of all the fertile eggs 69.8% have hatched and of these 57.7% have been reared to 30 days. These results are lower than expected and it is suspected that inbreeding depression may be partly, or largely, to blame (JONES ET AL. 1983; JONES AND TODD, in press). The captive populations are now being carefully managed to try and minimise genetic problems. The annual breeding results up to the end of 1986 are given in table 6.

Table 6 PINK PIGEON BREEDING SUCCESS AT THE GOVERNMENT AVIARIES BLACK RIVER (1977-1986)

YEAR	NO. EGG LAYING PRS.	NO. OF EGGS	MIN NO. FERTILE	NO. HATCHED	NO. REARED TO 30 DAYS
1977	2	8	6	3	3
1978	3	29	16	12	9
1979	6	70	44	30	16
1980	16	160	93	70	26
1981	13	203	104	73	38
1982	14	73	24	18	13
1983	8	50	10	10	8
1984	9	100	33	27	19
1985	13	148	44	26	20
1986	11	124	36	18	13
TOTALS		965	410	287	165

Updated from Jones et al., 1983

Release of Captive Bred Pink Pigeons in the Pamplemousses Botanic Gardens

By the early 1980s, enough Pink Pigeons had been bred in captivity to consider the release of some to the wild. A trial release was carried out in the Royal Botanic Gardens, Pamplemousses, to test techniques. The gardens, which cover 26 ha and are planted with a wide variety of trees, shrubs and climbers, are surrounded by areas, largely unsuitable to the pigeons, which it was hoped would discourage them from wandering too far. There is little dense undergrowth so the birds could be followed and monitored with relative ease. It was hoped that the release at this popular tourist spot would prove to be a valuable exercise in public relations and alert people to the plight of the Pink Pigeon and other endangered Mauritian birds.

Table 7 PINK PIGEON MOVEMENTS TO AND FROM THE BLACK RIVER AVIARIES

YEAR	IMPORTS			EXPORTS		
	Number		Source	Number		Destination
	Wild	Captive		Wild	Captive	
1976	4	-	Wild caught	-	-	-
1977	10	-	Wild caught	5	-	J.W.P.T.
1978	-	-	-	1	-	Released to wild
				3	-	C.B.P.
					3	J.W.P.T.
1979	1	-	Wild caught	-	2	C.B.P.
	-	2	J.W.P.T.	2	-	R.G.Z.
	2	-	C.B.P.			
1980	-	1	C.B.P.	-	2	J.W.P.T.
				-	1	C.B.P.
1981	1	-	Wild caught	-	6	J.W.P.T.
				-	4	C.B.P.
1982	-	5	J.W.P.T.	-	7	C.B.P.
				-	8	R.G.Z.
				-	8	N.Y.Z.S.
				-	8	V.W.G.
1983	-	-	-	-	6	R.C.S.
1984	-	1	C.B.P.	-	-	-
1985	-	-	-	-	6	C.B.P.
1986	-	1	C.B.P.	-	6	J.W.P.T/ R.C.S.
1987	-	-	-	1	5	J.B.P.
Totals	28			84		

Abbreviations:

J.W.P.T.	Jersey Wildlife Preservation Trust
C.B.P.	Casela Bird Park, Mauritius
N.Y.Z.S.	New York Zoological Society, USA
V.W.G.	Vogelpark, Walsrode, West Germany.
R.C.S.	Royal College of Surgeons, London, England, U.K.
R.G.Z.	Rio Grande Zoo, Albuquerque, USA
J.B.P.	Jurong Bird Park, Singapore.

Notes:
Only birds that reached 30 days of age are included. A small but unknown number of eggs and squabs taken from the wild failed to reach this age. The wild birds exported are the same birds that are wild caught in the imports column. All the birds received from the Casela Bird Park (except the 1986 bird) were originally exports from the Black River Aviaries. The other exports and imports (with just one exception) involve different pigeons. Out of the 84 exported birds 71 had been bred at the Black River Aviaries. Birds sent to and received from the Pamplemousses Gardens are not included, but these are listed in table 9. All the captive Pink Pigeons world-wide remain the property of the Government of Mauritius.

A total of 22 Pink Pigeons both juveniles and adults were released between 7 March 1984 and the 18 April 1985. They were provided with grains and seeds which supplemented the food they could find in the gardens. There were nine nesting attempts, where eggs were laid (table 8), though no pairs were successful in rearing young. Two pairs hatched squabs, which are thought to have died from trichomoniasis (TODD, 1985).

Table 8 CAUSES OF NEST FAILURE IN THE PINK PIGEONS AT PAMPLEMOUSSES.

	NUMBER OF NESTS
Eggs infertile	2
Eggs taken by predator } mynah	3
Cause of failure uncertain } predation?	1
Egg(s) broken on ground under nest	1
Young hatched but died from suspected trichomoniasis	2
	9

Pigeon mortality was high. The main reason for high death rate was predation by children with catapults, who are believed to have accounted for the injury or disappearance of 15 (68%) of the birds. The fate of the pigeons is given in table 9.
The study ended in July 1985 because of the high rates of predation, though two birds (a male and a female) were left in the garden. Both survived for over two years, most of this time without any supplemental feeding. The male finally disappeared in April 1987 but the female was still surviving in July 1987.
Birds released as juveniles and as adults survived equally well. The study gave useful information on release techniques and demonstrated that with adequate protection the pigeons could survive in a garden type environment. This study has provided us with the knowledge to develop the next stage of the Pink Pigeon's conservation, a release into the native forest.

Table 9 - FATE OF PINK PIGEONS AT THE PAMPLEMOUSSES BOTANIC GARDENS.

(1)	Killed by mongoose, or other predator, before release	2
(2)	Injured in release cage and returned to Black River	1
(3)	Disappeared soon after release, believed lost	3
(4)	Probably killed by poachers	11
(5)	Found dead with traumatic injuries	1
(6)	Found injured and returned to Black River	2
(7)	Found injured/dead by member of public	1
(8)	Captured and returned to aviary	2
(9)	Left in the gardens (see text)	2
		25

Notes: Sections 1 and 2 refer to three birs that were never released in the gardens. Sections 4-7 probably all refer to human predation.

Release of Captive-bred Pink Pigeons into Native Forest

The upland forests of Brise Fer and Macchabee used to support Pink Pigeons until the mid-1970s. Their disappearance from this area coincided with the destruction of the native vegetation on Les Mares. The whole of Les Mares was replaced with forestry plantations, and Pink Pigeons no longer fly from their roost, on the south facing scarp, over the pines to reach the forests of Macchabee and Brise Fer.
The Macchabe/Brise Fer forest is a relatively large area of 12 to 15 sq km of suitable habitat that could probably hold a small self-supporting population of Pink Pigeons. The birds are now available and the project started in June 1987. It is hoped to release 15-25 birds.

Supplemental feeding

We have already suggested that during the late dry season there are food shortages and the population may be food-stressed. The problem can be alleviated by the provision of additional food during the dry season. This may increase the number of Pink Pigeons that the habitat can hold and increase the rate of breeding. Supplemental feeding is a very safe management technique and it is planned to start feeding the wild birds at the end of 1987 on seeds, grains and pulses.

Gene Exchange between Wild and Captive Populations

In view of the small population size, it is important to increase the number of Pink Pigeons and to maintain genetic diversity. Gene exchange between the wild and captive populations can be easily achieved by rearing eggs from the wild in captivity and releasing captive-bred birds to the wild.
Careful genetic studies of both the wild and captive populations are called for so that the best use of the genetic material can be made, and deleterious characters can, if possible, be excluded from the population.

Translocation of Pink Pigeons to Reunion

The translocation of captive-bred Pink Pigeons to Reunion has been proposed (CHEKE, 1975; TEMPLE, 1981). This is ecologically sound since Reunion has more native forest with many of the same food plants as Mauritius, and there are no monkeys (yet!) or mongooses. Reunion once had its own endemic pigeon, C. duboisi, which may have been closely related to the Pink Pigeon. There are apparently several suitable localities where the pigeons could be released, Riviere St. Denis, Tatamaka, Riviere de l'Est, the western part of Plaine des Makes and possibly Riviere des Pluies. If the birds were to thrive in these areas they would probably spread through the middle altitude "bois des couleurs" (mixed evergreen forest) (CHEKE, 1975, 1978). Hunting pressure in Reunion is severe and any release there would have to be backed up with a suitable education campaign.

The main funding organisations have been the Government of Mauritius, World Wildlife Fund (US Appeal) (1973 - March 1981), World Wide Fund for Nature (International) (April 1981 - March 1983), New York Zoological Society (April 1973 - March 1981), Jersey Wildlife Preservation Trust and Wildlife Preservation Trust International (April 1983 continuing), International Council for Bird ¶reservation (USNational Section and International)(1973 - March 1985), Peregrine Fund (October 1982 continuing), Ian Pollard (April 1983 - March 1985), WW Brehm Fund (October 1983 - January 1984), Mauritius Wildlife APpeal Fund (March 1984 continuing). The work is administered jointly by the Government of Mauritius and JWPT.

$\mathcal{E}_{\prime}$

PINK PIGEON RELEASES AND TRANSLOCATIONS

18 April 1991

RELEASES

The first release was at the Royal Botanical Gardens, Pamplemousses on 7 March 1984. At the time we felt that this would be an ideal release site since it is a well defined area surrounded largely by sugar cane over which the pigeons would be unlikely to wander. The park-like setting would enable the birds to be easily followed and monitored and, since the gardens are a popular tourist spot, we felt it would be an important exercise in education and public-relations. The last release at Pamplemousses was on 18 April 1985 and our work here terminated soon after, since the mortality rate was high and it seemed unlikely that a self-supporting population could be established.

Nevertheless our studies provided us with valuable information and paved the way for a release in the native forest. Throughout 1986 we consolidated our work on the wild pigeons and examined the problems facing them in some detail. It became increasingly clear that the forest of Macchabe and Brise Fer, and area of about 15 sq km, was suitable for Pink Pigeons and they have occurred here regularly, apparently during all seasons, until the early 1970's. The last Pink Pigeon to be seen in this forest was on 6 September 1978. The reason why pigeons no longer used this area was not because it was unsuitable but because access to and from the forest had been cut off by pine plantations on Plaine Champagne and Les Mares, planted during 1973 to 1975, and because of the pigeon's reluctance to cross the Black River Gorges. This area was the most obvious place to reintroduce Pink Pigeons. Within the forest a release site was chosen on Plaine Lievre and the first pigeons were released on 24 July 1985. Releases in this area are still continuing.

We selected Plaine Lievre near Brise Fer as a release site within the Macchabe/Brise Fer forest. It comprises of low native scrub with open grassy areas and is very close to some of the best upland forest left on Mauritius. The release site is only 100m from the edge of the Manava Gorge, is easily accessible, is well within the Pink Pigeon's former range and is in a good mosaic of habitats.

Fate of Released Birds at Plaine Lievre:

Returned to Black River	2
Eaten by feral cat	1
Died, no obvious cause of death	1
Dispersed/disappeared	6
Released and still returning for food	8/9
Released and disappeared in less than 1 month	8
Total	27

Since July 1987 a total of 27 (9:11:7) birds have been released. These have been a mixture of adults over one year (5) and younger birds. We are still in the experimental phase of our releases and several different variations of the release technique have been tried. This last year we have built a larger and more elaborate release cage, and are working intensively to prefect release and management techniques. We hope to be able to reduce the number of birds which disappear during the first year following release.

There have been several breeding attempts. Not all nestings have been detected and it has not proved possible to closely monitor all the nesting attempts found. At least two young have been bred and have survived to maturity. One of these (a male) entered the wild population where it successfully reared one young (during the 1990/1991 season). The second young bird has paired (with its mother) and has fertilised an egg.

There are five birds due for release (April 1991) and we hope to increase the number of birds released per year to twenty.

TRANSLOCATIONS

The translocation of captive-bred Pink Pigeons to Reunion has been proposed (CHEKE, 1975; TEMPLE, 1981). This is ecologically sound since Reunion has more native forest with many of the same food plants as Mauritius, and there are no monkeys (yet!) or mongooses. Reunion once had its own endemic pigeon, *C.duboisi*, which may have been closely related to the Pink Pigeon.

Excursions were made to Reunion in 1986 and 1988 to identify specific topics of concern that required investigation if a release was to be attempted. During 20-30 March 1986, Jones and Strahm made an exploratory visit to Reunion. From 2-9 January 1988, Jones, Wendy Strahm and Tom Cade visited various parts of the island with Jeff Sayer, IUCN Tropical Forest Programme Director.

There are apparently several suitable localities where the pigeons could be released, Riviere St.Denis, Tatamaka, Riviere de l'Est, the western part of Plaine des Makes and possibly Riviere des Pluies. If the birds were to thrive in these areas they would probably spread through the middle altitude "bois des couleurs" (mixed evergreen forest). The exact area of suitable forest available is not known but is not likely to be large. Most of the apparently suitable forest exists in altitudes higher than the area in which they occur in Mauritius. Hunting pressure in Reunion is severe and any release there would have to be backed up with a suitable education campaign.

BLACK RIVER GORGES NATIONAL PARK

SUMMARY

The only sizable area of original forest remaining in Mauritius, home to a number of endangered species of birds and rare plants, is the Black River Gorges and surrounding area. This area has the highest priority for bird conservation in all of Africa, ranking first among 75 forested areas surveyed in 1988 by the International Council for Bird Preservation. It has been the site for the last fifteen years of a program of preservation of extremely rare, endangered endemic species, especially the Mauritian kestrel, pink pigeon, and echo parakeet.

Conservation of native flora and habitat for these endangered birds has also been underway. These habitats are badly degraded through destructive activities and through invasion by highly competitive exotic species.

Apart from being of paramount importance for conservation, the area possesses high scenic value and is one of the few places on Mauritius where people can go to enjoy nature and learn about their natural environment. It offers abundant opportunities for environmental education and recreation, as well as expansion of the country's tourism base. Additional benefits occur through watershed management and research.

Presently the inner gorges area are closed to most Mauritians and tourists as the area is leased for deer farming and hunting. A public park here would conserve this internationally significant area for world heritage and make the area available for environmental education, recreation, tourism, and research.

The proposed park boundaries enclose about 7630 hectares out of which about 6030 hectares are crown land and about 1600 hectares privately owned land.

The Government has approved the recommendations of the Steering Committee of the Conservation Unit to start off the implementation of the park within crown lands and to acquire the recommended privately owned areas according to a priority list.

The World Bank funded project would facilitate the establishment of Black River Gorges National Park as an area of international importance for conservation of endangered species, many of which are found only on the island of Mauritius. The project would focus primarily on preservation of species and restoration of habitat, and secondarily on developing facilities for administration, resources management, recreation, education, tourism, and research. Some areas of the park would be limited to research and conservation due to their critical and sensitive nature. Other areas, especially within the gorges, would be made available for more extensive use by the public for recreation and education. The rim of the gorges would continue to be used for scenic viewing and nature study.

The project also includes technical assistance and training for park management and for the establishment of programs and facilities for environmental education. The very successful tri-partite management and operation of the area currently underway would be institutionalized.

To meet these conservation objectives, the project would fund a number of resource management goals which are extremely important to ecosystems and species preservation and restoration. In particular the project would fund control measures for exotic plants and animals which are devastating indigenous species and natural communities.

To meet educational, recreational, and tourism objectives, the project would fund development of appropriate public facilities, staff to manage the park, and training of personnel in park management skills.

To meet the research and species preservation objectives, the project would fund an expanded captive breeding center, facilities for field researches, and equipment for ongoing research activities. International and Mauritian NGO's are committed to continuing their very substantial efforts in achieving this goal as well.

The park proposal would be implemented by the Ministry of Agriculture, Fisheries and Natural Resources (MAFNR), through a new National Park and Conservation Service (NP&CS), incorporating the present terrestrial Conservation Unit which would be strengthened through technical assistance and training. Park personnel positions would be funded though the program, supplemented by scientists, equipment, and materials from national non-governmental organizations (NGOs), such as the Mauritian Wildlife Appeal Fund, and from international organizations such as the Jersey Wildlife Preservation Trust.

This Very successful tripartite cooperation between Government, local scientists and NGOs and international organizations would be continued through the creation of an advisory board which would meet at least quarterly to evaluate progress on park implementation. After implementation, the board would continue to guide park management, policies, and funding. The Bolton report provides more detail on the possible composition of the board.

THE RELEASE AND MANAGEMENT AT LIBERTY OF CAPTIVE BRED PINK PIGEONS COLUMBA MAYERI ON MAURITIUS

C.G. Jones[1], D.M. Todd[2], K.J. Swinnerton[2] and Y. Mungroo[3]
Forestry Quarters, Black River, Mauritius, Indian Ocean

[1]Jersey Wildlife Preservation Trust Biologist
[2]Wildlife Preservation Trust Canada Biologists
[3]Scientific Officer, Ministry of Agriculture, Mauritius Government

ABSTRACT

This paper covers the release of captive bred Pink Pigeons on Mauritius. The work has been in two main phases: the trial release of 22 Pink Pigeons in the Royal Botanic Gardens in Pamplemousses and the release of 17 birds into the native forest at Plaine Lievre. At Pamplemousses there were nine nesting attempts, and two broods of young hatched but no birds fledged. The work at this site was stopped because predation upon the pigeons was high due to children. The releases at Plaine Lievre are still continuing. The pigeons adapt well to life in the native forest and exploit many of the same food plants that the truly wild pigeons do. There have been several breeding attempts and at least one young has been produced.

INTRODUCTION

The Pink Pigeon Columba mayeri is an endangered endemic bird from Mauritius in the Indian Ocean. There has been a conservation project for this species since 1976 and several captive populations have been established. The main ones are on Mauritius at the Government Captive Breeding Centre in Black River and at the Jersey Wildlife Preservation Trust, Channel Islands, UK, although there are others in the United States, Europe and Singapore.

The release of the captive bred Pink Pigeons has always been an aim of the conservation programme and since 1984 we have released 39 birds. The work is still in progress and here we give an account of the captive breeding and the rationale, techniques, results and future plans for the release project.

Before we discuss the releases it is necessary to provide some background information on the ecology and population of the pigeons (summarised from Jones, 1987; Jones and Owadally, 1988; Collar and Stuart, 1985; and unpublished observations), so that the limiting factors can be better appreciated.

POPULATION AND ECOLOGY

The Pink Pigeon is now found in native evergreen dwarf upland forest although historically it seems likely it was found in, or utilised, all vegetation types. It feeds largely on the fruit, flowers and leaves of native and exotic plants. Most feeding is done arboreally although it will descend to the ground to feed on fallen fruits and seeds. A wide range of plants are sampled but most of the food comprises just a few species. There are seasonal changes in the availability of the different foods and it is likely that there are food shortages at the end of the dry winter months (September to December). Pink Pigeons lay a one or two egg clutch. In captivity, Pink Pigeons will breed

in any month. In the wild they are seasonal. Males may start holding territories in late December or January but most of the eggs are laid March to June when there is plenty of food available. Nesting success is poor and only about one nest in ten succeeds in fledging young. During 1986 and 1987, 11 nesting attempts were followed and none reared young although one fledgling was seen which came from an undetected nest. The main cause of the low breeding success is probably egg predation by monkeys (Macaca fascicularis). At one of the nests watched in 1987, a monkey was seen in a neighbouring tree on the day the eggs disappeared.

On pristine Mauritius, the Pink Pigeon was probably widely distributed and common. Its decline was primarily the result of habitat destruction, although human persecution undoubtedly played a major role. By the 1830's it was already being described as rare and virtually all subsequent authors echoed this view. During the 1950's its population was thought to be 40-60 birds which were limited to an area of 200 sq km in the southwest and central parts of the island. The population was halved or more by Cyclone Carol in 1960 and, although the population made a good recovery, it was badly affected by habitat destruction and fragmentation in the mid 1970's. By the early 1980's the population had stabilized at about 20 individuals which were all limited to less than 25 sq km of wet upland forest in the south west of Mauritius (Figures 1 and 2).

In 1986 a maximum of 10 or 11 birds could be seen during the breeding season on any visit to the Cryptomeria grove (their only known nesting area). Breeding activity started early in 1987/1988 and birds were holding territories by November. This seems likely to have been due to the wetter than normal dry season. Up to seven territories were established at any one time although only one young bird is known to have fledged. The truly wild population is still estimated at 20 birds.

CAPTIVE BREEDING, RATIONALE AND TECHNIQUES

Captive Breeding on Mauritius and at the Jersey Wildlife Preservation Trust

The first captive birds were caught in 1976 (McKelvey, 1976; Durrell, 1977) and the first breeding results were obtained on Mauritius in 1976 (Hartley, 1976) and at the JWPT in 1977 (Jeggo, 1977). In these two main collections up until the end of 1986 a total of 1447 eggs had been laid. Only about 732 (50.6%) of these were fertile of which 370 (50.5%) hatched. Two hundred (54%) of these reached 30 days. About 63.2% of fledglings survive to reach one year (Jones et al, in press). These results are far below expected rates and since all the captive birds are derived from 11 founders, and the wild population has been small for over a century, inbreeding depression is thought to be the cause. Captive birds which have been inbred show even greater breeding failure than those wild caught birds that we have tentatively assumed are not inbred (Jones et al, in press). Nevertheless, enough birds have been bred in captivity to provide birds for release.

Rationale Behind the Releases

By the early 1980's enough Pink Pigeons were being bred in captivity to seriously consider a release programme. Since we did not understand all the reasons for the low numbers and density of pigeons it seemed pointless releasing birds into the wild where the limiting factors still persisted. Encouraged by

work on other species (e.g. Goodwin, 1952; Bedford, 1952), we felt that the first stage would be to try and establish a population at semi-liberty and thereby develop the techniques for the release and management of this species.

The first release was at the Royal Botanical Gardens, Pamplemousses on 7 March 1984. At the time we felt that this would be an ideal release site since it is a well defined area surrounded largely by sugar cane over which the pigeons would be unlikely to wander. The park-like setting would enable the birds to be easily followed and monitored and, since the gardens are a popular tourist spot, we felt it would be an important exercise in education and public-relations. The last release at Pamplemousses was on 18 April 1985 and our work here terminated soon after, since the mortality rate was high and it seemed unlikely that a self-supporting population could be established.

Nevertheless our studies provided us with valuable information and paved the way for a release in the native forest. Throughout 1986 we consolidated our work on the wild pigeons and examined the problems facing them in some detail. It became increasingly clear that the forest of Macchabe and Brise Fer, and area of about 15 sq km, was suitable for Pink Pigeons and they had occurred here regularly, apparently during all seasons, until the early 1970's. The last Pink Pigeon to be seen in this forest was on 6 September 1978. The reason why pigeons no longer used this area was not because it was unsuitable but because access to and from the forest had been cut off by pine plantations on Plaine Champagne and Les Mares, planted during 1973 to 1975, and because of the pigeon's reluctance to cross the Black River Gorges (see Figure 2). This area was the most obvious place to reintroduce Pink Pigeons. Within the forest a release site was chosen on Plaine Lievre and the first pigeons were released on 24 July 1985. Releases in this area are still continuing.

Release Procedure and Technique

The pigeons are held in an aviary prior to release. This allows them the opportunity to familiarise themselves with the area and provides a focal point to which the pigeons can return for feeding. The aviary also doubles as a trap so the released birds can be caught when necessary.

The aviary (Figure 3) is built with treated poles covered with small mesh wire netting to exclude predators and small birds. It is divided into two. One half is used to hold "decoy" birds, and the other holds the birds to be released. The decoy birds are usually surplus, non-breeders or birds due for release at a later date and they serve to attract the released birds back to the aviary for food. The two flights are 3.7 m long, 2 m wide and 2 m high. The roof is stepped and a release hatch is set into the step in the roof. Each flight has cross perches, a feeding platform and a bowl/basin for water. There is also a feeding platform on the roof where the pigeons are usually fed after release. Part of the roof and sides are screened against inclement weather. Shrubs and grasses grow in the aviary. The pigeons are fed on a mixture of seeds, grains and pulses similar to that used to feed the captive birds (Jones et al, 1985). Mongooses (Herpestes auropunctatus) are trapped around the aviary and rats (Rattus rattus and R. norvegicus) are trapped and poisoned.

The pigeons are ringed with a numbered aluminum ring, for permanent identification, and coloured rings so individual birds can be easily identified in the field. All the pigeons released since December 1984 have been screened

for pathogenic organisms. Blood smears are examined microscopically for parasites and swabs from the cloaca and throat are cultured (Cooper et al, in preparation). Only healthy birds are released although in Pamplemousses we released two birds with inclined feet. These birds were used to test release and management techniques and it was never intended to use them for breeding (see Cooper et al, 1987; Jones et al, in press for a description of inclined feet). The pigeons were kept in the aviary for 7 to 181 days (with a mean of 58 days at Pamplemousses and 36 days at Plaine Lievre) before being released (Tables 1 and 3). For one or two days prior to release the amount of food given to the pigeons was reduced or totally withheld.

The pigeons at Plaine Lievre have all been fitted with radio transmitters. The transmitter, which is attached to a piece of gauze cloth, is glued to the back feathers with "superglue" the day before, or on the morning of the release. We have experimented with two different designs of transmitters, the first weighing 2 g and lasting about 14 to 21 days (see Jones et al, in preparation for details) and the other weighing 5 g and lasting about 60 to 80 days. The latter transmitters have been favoured because they last longer and have a better range. These are epoxy-potted, single stage transmitters with a pulse repetition rate of 50-90/minute. The range of the transmitters is about 500 m in forest but from good vantage points ranges of at least 1.5 km are possible. We use a "Mariner" M-57 receiver and have a minimum of 10 kHz spacing between transmitters. So far we have not followed more than five pigeons at one time and the system has worked fairly well.

Pigeons have been released in groups of one to six (Tables 1 and 3). The birds are usually released in the afternoon but we have tried all times of the day. They are only released in calm weather. Food is placed on the outside food-platform and the hatch is opened. Typically the birds come out to feed on the platform and then fly to a nearby branch or re-enter the aviary, later returning to feed again. In subsequent days the birds become increasingly familiar with the surrounding area and learn to return to the release cage to be fed. Not all releases go to plan and some of these are discussed under the separate accounts.

The released pigeons are followed daily until they become independent. At Plaine Lievre this has necessitated establishing a permanent camp site about 200 m from the release aviary, so that field workers can live on site.

Source and Age of Birds

All of the Pink Pigeons have been captive bred on Mauritius with the exception of one wild caught adult (discussed below). The captive bred pigeons are reared under Barbary dove Streptopelia risoria foster parents and, after fledging, are socialised in groups (Jones et al, 1984). The age at release has varied from 88 to 1873 days, with a mean age of 290 days at Pamplemousses and 88 to 552 days with a mean age of 204 days at Plaine Lievre.

ACCOUNT OF RELEASES

In addition to the two main releases, a single wild-caught adult was released. This unsexed bird was trapped in April 1977 but failed to do well in captivity and showed no signs of breeding. It was released on 26 April 1978 in

the Cryptomeria grove. The bird was seen several times during the following months and was in good condition (Durrell and Durrell, 1980).

THE RELEASE AT THE ROYAL BOTANIC GARDENS, PAMPLEMOUSSES

This is a summarised and updated account from Todd (1984) (see also Jones and Owadally, 1988). The Royal Botanic Gardens at Pamplemousses cover an area of 26 ha. There are 546 species of trees, shrubs and climbers as well as various ornamental herbs, weeds and grasses (Owadally, 1976; Rouillard and Gueho, 1983). The gardens have many mature trees planted in belts and groups giving areas of continuous canopy. There are also open lawns and ponds (see Rouillard and Gueho, 1985; Owadally, 1976; Todd, 1984 for a map). The understory is open allowing easy entry to all parts of the gardens.

Release

The release aviary was constructed in the plant nursery, an area closed to public access at the north end of the gardens. In all, 25 birds were used of which 22 were released (Table 1). Two were killed in the release cage by a mongoose or another predator, having somehow gained access through the 2.5 cm netting. A third bird was returned to Black River with a permanent eye injury. Three birds disappeared soon after release. Two flew off on their first day never to be seen again and a third remained in the gardens for four days but did not relocate the release cage and finally disappeared. In the case of the two that disappeared on their first day, they flew up wind away from the gardens and quickly became lost. The presence of Village Weaver Birds Ploceus cucullatus and/or Madagascar Turtle Doves Streptopelia picturata prevented some of the newly released birds from feeding, and a strong breeze was also unsettling. Previously released pigeons usually proved to be an advantage, encouraging the newly released birds to stay in the area and feed. Occasionally, however, they did chase newly released birds away from the food platform. This situation was usually avoided by releasing the pigeons well before or after the feed-time of the troublesome bird. The provision of two or three additional feeding platforms near to the release cage helped avoid the problem of excessive competition for food from weavers, doves and other pigeons. The decoy birds did not prove to be necessary and were usually ignored by the released birds.

Behaviour at Liberty

Most of the released birds did not wander far from the release cage during their first days of freedom. The composite range of the nine birds that had established themselves in the gardens up until 31 December 1984 was only 26.8 ha (calculated from Todd, 1984) and the range at the end of the study in August 1985 was only marginally larger than this. The male number 128, between his release on 14 May and 31 December, had a range of just 17.8 ha and had during that time established five different nesting or prospective nesting territories which ranged between 0.3 ha to 1.1 ha in area. The nesting territories of pairs and well established single males have usually been over 0.6 ha in area while those held by younger males and single birds soon after release tended to be smaller. The territories were not static entities so it was difficult to obtain accurate figures for their areas. The boundaries sometimes changed daily and in many cases the male abandoned a territory to establish a new one at a distance from the first. In addition only disputed borders could be mapped with certainty

and the line of the others had to be estimated using the birds' movements and the locations of cooing perches as a guide.

The Pink Pigeons returned almost every day to the release cage to feed. Often they would feed in one large flock. They were also seen to eat the small fruits, flowers and leaves of 25 species of plant and take tentative pecks at a number of others. Some were eaten regularly, including the fruits of Passiflora suberosa and the leaves of Erythrina variegata. When in season the flowers of Gliricidia sepium and the young leaves of Toona ciliata were favoured. They also took the fruits of the Hurricane Palm Dictyosperma album. The pigeons were relatively selective in their choice of food since there were many species in the gardens that are known food items that were apparently not even sampled.

The released birds maintained good condition. Adult males (those over six months old) showed a range of weights of 268 g - 302 g (n=9) with a mean of 287 g. A female weighed 274 g. These weights compare well with those from captive birds (Cheke and Jones, 1987). The plumage of the released birds became far more bleached than those held in captivity.

Breeding Attempts

Those attempts where eggs were laid are summarised in Table 2. We briefly discuss the different pairings where breeding activity was recorded.

Male 98 x Female 129 The female was under four months old when released in March 1984, but within two months had paired up with the male number 98. Nest building started at the beginning of June and over the next three months three nests were constructed and other sites were prospected. No eggs were laid and the female was killed on 2 September.

Male 98 x Female 112 On 10 September we released female number 112 and on 14 September she had paired with male number 94 and joined him in his territory. They resumed work on the third nest from the previous pairing but the male disappeared on 27 September.

The male was a poor provider and in both the pairings he failed to collect nest material. The females apparently collected for, and constructed, the nests alone. This may have been a symptom of inexperience on the part of the male or incompatibility, a problem frequently encountered in captivity. The male copulated rather infrequently in both pairings and it is likely that no eggs were laid because of the male's low commitment to breeding.

Male 128 x Female 112 The female paired with the male number 128 on 1 October. The male delivered twigs which the female helped incorporate into a nest the male had already partly constructed. On 11 October the female laid her first egg. During incubation the female sat from about 15:00 hrs until 10:30 hrs the next morning, and the male took over in the middle part of the day. Two mornings later, a smashed egg was found at the base of the nest-tree and the pair were nowhere around. The eggshell was punctured suggesting predation by Common Mynahs Acridotheres tristis. The pair began building a second nest within two days and an egg had been laid by 22 October. The nest was deserted five days later, probably because the egg had been taken by a predator. The pair did not start building again until 4 December, but the female laid three days later. Incubation proceeded for only five days when a broken egg was found beneath the

nest. The failure was thought to be predation or the accidental displacement of the egg(s) from the nest. The female disappeared on 8 February 1985 while the pair were constructing another nest.

Male 128 x Female 139 The male paired with female number 139 and they had completed a clutch of eggs by about 22 February 1985. The nest was abandoned on 5 March and was found to be empty. The pair recycled and a clutch was completed about 24 March. At least one egg hatched about 6 April. The birds abandoned the nest on 16 April. The cause of failure was not known since the nest was inaccessible, but it is suspected that the young died from trichomoniasis. On 30 April the female was caught since she was sick. She weighed 219 g and had a large caseous and necrotic lesion around the tracheae. A throat swab was taken and examined under a microscope and elongated protozoan flagellates Trichomonas sp. were present. The condition responded to treatment with "Flagyl," an antiprotozoan drug and "Ampicillin," a wide spectrum antibiotic. She was fit enough to be released back into the gardens on 10 May.

The male had to be captured on 14 May since he had a fractured leg. He was returned to Black River.

Male 142 x Female 140 This pair laid eggs in mid-March which hatched at the very end of the month. The male disappeared on 3 April, believed killed by a poacher. The female continued to rear the young, but abandoned them on 14 April. She became very ill and was trapped on 30 April. She too had trichomoniasis and there was a large caseous nodule at the corner of the gape on the upper palette. Her weight was 230 g. Her treatment was the same as for female 139. She made a good recovery and was released back into the gardens on 10 May but disappeared nine days later.

Male 147 x Female 148 Two clutches were laid which were incubated but did not hatch and are believed to have been infertile. The male had inclined feet and it had never been our intention that he should breed. He was recaptured on 16 July 1985 and returned to Black River. The female survived in the gardens until at least July 1987.

Male 147 x Female 139 One clutch was laid about 23 June 1985 and disappeared on 2 July, believed to have been taken by predators. The female was recaptured and returned to Black River on 16 July where she still lives.

After the female was recaptured only two birds were left in the gardens; the male 147 and the female 148. These birds survived in the gardens for over two years but proved to be incompatible and never paired.

THE RELEASE AT PLAINE LIEVRE

We selected Plaine Lievre near Brise Fer as a release site within the Macchabe/Brise Fer forest. It comprises of low native scrub with open grassy areas and is very close to some of the best upland forest left on Mauritius. The release site is only 100 m from the edge of the Manava Gorge, is easily accessible, is well within the Pink Pigeon's former range and is in a good mosaic of habitats.

Releases

Twenty birds have so far been available for this study, of which 17 were released in six different groups (Table 3). One pigeon, number 394, died before release, following some fighting in the relatively cramped confines of the release aviary. A young pigeon, number 400, could not be released since it dislocated the ulna at the joint with the humerus. The cause of the dislocation was unknown. This bird was kept in the release aviary as a decoy until it died. A third bird, number 351, broke a wing and was returned to Black River.

The first release of four birds was on 24 July 1987. The birds stayed in the area of the release and, for the first three months, did not wander more than half a kilometre. One bird, number 377, disappeared on 4 August and there was no subsequent radio signal.

Another four birds were released on 24 August. The following day one of them, number 389, flew upwind and by dusk had flown 3.7 km from the release aviary. It roosted in a pine plantation and the following day, flew downwind back to the aviary. Following this it behaved normally.

The third release of three birds on 25 and 26 November was largely uneventful, although the release date had to be postponed several days due to strong winds. One of these birds, number 398, disappeared on 16 December.

Two birds were released on 4 July 1988. By this date none of the previously released birds were returning to the aviary. They did not keep in close association with each other and for the first four or five days, neither of the birds were spending much time around the release site. Pigeon number 399 was wandering at least 400 m to 500 m but usually returned to roost near the aviary. The second pigeon, number 401, was not located at all for the first seven days since his radio-transmitter was not functioning. After 9 July, the birds settled down and spent an increasing amount of time around the aviary. They were joined by the male 378 on 15 July.

At the release site the pigeons often displace each other at feed times, and this behaviour is usually initiated by the males 378 or 399.

On 17 December 1988 two birds were released, 404 and 405. They had very different personalities. Number 405 was aggressive and restlessly often flew from tree to tree. At the feeding platform on the release aviary it would chase away the other pigeons, and consequently had to be trapped at feed times while the others fed. Number 404 was timid and intimidated by 405, would sit quietly about 20-30 m away from the release aviary and rarely returned. They both disappeared on 20 December and there has been no sign of them since.

Another two birds, 403 and 409, were released on 3 February 1989. Number 403 became disorientated and seemingly distressed and spent a lot of time sitting on the floor and did not return to the release aviary. On 9 February this pigeon could not be located and the following day its remains were found about half a kilometre from the release aviary where it had probably been killed and eaten by a feral cat Felis catus. In contrast 409 was very active, flying up to 30 m away from the aviary before returning. He sampled several different native fruits and leaves and is increasingly familiarising himself with his environs

and with the already established pigeons with which he feeds in close association.

At Plaine Lievre mongooses and feral cats are potentially the most dangerous predators of Pink Pigeons. Between 30 July and 7 November 1987 we trapped 19 (16:3) mongooses in and around the release cage, a trap rate of 0.19 per day. This is similar to the rate we get in lowland forest around kestrel release sites (Jones et al, in preparation).

Behaviour at Liberty

For the first three releases a mixture of grains and pulses was put out for the pigeons every afternoon until the end of December 1986. The mixture was then gradually reduced to just barley and the rate of feeding to every other day, then every third day. As the pigeons appeared to have no difficulty finding enough food for themselves, feeding was stopped altogether on 21 February 1988. The eight surviving Pink Pigeons were seen together in trees near the abandoned camp site on Plaine Lievre on 3 March and all looked in good condition. Later during the month there were observations of single pigeons and a pair but their identities could not be established. Number 396 was, however, seen on 18 May 1988 in the company of an unknown partner. Since March only 378 and 396 have been located.

In 1987 the dry season was wetter than usual and the wet season drier, although in the uplands there was enough rain to support continued flowering and fruiting of the trees. Even so it was noticeable that the pigeons became independent in February during the wet season when most of the native trees are flowering and fruiting. Birds released during the dry months remained around the release cage and fed largely on the food provided. This trend supports the belief held by Jones (1987) and Jones and Owadally (1988) that there are seasonal food shortages during the dry winter months. While at liberty they have been seen feeding on 16 different food plants (Table 4) and several of these have also been recorded as food items for the wild pigeons (Jones, 1987). The pigeons have often been seen just sampling unfamiliar plant species. It is very encouraging that captive bred pigeons should independently exploit many of the same food plants as the wild birds.

At the beginning of September, two months after the fourth release, 399 and 401 were beginning to wander more and were seen feeding on the flowers of Nuxia verticillata about half a kilometre from the release site. The pair 378 and 401 have often been seen foraging together on the forest floor, flicking over dried leaves with their beaks and picking up grit and seeds.

The released birds have proven adept at coping with inclement weather and usually roost in areas of good native forest or around the release site, where they roost in the dense crowns of native trees. Cyclone "Firinga" passed close to Mauritius during the night of 28-29 January 1989. The cyclonic weather persisted for 21 hours with wind gusts of up to 190 km/h and 415 mm of rain was recorded by the meteorological department. None of the released birds are known to have suffered as a result, but the pigeon 396 returned to the release cage ten days later in poor condition, perhaps suffering from the consequences of post-cyclone food shortages.

There are several weights available from the free living birds, these data include some reweighings of the same birds. The males weighed on average 288 g with a range of 258-327 g (n=13). The female's averaged 268 g with a range of 228-288 g (n=5). These birds were in good condition and the weights fall comfortably within the ranges given by Cheke and Jones (1987) for captive birds in good condition. The female 396 returned on 7 February 1989 after an absence of several months. She was in poor condition and weighed 217 g on 8 February. This weight is at the lower end of the range given by Cheke and Jones and is 25% lighter than average. A sub-adult male thought to be about six months old that returned with the female (see below) weighed 278 g and was in good condition.

Breeding Attempts

There have been at least two or three different breeding attempts where eggs were laid and at least one young bird has been produced. It is probable that there have been undetected nestings.

Male 392 x Female 389 On 6 December the male was seen searching for nest material near the camp site. He was followed and the pair was found to be building a nest in an area of tall forest on Plateau Todd, a broad ledge above Manava Gorge. The nest was about 12 m up in a tangle of liana covering a tree. It was not possible to see the sitting bird from the ground. Nest-building continued until almost the end of the month. The male collected some twigs from the ground and bushes under the nest tree, but also visited the camp site over 500 m away to pick up rootlets. The female also collected some nest material. While on the nest the female called to the absent male and sometimes left to look for him. On 31 December the nest had apparently been abandoned with no evidence that eggs had been laid. The pair were found nest-prospecting that day, and in early January they were building another nest in a tree near to the first. On 22 January the pair were still nest building, but subsequently lost interest and there have been no further signs of breeding from this pair (Young, 1988a and 1988b).

Male 378 x Female 401 Courtship was first observed on 19 September and the pair started to spend more time together. The first copulation was seen on 21 November. The pair were frequenting the north slope of the Brise Fer Ridge and on 22 November the male was collecting nest material from the forest floor. On 3 December the pair were building a nest with the male delivering twigs to the female who arranged them. The pair was also more aerial and the same day was displaying above the forest canopy with courtship chases. At one stage the female was seen following the male. The following day the birds continued their displays and a second nest was found being constructed about 150 m from the first. The nest was about 7 m above the ground in the dense foliage of a native tree and the surrounding forest bädly degraded with relatively low guava Psidium cattlianum and privet Ligustrum robustum var. walkeri bushes. The male collected the nest material from the ground or snapped dried twigs off branches. All the material was apparently collected from within 50 to 60 m of the nest tree and most of it from 5 to 10 m around its base. The pair laid a clutch of eggs during the second week of December, but following a period of heavy winds and rain two smashed eggs were found beneath the nest on 14 December.

After the failure of this nesting attempt the pair apparently laid a second clutch. On 16 December they were found about 150 m away prospecting among some native trees and the female was seen apparently soliciting copulation. A nest

site was chosen about 12 m high next to the tree trunk rendering the sitting bird all but invisible from below. On 4 January 1989 the male was sitting, and by the seventh, the birds were sitting tight. The pair adopted the normal routine, the male incubating from about 08:30 hrs until about 16:00 hrs and the female for the rest of the time. The male, however, often came off the nest at about 10:00 hrs or 14:00 hrs for half or three quarters of an hour and was replaced by the female. After the passage of Cyclone "Firinga" on 28/29 January, the pair became less attentive and had abandoned the nest by mid February.

Male (?)378 and Female (?)396 On 8 February 1989, after an absence of over 11 months, 396 returned to the release cage accompanied by an unringed, well grown sub-adult male at least six months of age. The sub-adult was trapped on 8 February and given the number 413. It is assumed that the subadult is 396's progeny. When last seen in May 1988, 396 was apparently paired to 378. Number 396 was in poor condition when she returned (see above) and it is assumed that they visited the release cage for food because they were foraging further afield as a consequence of post cyclone food shortages.

During December 1987 and January 1988 all the male birds had set up territories on Plateau Todd and called loudly from the tops of the trees. The odd male 399 first started to territorial coo in mid-August 1988. He was seen to court 401 on 19 September and unsuccessfully competes with 378 for her attentions. This male has been seen territorial cooing on the Brise Fer ridge, but in late January established a territory around the camp site and built a nest. He defends this area from other pigeons and displays and wing claps above the site.

DISCUSSION

It is worth commenting on the techniques we used and suggest ways in which the work can be developed and improved.

Release Technique

The release aviary has proven to be a good functional design. It is, however, a little small if more than three or four birds are being held. The losses of, and injuries to, birds in the aviaries should be avoidable. Greater diligence needs to be taken to exclude predators and intraspecific fighting can be prevented by constructing aviaries with three or four divisions so that offending birds can be separated. At the Plaine Lievre aviary we have used 1.2 cm wire netting which is sunk into the ground and has effectively excluded most rats and mongooses. A mongoose did, however, enter the aviary via the open release hatch. Fortunately most mongooses can be trapped around the release aviary with cage traps.

Ideally, we would have liked to place both release aviaries in a prominent position from which the pigeons could see the surrounding country and where they could easily find their way back, once released. This was not possible for either site but, nevertheless, the release sites proved to be adequate.

The period that the pigeons should be kept in the aviary prior to release has varied but a minimum of 30 to 40 days is suggested. The three birds that were lost at Pamplemousses soon after release had only been held in the aviary for ten, 17 and 27 days respectively. Prior to release, we suggest that food

be completely withheld for a day and the birds released in the afternoon. The released pigeons will then hopefully spend most of their first afternoon at liberty near the main source of food and will learn the position of the aviary in relation to the surrounding areas from new vantage points.

On the day of release, any disturbance must be avoided since, if a bird panics and flies out of the immediate area, it may become lost. Pink Pigeons that chase others at or near the aviary should be caught up before new birds are released.

Several of the birds at both sites have appeared distressed and disoriented after release. They either nervously fly around or sit listlessly, apparently lost, although they may only be a few hundred meters from the release site. Some of these have permanently disappeared. Goodwin (1952) has noted that liberty Barbary Doves can become hopelessly lost less than a quarter of a mile from home.

Health, Disease and Mortality

Most of the birds were screened for pathogenic organisms prior to release. Data from the Pamplemousse birds has been summarised by Cooper et al (in press). Of the birds released at Plaine Lievre, no parasites were detected and cultures of oesophageal and cloacal swabs revealed pure growths of lactose fermentation coliform bacteria, in particular E. coli.

The causes of mortality at Pamplemousses are given in Table 1. Three birds were killed or injured prior to release, three were lost soon after release and up to 15 (68% of those released) were killed or injured by boys with catapults. Two healthy birds were returned to the aviaries at Black River and two survived in the gardens for over two years. Excluding the birds returned to Black River, males survived an average of 203 days (n=11) and the females, 189 days (n=9) at liberty. The age at death, or injury and subsequent removal, averages 560 days for males and 431 days for females. The shorter life span of the females is also seen in captive birds (Jones et al, in press).

The only case of disease that we encountered at Pamplemousses was the outbreak of trichomoniasis which is believed to have killed two broods and debilitated two adult females. Trichomoniasis has been encountered in captive Pink Pigeons (Jeggo, 1977; McKelvey, 1977; Jones et al, in press), but this is the first record from free-living birds. We believe the host for the trichomoniasis was the Barred Ground Dove Geopelia striata that are common in the gardens. A dead Barred Ground Dove was found in the gardens at the time of this outbreak with large caseous masses in the throat, characteristic of the disease (Keymer, 1982). Trichomoniasis has been isolated from wild Barred Ground Doves in Hawaii (Kocan and Banco, 1974).

The pigeons at Plaine Lievre have been free of disease and the causes of disappearance are not known. Our studies at this site are still too early to be able to give details on rates of mortality and longevity.

At both sites we have occasionally found Hippoboscid flies on the pigeons. Infected birds usually have one or two flies.

Future Development of Pink Pigeon Management

The future of our Pink Pigeon work can be divided into three broad categories: further releases, supplemental feeding and egg manipulation of wild populations.

Further Releases A possible release site for Pink Pigeons is Ile aux Aigrettes in the Mahebourg Bay. This 60 acre coralline islet is a Government nature reserve, leased to the Mauritius Wildlife Appeal Fund who manage it. The islet has no mongooses or monkeys and rats and feral cats have been largely, if not completely, eradicated. The islet is covered by native coastal vegetation including an endemic, but locally common, ebony tree Diospyros egrettarum and has a watchman who prevents unauthorised access. The islet may well be able to hold a small population of pigeons which would be supplementally fed. We feel confident that the pigeons would not leave the island since Pink Pigeons are reticent about crossing areas of unfamiliar habitat and it is a common characteristic of island birds not to cross large expanses of water (Diamond, 1985).

Several authors have recommended that Pink Pigeons are released on the neighboring island of Reunion (Cheke, 1975, 1978; Temple, 1976, 1981; Jones, 1987; Jones and Owadally, 1988; Collar and Stuart, 1985) where there is suitable habitat, a lack of mongooses and monkeys and an apparent vacant niche, since the same or a similar pigeon (Columba duboisi) once occurred on the island but was apparently extirpated by human predation. A.W. Diamond (1985) and Jones and Owadally (1988) have further suggested that such an introduction would only be feasible if hunting was strictly controlled in the areas where pigeons were introduced. Jones et al (in press) have recently conducted a feasibility study on the introduction of the Pink Pigeon and Mauritius Kestrel to Reunion and which should be consulted for further details.

Supplemental Feeding It has been suggested that seasonal food shortages are limiting the numbers of Pink Pigeons (Jones, 1987; Jones and Owadally, 1988). Jones and Owadally suggested that supplemental feeding of the wild birds at the end of the winter could increase the holding capacity of the habitat and would probably extend the breeding season. The pigeons could be fed at a regular feeding station at or near the Cryptomeria grove. Released decoy birds could attract the wild birds back to the feeding station and encourage them to take grains and pulses.

Egg Manipulations The productivity of the wild pairs could be greatly increased if eggs were harvested for captive rearing. Our successes at hatching and rearing Pink Pigeons is considerably better than in the wild since we do not have to contend with a high rate of egg predation (Jones et al, in press). It was originally suggested that eggs should be removed, incubated and reared safely in captivity and the young returned to the wild after fledging (Jones in Collar and Stuart, 1985). Jones and Owadally (1988) suggest, however, that wild eggs should be harvested for captive rearing and breeding and that captive bred young should be released to obtain good gene flow between the populations. We hope to harvest eggs this coming season. In addition to providing us with additional birds it will also give us very valuable information on rates of fertility, embryonic death and squab fitness and survival. These data will be very important for comparison with the productivity of our captive birds, which is

very poor when compared with the breeding success recorded from other species of pigeons (Jones et al, in press).

The work clearly indicates that captive bred Pink Pigeons can be relatively easily introduced to the wild. The release at Pamplemousses was very disappointing in that human predation was high but very encouraging in that the birds did adapt to a garden/park setting and produce young. The results from Pamplemousses and Plaine Lievre auger well for the future of the Pink Pigeon in modified habitats and it seems likely that, with supplemental feeding, breeding populations of pigeons could be kept at liberty in a wide range of habitats.

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Table 1. Life history data from the Pink Pigeons at the Royal Botanical Gardens, Pamplemousses.

Ref. No.	Sex	Date hatched	Date released	Date last seen or removed	Days in release cage	Age at release (days)	Days in Gardens
131	?F	4 Dec 83	-	29 Feb 84	3	-	0
119	F	14 Oct 82	7 Mar 84	7 Mar 84	10	510	1
128	M	6 Nov 83	7 Mar 84	14 May 85	10	120	433
127	M	19 Sep 83	20 Mar 84	16 Jul 85	7	183	483
129	F	2 Dec 83	20 Mar 84	2 Sep 84	7	109	166
130	?M	3 Dec 83	20 Mar 84	20 Mar 84	10+ 7	108	1
98	M	29 Oct 81	1 Apr 84	27 Sep 84	11	885	179
133	M	25 Feb 84	1 Aug 84	20 Sep 84	80	158	50
134	M	5 Apr 84	1 Aug 84	29 Dec 84	68	118	150
135	?F	5 Jun 84	1 Sep 84	22 Oct 84	22	88	51
25	M	26 Jul 79	10 Sep 84	8 May 85	166+15	1873	239
112	F	21 Apr 82	10 Sep 84	8 Feb 85	89+15	873	151
137	F	20 Aug 84	6 Jan 85	8 May 85	82	139	122
138	?	29 Aug 84	-	11 Nov 84	26	-	0
139	F	1 Sep 84	6 Jan 85	16 Jul 85	82	127	114+67
140	F	2 Sep 84	6 Jan 85	19 May 85	82	126	114+ 9
142	M	7 Sep 84	6 Jan 85	3 Apr 85	82	121	87
143	M	8 Sep 84	6 Jan 85	6 Mar 85	82	120	59
145	M	23 Sep 84	4 Feb 85	15 Apr 85	85	134	70
147	M	7 Oct 84	4 Feb 85	? Apr 87	85	120	920
148	F	28 Oct 84	26 Feb 85	? Jul 87	51	121	1000
149	?F	12 Nov 84	26 Feb 85	19 May 85	51	106	82
146	M	2 Oct 84	24 Feb 85	10 Apr 85	49	145	45
352	?F	7 Dec 84	18 Apr 85	21 Apr 85	27	108	4
353	?M	3 Feb 85	-	25 May 85	19	-	0

Notes: 131 and 138 ? killed by mongoose in release cage. 119 and 352 disappeared on day of release, or soon after, without returning to feed. 128 recaptured after its leg had been broken, probably by a poacher. 127 returned to Black River, had inclined feet. 129 bird or body taken by boy visiting the gardens. 130 slightly injured in release aviary, temporarily removed to Black River and disappeared on day of release. 98 disappeared while nest-building, killed by poacher? 133, 135, 143, 145 and 146 disappeared, killed by poacher? 134 not seen since caught for parasite screening tests, killed by poacher? 25 and 112 decoy birds returned temporarily to Black River; 25 recaptured after its leg had been broken, probably by a poacher and 112 disappeared while nest-building killed by poacher? 137 not seen since been caught for routine weighing, killed by poacher? 139 and 140 removed 30 April - 10 May 1985 to be treated for trichomoniasis; 139 returned to Black River, 140 disappeared, killed by poacher? 142 disappeared while feeding squabs, killed by poacher? (? body found by labourer). 149 found dead with traumatic injuries probably caused by poacher. 353 removed to Black River with infected eye.

Table 2. Breeding attempts by the Pink Pigeons at the Royal Botanic Gardens Pamplemousses.

Parents	Date egg(s) laid	Date hatched	Date failed	Cause of failure
128 x 112	11 Oct 84	-	13 Oct 84	? predation by mynahs
128 x 112	22 Oct 84	-	27 Oct 84	unknown
128 x 112	7 Dec 84	-	12 Dec 84	egg broken on ground
128 x 139	22 Feb 85	-	5 Mar 85	predation, nest empty
142 x 140	17 Mar 85	30 Mar 84	14 Apr 85	trichomoniasis
128 x 139	24 Mar 85	6 Apr 84	16 Apr 85	trichomoniasis
127 x 148	2 May 85	-	19 May 85	eggs infertile
127 x 148	3 Jun 85	-	23 Jun 85	eggs infertile
147 x 139	23 Jun 85	-	2 Jul 85	predation, nest empty

Table 3. Life history data from the Pink Pigeons at Plaine Lievre.

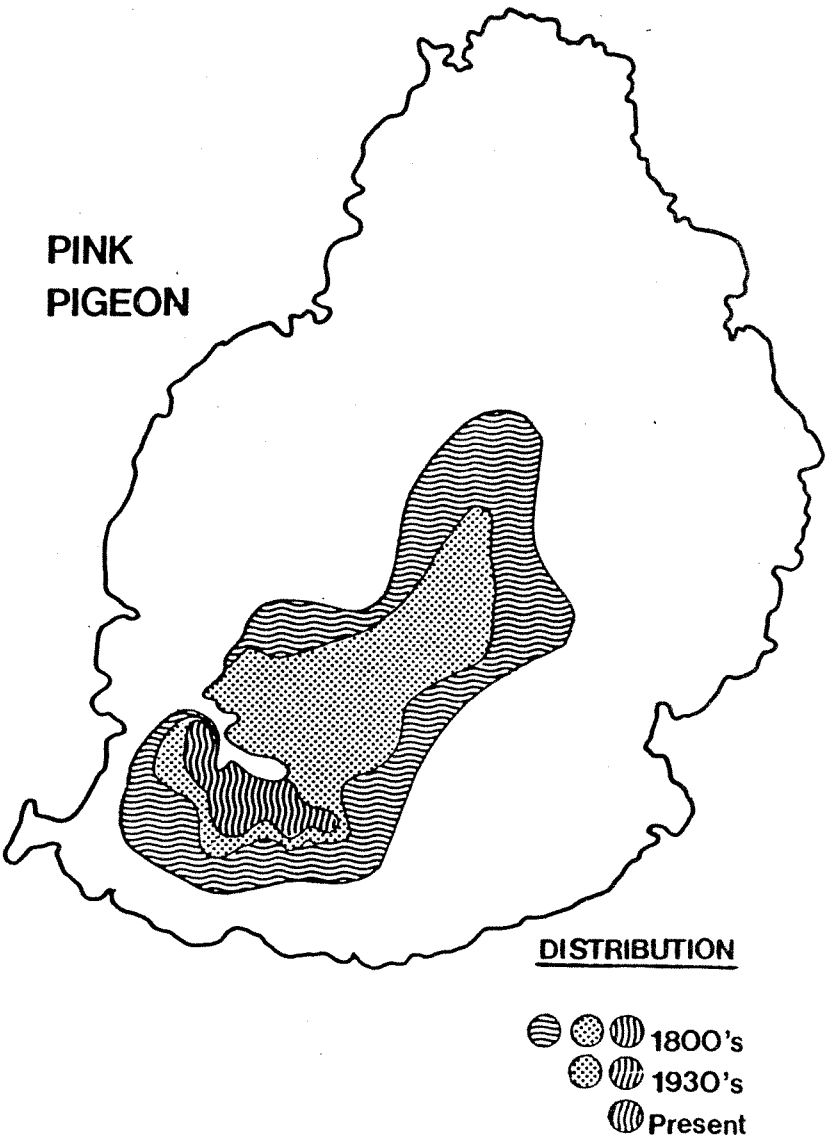
Ref. No.	Sex	Date hatched	Date released	Date last seen/died/ removed	Days in release cage	Age at release (days)
377	?M	9 Sep 86	24 Jul 87	4 Aug 87	30	318
388	M	3 Nov 86	24 Jul 87	3 Mar 88	30	231
378	M	10 Sep 86	24 Jul 87	returning	30	317
375	M	18 Jan 86	24 Jul 87	3 Mar 88	30	552
387	F	12 Nov 86	24 Aug 87	3 Mar 88	25	285
391	M	21 Jan 87	24 Aug 87	19 Oct 87	25	215
392	M	1 Feb 87	24 Aug 87	3 Mar 88	25	204
389	F	9 Jan 87	24 Aug 87	3 Mar 88	25	227
394	?	17 May 87	-	22 Nov 87	-	-
396	?F	22 Jul 87	25 Nov 87	returning	40	126
397	F	12 Aug 87	25 Nov 87	3 Mar 88	40	104
398	?F	24 Aug 87	26 Nov 87	16 Dec 87	40	93
399	M	21 Jan 88	4 Jul 88	returning	53	163
400	?		4 Jul 88	11 Oct 88	-	-
401	F	14 Mar 88	4 Jul 88	returning	53	112
404	?	8 Aug 88	17 Dec 88	20 Dec 88	44	131
405	?	20 Sep 88	17 Dec 88	20 Dec 88	44	88
351	M	1 Oct 84	-		-	-
403	?	16 Jul 88	3 Feb 89	9 Feb 88	37	212
409	?	31 Oct 88	3 Feb 89	returning	37	95

Table 4. Food plants eaten by the released Pink Pigeons on Plaine Lievre

Species	Part eaten
Burseraceae	
Protium obtusifolium	leaves
Ebenaceae	
Diospyros tessellaria	fruit (seeds only?), flowers
Diospyros sp.	leaves sampled
Euphorbiaceae	
Stillingia lineata	leaves (in cage only)
Filices	
Unidentified terrestrial fern	fronds sampled
Flacourtiaceae	
Aphloia theiformis	fruit, young leaves sampled
Erythrospermum monticolum	fruit
Loganiaceae	
Nuxia verticillata	flowers, young leaves regularly eaten
Melastomataceae	
Memecylon trinerve	leaves regularly taken
Myrsinaceae	
Ardisia crenata (I)	fruits
Ochnaceae	
Ochna mauritiana	young leaves sampled
Oleaceae	
Ligustrum robustum (I)	flowers
Rosaceae	
Grangeria borbonica	leaves
Rubiaceae	
Antirhea borbonica	leaves
Gaertnera sp.	fruits
Thymlaeaceae	
Wikstroemia indica (I)	leaves
Umbelliferae	
Centella asiatica (I)	leaves regularly eaten in cage
Verbenaceae	
Premna corymbosa	young fruits

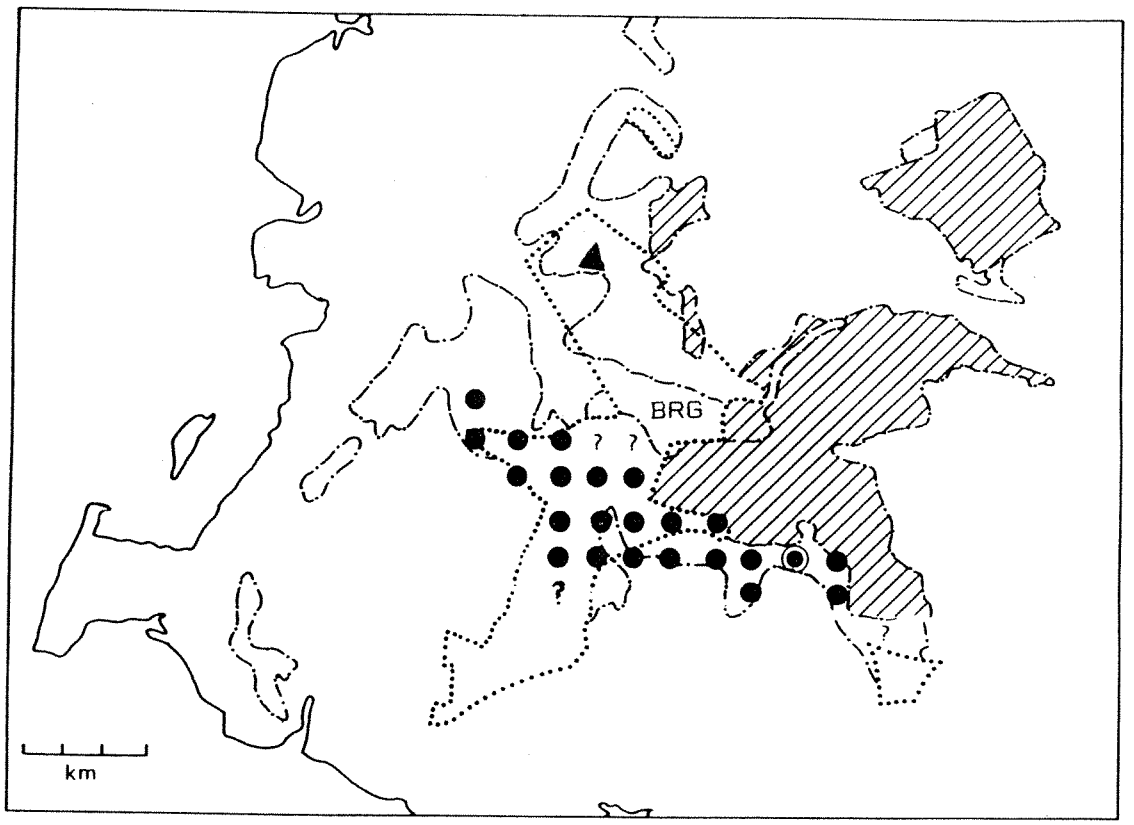
All plants indicated (I) are exotic.

Figure 1. Past and present distribution of the Pink Pigeon



The map shows the contracting distribution of the Pink Pigeon. In 1800 the pigeon had a distribution of about 400 sq km, today the distribution is less than 25 sq km. The island is 1865 sq km.

Figure 2. The present distribution of Pink Pigeons and the Plaine Lievre release site



Native forest

Native forest cleared 1973-84

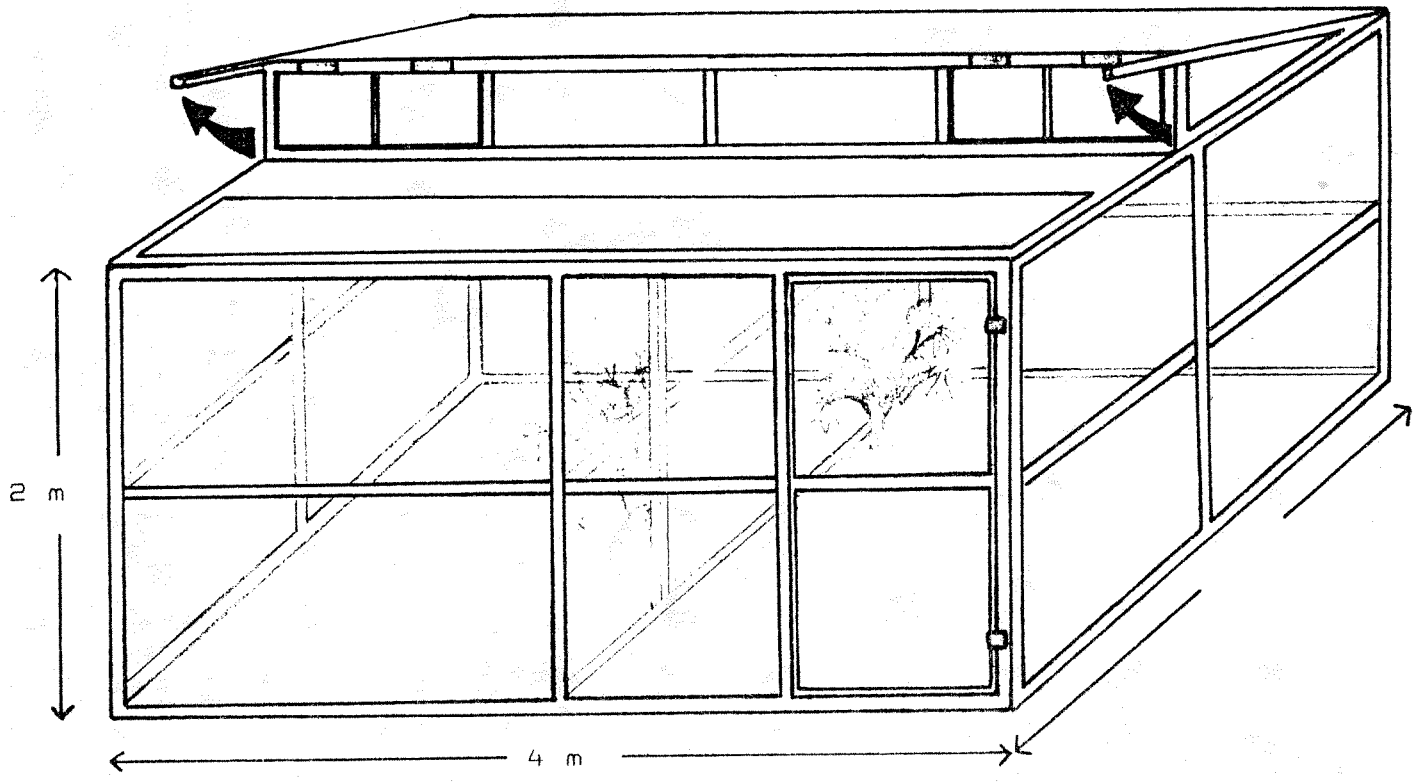
Nature reserve boundary

A kilometre square used by Pink Pigeons

A known breeding and/or roosting site

The figure shows kilometre squares where the wild Pink Pigeons were recorded 1980 - 1988 and illustrates how the pigeons have been cut off from their former habitat on the north side of the Black River Gorges by habitat destruction. The Plaine Lievre release site, indicated by a triangle, is within their former distribution. Updated from Jones (1987).

Figure 3. Pink Pigeon release cage



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COLUMBA (NESOENAS) MAYERI

PINK PIGEON

CONSERVATION VIABILITY ASSESSMENT

REPORT

SECTION 3

POPULATION VIABILITY ANALYSIS

PINK PIGEON (*Nesoenas mayeri*) PVA

M.W. Bruford, C.G. Jones, U.S. Seal

Stochastic simulations of population growth and size fluctuation using the VORTICES program: application to the extant wild population of the pink pigeon.

INTRODUCTION

This introduction will set out the necessary background information in order to put the model and simulations into context with the rest of the PVA. Its aim is to assist in the interpretation of the results and recommendations, and it is divided into the following three sections:

(1) the model -its design and function,
(2) parameters of the wild population and
(3) goals for recovery.

1. The model - its design and function.

The VORTICES program (written by R. Lacy, Chicago Zoological Society) simulates the history of populations affected by demographic processes. The program is designed to follow the progress of small, often isolated populations. Such populations are especially vulnerable to the effects of stochastic processes, and the resultant fluctuations in size (numbers of indivduals) can lead to population extinction even if there is an average positive growth.

The model simulates demographic events in a population's history, and models processes as discrete, sequential events with a probabilistic outcome determined by a pseudo random number generator. Random numbers are generated to simulate birth and death processes and the transmission of different alleles from parent to offspring. The program tracks the fate of the population over a defined time span and its output includes summary statistics on the probability of extinction over specified time intervals, the mean time to extinction of the simulated populations that went extinct, the mean size of populations that did not go extinct and the levels of genetic variation remaining in the surviving populations.

A fuller treatment of the structure of the program and the parameters that are entered can be found in the software documentation section of this volume.

VORTICES is the metapopulation version of VORTEX, and its chief advantage over VORTEX is that it can track the fate of multiple sub-populations taking into account user-specified migration rates between those subpopulations. The VORTICES output comprises summary statistics on each sub-population, and also on the metapopulation. In this case VORTICES was run for just one population because this will allow for the eventual inclusion of the re-released population in the calculations, either as a sub-population or as part of one population with the truly wild birds.

2. *Parameters of the wild population.*

Accurate estimates of means and variances of population parameters are important if results from population viability analysis are to be meaningful. Some of the parameters of the wild pink pigeon population have yet to be determined accurately, and indeed are difficult to quantify due to the extremely small number of individuals from which data could be extracted. The numbers used in this analysis were largely obtained from field studies carried out by JWPT biologists and others since 1973. Where data were not available, we used best guess estimates based on any available or circumstantial evidence and captive population data.

Population size.

Historically, the pink pigeon may have ranged over the whole of the island of Mauritius, as subfossil bones have been discovered in lowland sites (Jones 1987). However, all specimens collected in the nineteenth century, for which data has been obtained, were located on the south-west plateau, indicating that the bird's distribution was already restricted (Jones 1987). Since the turn of the twentieth century, the bird has always been described as rare, though estimates of population size based on census, only started in the 1950's, where three separate estimates put the population size at 40-60 (probably nearer 60) (Jones 1987).

The present size of the wild population is estimated at between 16 and 22 birds. This census size is the result of a recent ringing program. Figure 1 charts the most likely path for decline in numbers since 1950. The population is located in one small area, utilising approximately 25 sq. km. within an additional area of 15 sq. km. of suitable habitat which is infrequently utilized.

Reproduction rates.

Pink pigeons almost always produce one clutch per year, with a maximum of two eggs per clutch. Field studies have shown that mean cutch size is 1.70 (Jones 1987), and mean brood size per successful nesting attempt is 1.1. The sex ratio of male:female at fledging is 1.1:1 (Jones 1987). Currently, however, breeding success is very low (0.12 young fledged per nesting attempt) due primarily to predation (Jones 1987).

The birds are loosely seasonal in the wild, egglaying peaks towards the end of the wet summer in April, and ceases before the end of the dry winter at around August/September. These dates vary considerably with annual weather patterns and food availability (Jones, 1987). Breeding usually occurs once a year, with the juveniles foraging with the parents for up to four months. Birds can breed in their first adult year and can continue to do so for their lifespan.

Nest and chick predation by black rats (*Rattus rattus*) and the crab eating macaque (*Macaca fascicularis*) means that at best 50% of females rear one or more young to independence. Data from Jones (1987) has shown that currently female productivity might be as low as 8.2%, if the same level of hatchability of fertile eggs occurs in the wild as in captivity. A range of production rates were tested in the model, and 50% or greater appears prerequisite for long term survival. Assuming that chick mortality is independent of clutch size, 88% of females that successfully rear young to independence were treated as rearing one offspring, with 12% rearing two. A standard deviation 10% of the value was assigned arbitrarily in the absence of other data.

Mortality rates.

Mortality during the first year, due to the long period (up to six months) of offspring dependence, is thought to be low - approximately 25% (s.d. 5%) [C.G. Jones pers. comm.] and is approximately the same for both sexes. Adult mortality is also ordinarily low (10 - 15%, s.d. 2%), except in the event of catastrophes (see overleaf). The maximum lifespan of this species is approximately 15 years.

Carrying capacity.

Currently, approximately 60% of the available suitable habitat is occupied by pink pigeons at a relatively low density. This habitat is much degraded, with indigenous trees and plants interspersed by large arease of introduced species. Introduced species are unable to withstand the effects of the considerable cyclonic damage inflicted about every fifteen years, and greatly reduce the potential carrying capacity of the area. During the dry winter months, the lack of indigenous food producing plants leads to food shortage, and it is this which limits carrying capacity in the area. Nest-sites are not thought to be limiting as there are still sufficient nesting trees available to support the population at high density.

It is thought that presently, the maximum carrying capacity is approximately 35. This is obviously insufficient to support a viable population, and needs to be increased if the population is to survive at all. A supplementary feeding regime implemented especially during the dry winter months, can increase the carrying capacity; this is currently taking place. Simulations concentrated on carrying capacities of 100 or 200; the former being thought achievable, the latter ideal (Jones, pers. comm.).

Genetic variation and inbreeding depression.

Results from genetic fingerprinting studies carried out on the captive population held at the Jersey Wildlife Preservation Trust (MWB et al., elsewhere in this volume) indicate that there is still considerable genetic variation (band-sharing coefficient between unrelated individuals = 0.39) in the population. Reported abnormalities attributed to inbreeding depression in captive birds are now thought, in most cases, to be due to husbandry problems, although there is evidence of possible inbreeding in captive animals with inbreeding coefficients of 0.25 (Jones et al., 1985).

The level of genetic variation in the wild population has yet to be measured, but should be at least as high as in the captive population (which was founded by eleven individuals), although the possibility of genetic drift (Crow and Kimura, 1970) having occurred after one or more of the cyclone mediated population "bottlenecks" cannot be ruled out. The lowest wild population size recorded is 16 (present level). Inbreeding depression was modelled, due to the bottlenecking effects of several of the catastrophes incorporated into the simulations. Because of the relatively high level of heterozygosity present in the population (revealed by molecular studies), the recessive lethals model of inbreeding depression was incorporated as opposed to the heterosis model. It is a priority to study molecular variation in the wild population in order to assess the capacity for adaptive evolutionary response that still exists.

Supplementation.

In order to give the wild population a better chance of surviving the early years of the simulation, a program of supplementation of birds from captive stocks was introduced into the model. In early 1991, the captive population stood at some 160 birds, and it could be possible to build up a viable population in captivity whilst simultaneously supplementing the wild.

Introduced birds currently suffer approximately a 50% mortality rate during the first year (Jones et al 1988), and this was incorporated into the simulations as a harvest figure.

Supplementation regimes of 4, 6, 8, 12, 16 and 20 individuals (sex ratio 1:1) per year were modelled, with releases every year for the first ten years or every two years for the first fifty years.

Catastrophes.

Three types of catastrophe were incorporated into all models, and were as follows;

1. Cyclones - severe cyclones occur approximately every 15 years (6% probability), and have resulted in the mortality of around 50% of the population. The birds that survive reproduce normally, as the extra rainfall leads to an abundance of food (Jones, 1987).
2. Shooting - incidents have occurred where birds have been shot during hunts. These incidents are rare, and would have little impact once the population becomes well established, because the birds rarely flock and their distribution in this difficult terrain makes a mass slaughter unlikely. This catastrophe was modelled at 3% probability with a 10% effect on survival and no effect on reproduction.
3. Disease - no data are available on previous disease outbreaks, however we felt it prudent to model this type of catastrophe in such a small population. Data on avian epidemics led us to input the probability as 1% with a 50% mortality and a 10% negative effect on reproduction in the survivng birds.

3. Goals for the recovery of the wild population.

The establishment of a *"viable population"* (Gilpin and Soulé 1986) both in the wild and in captivity should form an important part of the recovery goals for the pink pigeon. Genetic analysis followed by management of both the wild and captive population is important in order to enable the preservation of as much of the extant genetic variation as possible (Fuerst and Maruyama 1986, Lacy 1987, 1988). This minimizes the chances of usually maladaptive genetic processes occurring such as inbreeding (which can lead to fitness depression in captive populations [Ralls et al 1979]), genetic drift (Crow and Kimura 1970) and selection for captive conditions (Lacy 1987).

Genetic management also increases the chance of successful supplementation of the wild population as the crucial capacity to evolve with environmental change is more likely to be retained (O'Brien and Evermann 1988). A common goal in genetic management stategies is to maintain 90% of the extant heterozygosity over 100 - 200 years (Shaffer 1987, Soulé et al 1986).

METHODS

Simulations were carried out over a time period of 100 years (approximately 20 generations) with population progress reports generated every ten years.

Initially, in order to gain an insight into the parameters which had the greatest effect on the survivorship of the populations, 54 scenarios (ten simulations each) were run. The constant and variable parameters used are summarised as follows;

Simulation time = 100 years
No. of simulations = 10
Extinction report intervals = 10 years
Populations = 1
Types of Catastrophes = 3
Inbreeding depression = yes/no
Heterosis or Lethals = L
Monogamous or polygamous = m
Female breeding age = 1
Male breeding age = 1
Maximum age = 15
Proportion males at birth = 0.55
Maximum litter size (fledged) = 2
Percent litter size 0 = 60/40/20
Percent litter size 1 = 35/53/70
Percent litter size 2 = 05/07/10
EV (environmental variation in) reproduction = 4/6/8
Female mortality age 0-1 (post fledging) = 25%
EV female mortality 0-1 = 05%
Female mortality - adult = 15%/10%
EV female mortality adult= 05%/02%
Male mortality age 0-1 (post fledging) = 25%
EV male mortality 0-1 = 05%
Male mortality - adult = 15%/10%
EV male mortality adult = 05%/02%
Probability of catastrophe 1 = 6% (cyclone)
Severity - reproduction = none
Severity - survival = 50% die
Probability of catastrophe 2 = 3% (shooting)
Severity - reproduction = none
Severity - survival = 8% die
Probability of catastrophe 3 = 1% (disease epidemic)
Severity - reproduction = 5% decrease
Severity - survival = none/50%/80% die
All males breeders? no
Percent males in the breeding pool = 80%
Start at stable age distribution = yes
Initial population size = 16

Carrying capacity K = 75/200
EV carrying capacity = 7.5/20
Trend in K? no
Harvest? yes/no
First year harvest = 1
Last year harvest = 10/50
Harvest interval = 1/2 yr
Adult females harvested = 1/2/3/4/5
Adult males harvested = 1/2/3/4/5
Supplement? yes/no
First year supplement = 1
Last year supplement = 10/50
Supplement interval = 1/2 yr
Adult females supplemented = 2/4/6/8/10
Adult males supplemented = 2/4/6/8/10

All combinations of simulations involving 40% female productivity were tried (30), and a representative sample of these were run using 60% and 80% productivity. In this way parameters with very obvious effects on the outcome of the simulations were identified for subsequent more rigorous simulations. These parameters were female productivity, carrying capacity, adult mortality, mortality from catastrophe type 3, and supplementation number/duration.

Once these parameters had been identified, eleven scenarios of 1,000 simulations were run. These scenarios included differences in production rates (50%, 55% and 60%), inbreeding depression (recessive lethals, no depression), carrying capacity (100, 200) and supplementation (every year for the first ten years or every other year for the first fifty years). Adult mortality was set at 10% (S.D. 2), mortality due to catastrophe type 3 was set at 50% (S.D. 5) and supplementation at ten pairs per year.

RESULTS

The results of the 54 ten-simulation tests indicated that regardless of carrying capacity or supplementation rates, all populations where female productivity (percentage of breeding age females fledging one or more offspring per year) was 40% or less, went extinct by year 80. The most optimistic simulations predicted 90% survivorship but this depended on the probably unrealistic productivity rate of 80% and a carrying capacity of 200.

Supplementation number and duration was found to have a significant impact on population survivability. The optimal (but realistic) number of animals per release was ten pairs. A release program lasting 50 years, where animals were released every two years gave the greatest chance of population survival.

The results of the more rigorous 1000-run simulations are tabulated below.

Table 1.

SIM	LTN. PROD.	IBD	K	S	r		L	% SURV.	M.F.P.
1	50%	L	200	10	0.035	1.035	62		71
2	50%	L	200	50	0.035	1.035	90		88
3	50%	N	200	10	0.035	1.035	72		82
4	50%	N	200	50	0.035	1.035	93		91
5	50%	L	100	10	0.035	1.035	42		31
6	50%	L	100	50	0.035	1.035	79		38
7.	50%	N	100	10	0.035	1.035	53		40
8.	50%	N	100	50	0.035	1.035	83		43
9.	60%	L	200	50	0.072	1.075	98		133
10.	60%	L	100	50	0.072	1.075	94		62
11.	55%	L	200	50	0.055	1.057	96		113
12.	55%	L	100	50	0.055	1.057	85		58

Where: SIM. NO. = simulation number
PROD. RATE = female productivity (probability of fledging ≥ 1 young)
IBD = Inbreeding depression (L = lethal recessive model, N = no depression)
K = carrying capacity
S = supplementation rate (see notes)
L = lambda, the percent of population change per year
r = population growth rate.
% SURV = percentage of simulations where populations survived.
M.F.P. = mean final population size.

It can be seen that the required conditions for the desired level of a 98% probability of the population surviving 100 years are only met in simulation number 9 (although a similar simulation not incorporating inbreeding depression would almost certainly give the same, or even a more optimistic result). Interestingly, simulation 10 indicates that the effects reducing the carrying capacity to 100 only marginally affects population survivorship.

98% survivorship conditions require supplementary feeding or habitat enrichment to enable carrying capacity to accommodate 200 individuals, with ten pairs released every two years for the first fifty years. The simulation also assumes 60% female productivity, against a background of high nest predation rates. This scenario predicts retention of 95.4% of the heterozygosity (90-95% is normally regarded as the desirable range).

Figures 2 and 3 illustrate the change in population size and percentage of populations surviving through time in the eight scenarios which included the effects of inbreeding depression. Although certain scenarios predict the survival of nearly all population simulations (Fig. 2), it is important to note that population size always drops significantly once supplementation has ceased (Fig. 3). In most cases, population numbers stabilize towards the end of the 100 year period, or even decrease slightly. In no cases does population size increase significantly once supplementation has stopped.

CONCLUSIONS

As seen in the results section, a 98% probability of population survivorship over the next 100 years with the retention of ≥ 95% of the extant heterozygosity can only be achieved under the conditions set out in simulation 9 (see appendix 1), or a similar simulation omitting the effects of inbreeding depression. The crucial parameters appear to be female productivity reaching 60% and the release of ten pairs of birds into the wild population every two years for the next fifty years. Although carrying capacity had some effect on the outcome, if similar parameters were applied to the population where the carrying capacity was reduced to 100, the simulation still achieved 94% probability of survival although only 91% of the heterozygosity was retained.

The biggest problem to overcome when considering recovery plans for with this species is its low productivity: the pink pigeon is currently a reproduction limited species. Hence, even in simulations where there was a high probability of survival, a mean final population size of 70% or more of the carrying capacity was never reached. Figures 2 and 3 graphically illustrate this problem, and it would appear that without continued supplementation, and under the present environmental constraints, the population can at best be expected to remain stable at 50-70% of carrying capacity. This low productivity also renders the species extremely vulnerable to stochastic effects, especially cyclone related mortality which will almost certainly happen several times over the next hundred years.

In order to achieve the 60% female productivity required, the high nest predation rates suffered, due to the crab eating macacque and black rat, must be dramatically reduced. In addition it is clear that at the very least, sufficient supplementary feeding must be carried out to increase the carrying capacity of the habitat to 100. These requirements lead to the conclusion that **very close management** of the wild population will be required over the next hundred years in order for it to survive.

RECOMMENDATIONS FOR THE WILD POPULATION

1. In order for the wild population to survive the first hundred years, an important factor is that at least 60% of adult females must fledge one or more offspring per year. In order for this to occur, conservation efforts must concentrate on finding effective methods of *protecting nests from predators (the crab eating macacque and black rat)*. 70-80% of nesting attempts fail annually due predation of eggs or young.

2. Due to the low carrying capacity of the habitat currently occupied by the pigeons, it is recommended that;
   A. a comprehensive supplementary feeding program is carried out. The effective carrying capacity must be raised to accomodate at least 100 birds over the next 100 years.
   B. steps should be taken to protect the feeding sites during the dry winter season, so that the black rat population is prevented from competing for it.

3. The wild population should also be supplemented from the captive population. The most optimistic simulations required the release of ten pairs every two years for the next fifty years. However, this level of release should not be allowed to compromise the attainment of a viable population in captivity over the next ten years. In this species, a viable population should consist of at least 500 birds, so that any chance loss of genetic variation is compensated for by new mutation events. Therefore, we recommend that the number of birds released into the wild is decided by the number of birds available from captivity within the framework of the production of a viable captive population over the next ten years.

4. Epidemics in growing wild populations that result in greater than 50% mortality have an appreciable effect on the chances of survival for the population. We therefore recommend epidemiological assessment studies, particularly on highly virulant potential pathogens - possibly followed by treatment (such as vaccination) of wild birds. Such studies should use data from recorded deaths of both wild and captive birds (J.E. Cooper) and information available from studies carried out on feral pigeons.

5. In order to lessen the genetic impact of environmentally mediated bottlenecks and to improve the efficacy of gene flow between the major captive and wild populations, it is recommended that DNA fingerprinting studies are carried out on all populations, and that breeding decisions fully take into account these data.

6. In order that the wild population can become viable without hands on management, the quality of available habitat must be improved by the enrichment of the area with important indigenous, and favoured exotic plant species. This could be done within the framework of the establishment of a national park around the Black River Gorge area. This requires the systematic removal of introduced animal and plant species, such that some areas are returned to similar conditions under which the pink pigeon (and all other threatened endemic species) once thrived, although this may not be possible on a large scale.

7. Due to the precarious situation of the wild population of the pink pigeon, the progress of the population should be intensively monitored with regular meetings of interested biologists, and PVA meetings held every 3-5 years, such that appropriate action can be decided upon as the situation develops.

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Pink pigeon decline since 1900

By number of individuals

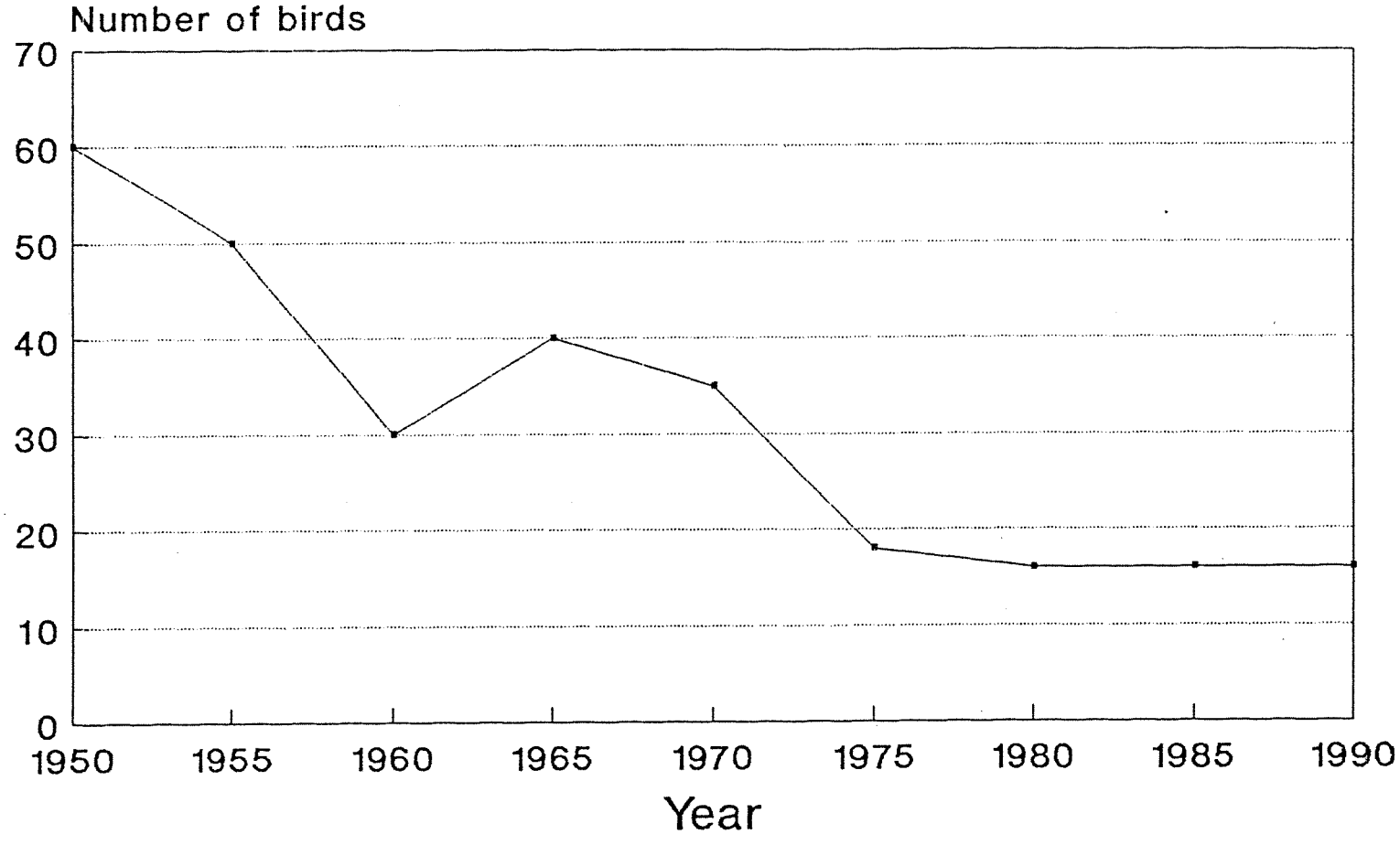

Fig. 1

Simulation of population survival

pink pigeon - over 100 yrs

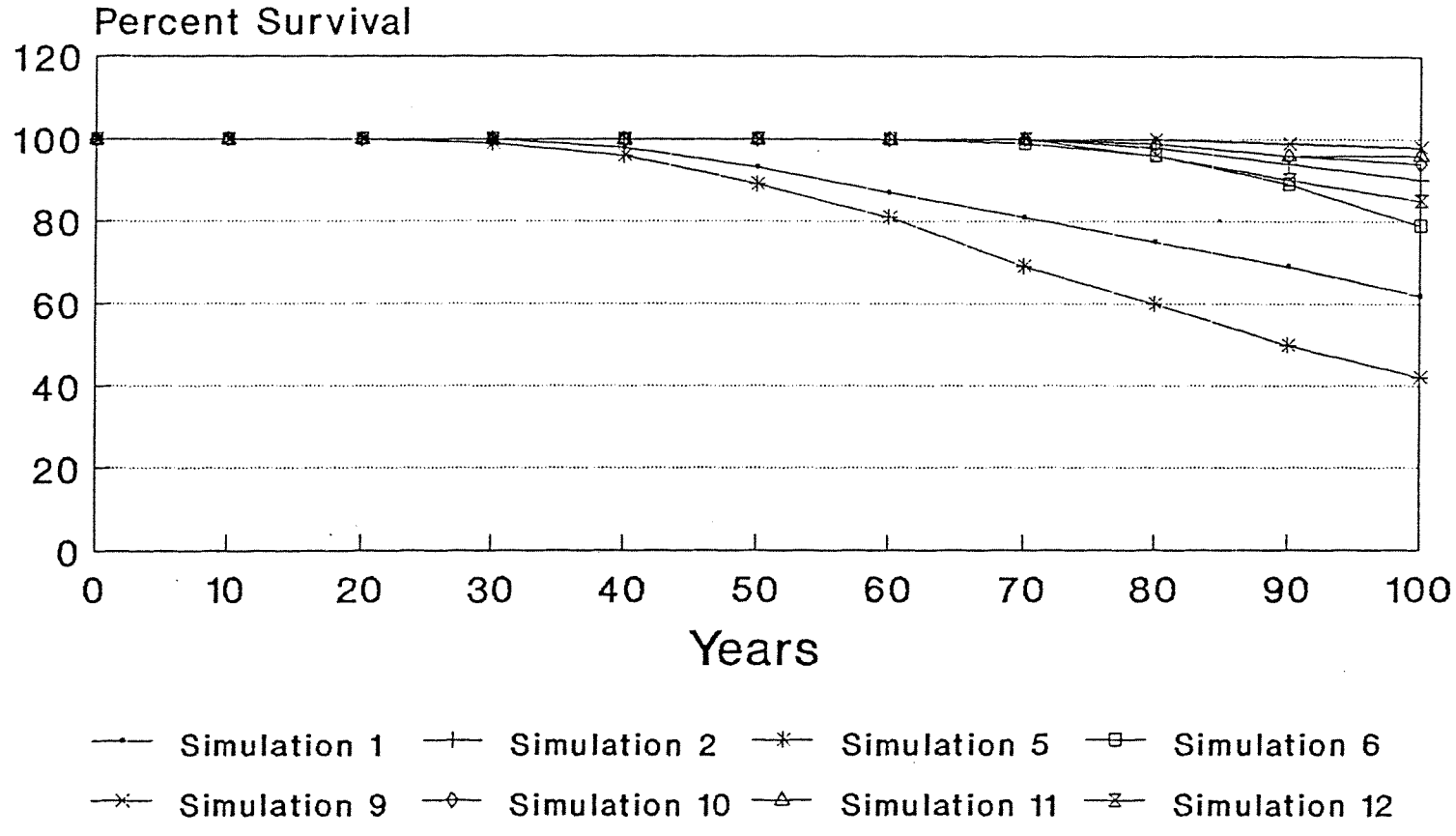

Fig. 2

Simulation of population number
pink pigeon - over 100 yrs

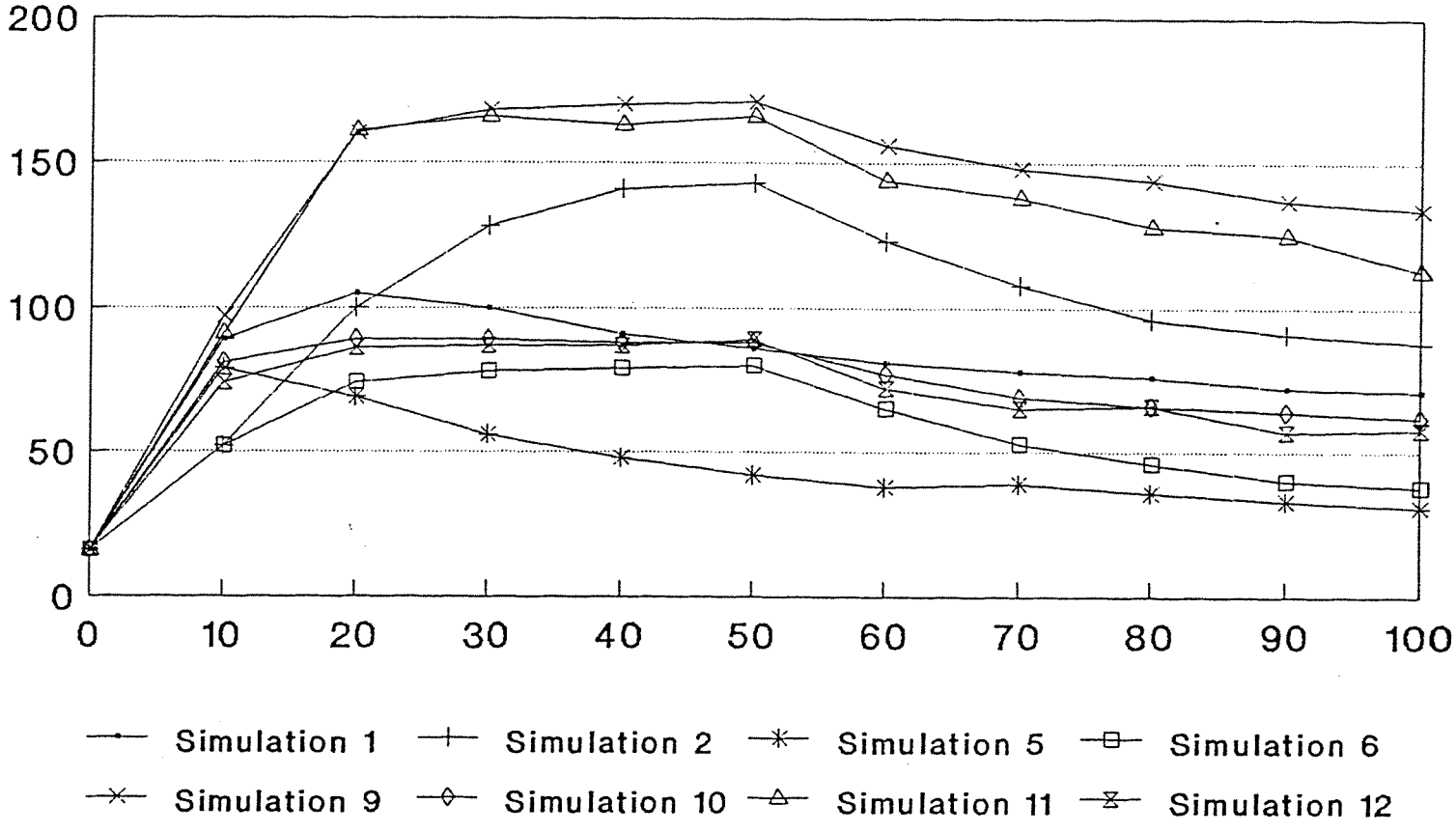

Fig. 3

VORTICES -- simulation of genetic and demographic stochasticity

pink18I

1 population(s) simulated for 100 years, 1000 runs

RECESSIVE LETHALS model of inbreeding depression
First age of reproduction for females: 1 for males: 1
Age of senescence (death): 15
Sex ratio at birth (proportion males): 0.5500

Population 1:

40.00 (EV = 6.00 SD) percent of adult females produce litters of size 0
53.00 percent of adult females produce litters of size 1
7.00 percent of adult females produce litters of size 2

25.00 (EV = 5.00 SD) percent mortality of females between ages 0 and 1
10.00 (EV = 2.00 SD) percent annual mortality of adult females
(1 <= age <= 15)
25.00 (EV = 5.00 SD) percent mortality of males between ages 0 and 1
10.00 (EV = 2.00 SD) percent annual mortality of adult males (1 <= age <= 15)

Frequency of type 1 catastrophes: 6.000 percent
with 1.000 multiplicative effect on reproduction
and 0.500 multiplicative effect on survival

Frequency of type 2 catastrophes: 3.000 percent
with 1.000 multiplicative effect on reproduction
and 0.900 multiplicative effect on survival

Frequency of type 3 catastrophes: 1.000 percent
with 0.900 multiplicative effect on reproduction
and 0.500 multiplicative effect on survival
Monogamous mating; 80.00 percent of adult males in the breeding pool.

Initial size of Population 1:
(set to reflect stable age distribution)

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
	1	2	1	1	1	0	1	0	0	1	0	0	0	0	0	8 Males
	2	1	1	1	0	1	0	1	0	0	0	0	1	0	0	8 Females

Carrying capacity = 200 (EV = 20.00 SD)

Animals harvested from population 1, year 1 to year 50 at 2 year intervals:

5 female adults (1 <= age <= 15)
5 male adults (1 <= age <= 15)

Animals added to population 1, year 1 through year 50 at 2 year intervals:

10 females 1 years old
10 males 1 years old

Deterministic population growth rate (based on females, with assumptions of no limitation of mates and no inbreeding depression):

r = 0.072 lambda = 1.075 R0 = 1.435

Generation time for: females = 5.00 males = 5.00

Stable age distribution:

Age class	females	males
0	0.104	0.127
1	0.070	0.085
2	0.056	0.069
3	0.045	0.055
4	0.037	0.045
5	0.029	0.036
6	0.024	0.029
7	0.019	0.023
8	0.015	0.019
9	0.012	0.015
10	0.010	0.012
11	0.008	0.010
12	0.006	0.008
13	0.005	0.006
14	0.004	0.005
15	0.003	0.004

Ratio of adult (>= 1) males to adult (>= 1) females: 1.222

Population 1

Year 10
N[Extinct] = 0, P[E] = 0.000
N[Surviving] = 1000, P[S] = 1.000
Population size = 96.90 (1.08 SE, 34.22 SD)
Expected heterozygosity = 0.986 (0.000 SE, 0.003 SD)
Observed heterozygosity = 0.998 (0.000 SE, 0.004 SD)
Number of extant alleles = 110.64 (0.79 SE, 25.05 SD)

Year 20
N[Extinct] = 0, P[E] = 0.000
N[Surviving] = 1000, P[S] = 1.000
Population size = 160.42 (1.50 SE, 47.39 SD)

```
     Expected heterozygosity =    0.988 (  0.000 SE,   0.002
SD)
     Observed heterozygosity =    0.997 (  0.000 SE,   0.004
SD)
     Number of extant alleles =  147.06 (   0.87 SE,   27.40
SD)

Year 30
     N[Extinct] =       0, P[E] = 0.000
     N[Surviving] =  1000, P[S] = 1.000
     Population size =          167.99 (   1.34 SE,   42.42
SD)
     Expected heterozygosity =    0.988 (  0.000 SE,   0.002
SD)
     Observed heterozygosity =    0.997 (  0.000 SE,   0.005
SD)
     Number of extant alleles =  150.52 (   0.73 SE,   23.23
SD)

Year 40
     N[Extinct] =       0, P[E] = 0.000
     N[Surviving] =  1000, P[S] = 1.000
     Population size =          169.91 (   1.25 SE,   39.66
SD)
     Expected heterozygosity =    0.988 (  0.000 SE,   0.002
SD)
     Observed heterozygosity =    0.996 (  0.000 SE,   0.005
SD)
     Number of extant alleles =  151.53 (   0.68 SE,   21.40
SD)

Year 50
     N[Extinct] =       0, P[E] = 0.000
     N[Surviving] =  1000, P[S] = 1.000
     Population size =          171.22 (   1.31 SE,   41.41
SD)
     Expected heterozygosity =    0.988 (  0.000 SE,   0.002
SD)
     Observed heterozygosity =    0.997 (  0.000 SE,   0.005
SD)
     Number of extant alleles =  151.44 (   0.73 SE,   23.07
SD)

Year 60
     N[Extinct] =       1, P[E] = 0.001
     N[Surviving] =   999, P[S] = 0.999
     Population size =          156.29 (   1.58 SE,   49.92
SD)
     Expected heterozygosity =    0.976 (  0.000 SE,   0.009
SD)
     Observed heterozygosity =    0.992 (  0.000 SE,   0.009
SD)
     Number of extant alleles =   76.03 (   0.52 SE,   16.55
SD)

Year 70
     N[Extinct] =       1, P[E] = 0.001
     N[Surviving] =   999, P[S] = 0.999
```

```
     Population size =            148.01 (   1.72 SE,   54.43
SD)
     Expected heterozygosity =     0.962 (  0.001 SE,   0.022
SD)
     Observed heterozygosity =     0.984 (  0.001 SE,   0.018
SD)
     Number of extant alleles =    49.80 (   0.39 SE,   12.22
SD)

Year 80
     N[Extinct] =        4, P[E] = 0.004
     N[Surviving] =    996, P[S] = 0.996
     Population size =            143.72 (   1.85 SE,   58.41
SD)
     Expected heterozygosity =     0.945 (  0.001 SE,   0.045
SD)
     Observed heterozygosity =     0.975 (  0.001 SE,   0.037
SD)
     Number of extant alleles =    36.73 (   0.31 SE,    9.78
SD)

Year 90
     N[Extinct] =        7, P[E] = 0.007
     N[Surviving] =    993, P[S] = 0.993
     Population size =            137.28 (   1.94 SE,   61.27
SD)
     Expected heterozygosity =     0.929 (  0.002 SE,   0.058
SD)
     Observed heterozygosity =     0.964 (  0.002 SE,   0.049
SD)
     Number of extant alleles =    28.91 (   0.27 SE,    8.66
SD)

Year 100
     N[Extinct] =       17, P[E] = 0.017
     N[Surviving] =    983, P[S] = 0.983
     Population size =            133.79 (   1.99 SE,   62.55
SD)
     Expected heterozygosity =     0.913 (  0.002 SE,   0.064
SD)
     Observed heterozygosity =     0.952 (  0.002 SE,   0.061
SD)
     Number of extant alleles =    23.83 (   0.24 SE,    7.50
SD)


In 1000 simulations of 100 years of Population 1:
17 went extinct and 983 survived.

This gives a probability of extinction of 0.0170 (0.0041 SE),
or a probability of success of 0.9830 (0.0041 SE).

17 simulations went extinct at least once.
Of those going extinct, mean time to first extinction was
88.65 years (2.86 SE, 11.79 SD).

No recolonizations.
```

Mean final population for successful cases was 133.79 (1.99 SE, 62.55 SD)

73.88 Males
59.91 Females

During years of harvest and/or supplementation mean lambda was 1.1844 (0.0013 SE, 0.2089 SD)

Without harvest/supplementation, prior to carrying capacity truncation, mean lambda was 1.0522 (0.0006 SE, 0.1573 SD)

Note: 99 of 125000 harvests of males and 136 of 125000 harvests of females could not be completed because of insufficient animals.

Final expected heterozygosity was 0.9134 (0.0020 SE, 0.0638 SD)
Final observed heterozygosity was 0.9520 (0.0019 SE, 0.0610 SD)
Final number of alleles was 23.83 (0.24 SE, 7.50 SD)

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Genetic variation in the Jersey captive population of the pink pigeon (*Nesoenas mayeri*) revealed by DNA fingerprinting.

M.W. Bruford*, A.P. Krupa@ and T. Burke@.

* Institute of Zoology, Regent's Park, London NW1 4RY.
@ Department of Zoology, University of Leicester, University Road, Leicester LE1 7RH.

Introduction

The efficient genetic management of captive populations has important implications for long term species survival and the avoidance of the deleterious effects of inbreeding. This type of management has until now been carried out using studbook information where it is available. The major problem with this approach is that it cannot accurately tell the breeder the level of inbreeding in the population, as it does not take into account the degree of relatedness between individuals in the founder population, i.e. it assumes it to be zero. Such information is likely to be of great importance with small populations of endangered species. Population substructuring due to environmental factors or low effective population size due to social structure can lead to localized inbreeding (Mace 1986). These are important considerations when designing captive breeding programs.

Additionally, studbook information is of course only useful when it is there; i.e. genetic management is almost meaningless unless the breeder has a full studbook which traces families back to founder stock.

These problems could, in theory be overcome using a method which can uncover levels of relatedness between individuals in a population without prior knowledge. Such a method could be DNA fingerprinting (Jeffreys et al 1985a, 1985b; Burke and Bruford 1987), as this technique is known to be able to descriminate between certain levels of relatedness in wild populations. Individuals within most captive populations of endangered species would however, be predicted to have a higher degree of relatedness (and therefore a higher DNA fingerprint similarity) than most of the wild populations studied to date, and therefore it is important to investigate whether the technique has any value in these situations.

The Mauritius pink pigeon (*Nesoenas mayeri*), exemplifies the type of endangered species mentioned previously. The captive population at Jersey is known to be derived from six founder birds, and the studbook is complete. Furthermore there is evidence for the existence of inbreeding depression in captive pink pigeons (Jones et al 1985), and therefore there is a clear need for genetic management. We investigated the relationship between fingerprint similarity and genetic relatedness in this type of population, and the relationship between four of the six founders we could sample.

Methods

DNA fingerprinting and analysis was carried out on 31 pink pigeons, using methods described in Jeffreys et al (1985a), Burke and Bruford (1987), Birkhead et al (1990) and Bruford et al (1991). Briefly, a small blood sample (< 0.5 ml) was taken, and DNA was extracted following high salt precipitation of blood proteins. Approximately 5µg of DNA was taken from each sample, and digested to completion with the restriction enzyme *Alu* I. The samples were electrophoresed through either 0.8 or 0.9% agarose in 1 x TBE pH 8.8, until restriction fragments of 2 kilobases had migrated approximately 22 cm. The DNA samples were then Southern transferred onto nylon membranes (Amersham Hybond N), and fixed by baking at 80°C for two hours, or by UV irradiation. The membranes were hybridized with the Jeffreys probes 33.6 and 33.15 in 0.5 M Na phosphate, 7% SDS, 1 mM EDTA, 1% BSA fraction V (Sigma) pH 7.4 at 61°C overnight. The membranes were washed at 61°C sequentially in (i) 0.5 M Na phosphate, 1% SDS, (ii) 2x SSC, 0.1% SDS, (iii) 1x SSC, 0.1% SDS each for 15 minutes. The radiolabelled membranes were placed next to autoradiographic film with two intensifying screens for between two days and two weeks.

Results

DNA fingerprints were obtained (see figure 1) and analyzed as in Burke and Bruford (1987) and Birkhead et al (1990). Mean probability of band sharing x, was estimated by comparing fingerprints, where possible of similar intensity, run in adjacent lanes. x was found as the mean of each pairwise comparison of the proportion of the bands in an individual A that were matched by a band of similar intensity (less than two-fold difference) and electrophoretic mobility (migration distance of band centres less than 0.5mm) in an individual B. For bands >2 kilobases the mean probability of two individuals sharing a band was 0.55 ± 0.018 SE for probe 33.6 (41 comparisons), 0.49 ± 0.018 SE for probe 33.15 (57 comparisons) and 0.500 ± 0.014 SE for combined data (77 comparisons). These probes have been demonstrated to detect almost completely independent loci in other avian species (Burke and Bruford 1987, Burke et al 1989, Birkhead et al 1990) and hence have been treated as independent data points where the same pair-wise comparisons were made using both probes (21 cases).

Assuming all alleles to be of equal frequency, the mean allele frequency q, is found from $x = 2q-q^2$, hence for all loci (33.6 and 33.15) q = 0.295. The mean number of alleles per locus was 3.39 (Jeffreys et al 1985b). Mean number of bands scored on 33.6 fingerprints (DNA fragment size range 16 - 2 kb) was 31.8 ± 7.09 (s.d.), and for 33.15 fingerprints (fragment range 18 - 2 kb) 37.7 ± 5.85 (s.d.).

To establish the efficacy of the technique in distingushing between levels of relatedness in the population, pair-wise comparisons were grouped into three classes; first degree relatives, second degree relatives and "unrelated" individuals (in practice, third degree relatives and below). Data were analyzed for 33.6, 33.15 and for both probes combined. The band sharing coefficients of all classes are significantly different (with the exception of the class 2/3 comparison with 33.6), using

Mann-Whitney ranked sample tests. Figures 2 and 3 illustrate the results which are tabulated below.

Table 1 **Mean band-sharing coefficients for all classes and probes.**

	Mean band-sharing coefficient (± SE)			
Probe	Overall	1st deg.	2nd deg.	unrel.
33.6	0.545 ± .018	0.607 ± .026	0.491 ± .023	0.468 ± .016
33.15	0.485 ± .018	0.582 ± .016	0.451 ± .023	0.333 ± .018
Comb.	0.500 ± .014	0.583 ± .015	0.477 ± .017	0.388 ± .021

It was not possible to demonstrate independent segregation of bands, due to small family sizes available, and the elevated levels of homozygosity consequential of the inbreeding process and small founder number. Therefore, predictions of band sharing between individuals of different levels of relatedness are carried out assuming low levels of linkage between loci and low numbers of loci where both alleles are resolvable in the fingerprint pattern. These assumptions may not necessarily hold true, however minisatellite loci studied in most avian species to date segregate independently. Based on these assumptions, and using the "unrelated" band sharing coefficients tabulated above, first degree relatives show a significantly lower than expected level (data not shown) of band sharing (Jeffreys et al 1985c). The most probable reason for this is the fact that the "unrelated" class contains relatives up to the level of third degree. Hence, mean band sharing for unrelated individuals, which is used to predict band sharing coefficient for higher order relatives, is upwardly biased.

The distribution of band-sharing against degree of relatedness is illustrated in figure 4, and gives an impression of the predictability of the method. It can be seen that there is, as expected some degree of overlap between the classes. However the distribution is such that, in practice, one would predict that birds with $x = 0.25-0.45$ are "unrelated", $x = 0.46-0.58$ are second degree relatives and $x = 0.59-0.75$ indicate first degree relatives. Mean band sharing coefficients of the founder individuals sampled (B515 [9], B518 [12], B519 [13] and B787 [6]) ranged from 0.31-0.45 (i.e. in the "unrelated" range) except for B515/B519 whose coefficent (0.5) is in the second degree relative range.

Kuhnlein et al (1990) showed the possibility of assessing inbreeding by DNA fingerprinting by developing a calibration curve using strains of chickens with defined inbreeding coefficients. Although the chromosomal architecture of the *Columbidae* is demonstrably different to that of the *Phasianidae*, it is possible that this calibration curve could be applied to the pink pigeon population. The mean allele frequency of this population is 0.295, corresponding to an inbreeding coefficient of approximately 0.08 using the cailbration curve. The next stage of the analysis is to arrive at a mean inbreeding coefficient

from the studbook data, to see if the two measures coincide.

Conclusions

We have shown that DNA fingerprinting can be used to discriminate between individuals of different levels of relatedness within a captive population of pink pigeons. This has been possible due to the completeness of the studbook. Using this technique, practical management decisions can be made, where studbooks are incomplete provided a few individuals of known relatedness can be tested.

DNA fingerprinting also gives the breeder a general idea about the level of genetic variability in the population. This information is of critical importance in coordinated captive breeding programs, where information can be gained on comparative levels of variation in different captive populations. These data could be extrapolated to produce inbreeding coefficients, correlating band sharing coefficient between individuals of the same, known inbreeding coefficent. DNA fingerprinting is less useful at showing the relative degrees of relatedness of different populations, because shared bands are less likely to represent identical alleles of the same locus, i.e. they likely to be shared by chance due to the large number of different alleles which exist at each locus. In these cases, the use of single locus probes (Armour et al 1990, Hanotte et al 1990, Bruford et al 1990) is likely to be of greater use because allele frequencies will have been determined at specific loci. Furthermore, in populations where genetic variation is reduced, such probes are the most likely markers to detect variation.

In certain circumstances DNA fingerprinting can be used to deduce the degree of relatedness between founders, if samples are available. The authors suggest freezing founder corpses where possible for this subsequent purpose. In this population most of the individuals appear to be unrelated, with the possible exception of B515 and B519. This knowledge could prove to be very important when designing breeding programs.

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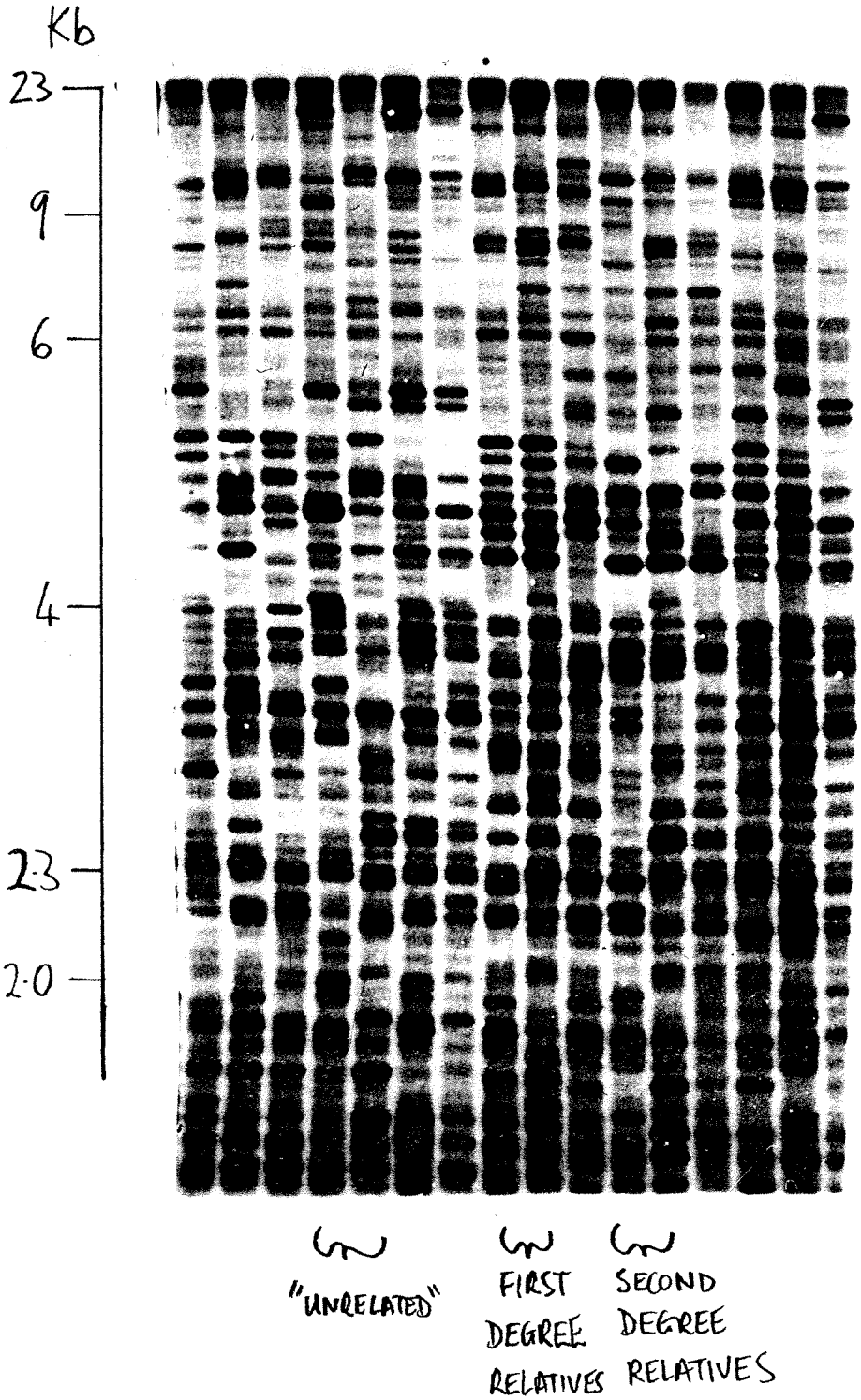
FIGURE 1.


Kb
23
9
6
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"UNRELATED"
FIRST DEGREE RELATIVES
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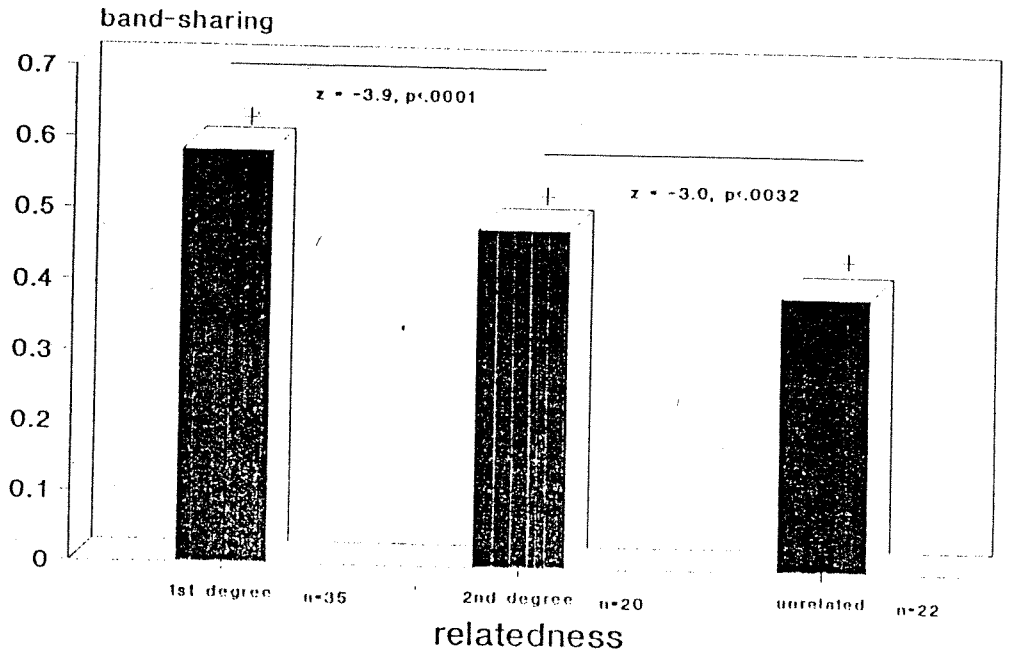
FIG. 2


Relatedness and band-sharing
33-15 and 33-6 combined
band-sharing
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
z = -3.9, p<.0001
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1st degree
n=35
2nd degree
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unrelated
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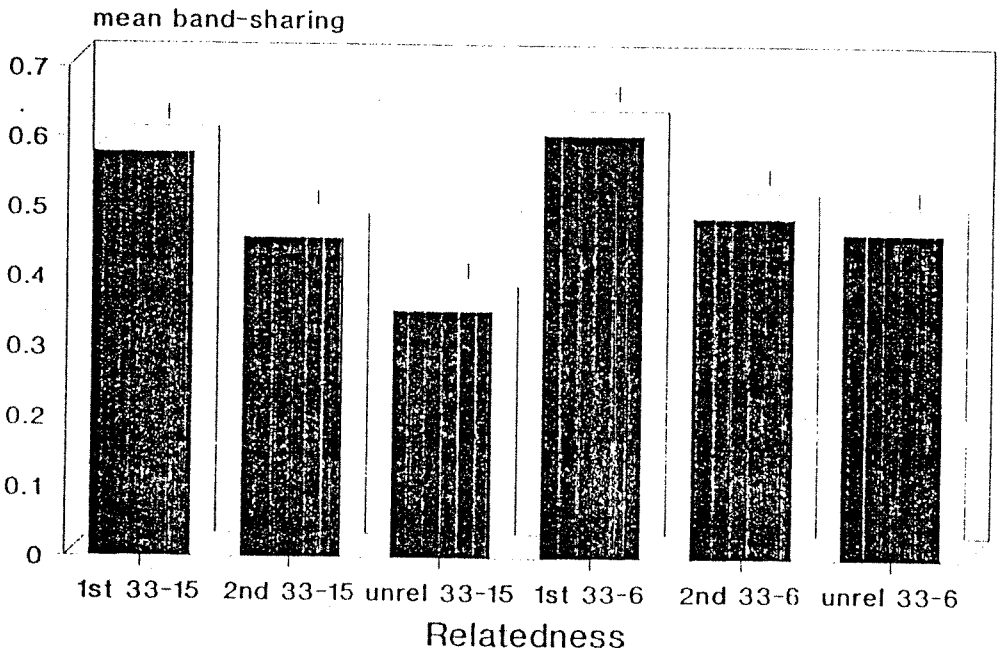
FIG. 3


Relatedness and mean band-sharing
pink pigeon
mean band-sharing
0.7
0.6
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1st 33-15
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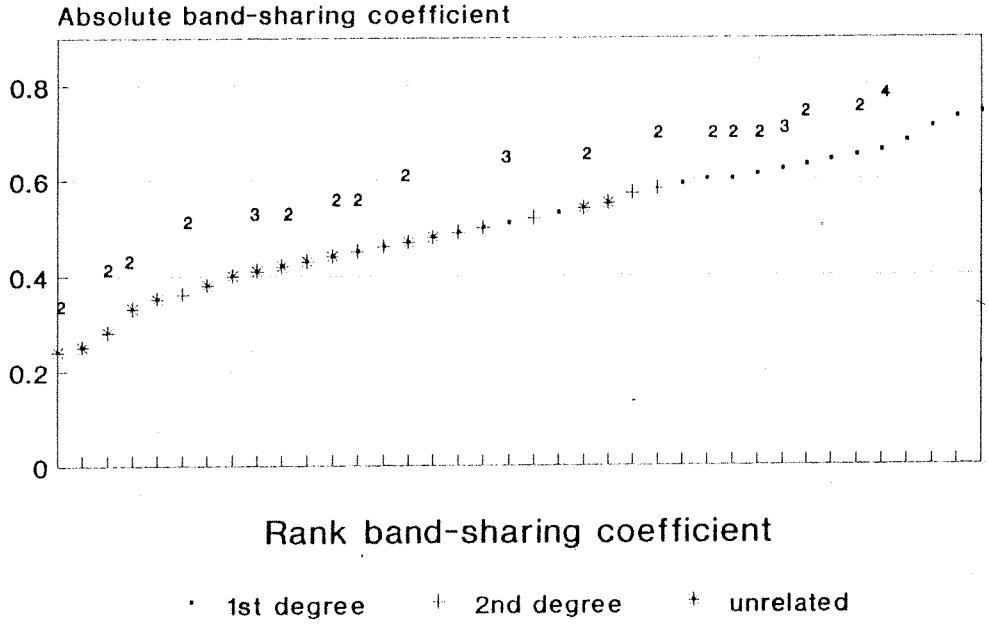
Relatedness

Figure 4

Band-sharing ranges

all levels of relatedness



numerals indicate multiple occurrences

COLUMBA (NESOENAS) MAYERI

PINK PIGEON

CONSERVATION VIABILITY ASSESSMENT

REPORT

SECTION 4

CAPTIVE POPULATION BIOLOGY AND MANAGEMENT

ICBP Technical Publication No. 10, 1989

MORTALITY, MORBIDITY AND BREEDING SUCCESS OF THE PINK PIGEON (*COLUMBA (NESOENAS) MAYERI*)

CARL G. JONES, DAVID M. TODD & YOUSOOF MUNGROO

Forestry Quarters, Black River, Mauritius

ABSTRACT

The Pink Pigeon is a highly endangered species with a wild population of fewer than 30 individuals. Captive populations have been established, and the two main ones are at the Government Aviaries in Black River, Mauritius, and the Jersey Wildlife Preservation Trust. In these two collections, 1447 eggs were laid between 1977 and 1986. Only about 732 (50.6 percent) were fertile, of which 370 (50.5 percent) hatched. Of these, 200 (54 percent) reached 30 days; 63.2 percent of fledglings survive to reach one year. The various factors that may contribute to these high mortality rates are appraised. Breeding success among the wild (free-living) Pink Pigeons is very low, and fewer than 10 percent of nests succeed in fledging any young.

Inbreeding is suspected to be depressing the breeding results of the captive birds and elevating the rates of mortality. The nesting failures of the wild pigeons are primarily due to egg predation.

Careful long-term management of both the wild and the captive populations will be essential in order to avoid the species' extinction.

INTRODUCTION

The Pink Pigeon (*Columba (Nesoenas) mayeri*), which is endemic to the island of Mauritius in the western Indian Ocean, has been the subject of a captive breeding programme for ten years. Since the first three were caught in March 1976 (McKelvey 1976), nearly 200 Pink Pigeons have been fledged at the Government Aviaries at Black River, Mauritius, and at the Jersey Wildlife Preservation Trust (JWPT). Captive-bred birds from these two collections have been used to establish four other breeding populations. Practical details of the captive breeding programme are given by Jones *et al.* (1983). In 1984/5, 22 Pink Pigeons bred in captivity were released into the botanical garden at Pamplemousses, Mauritius, to test the feasibility of a more ambitious release into an area of native forest (Todd 1984). The wild population has meanwhile apparently stabilized and now numbers about 20 birds.

Despite the success of the captive breeding programme, there is cause for concern because of the low rate of successful breeding, the incidence of developmental defects, and the relatively high mortality among sub-adult birds. A

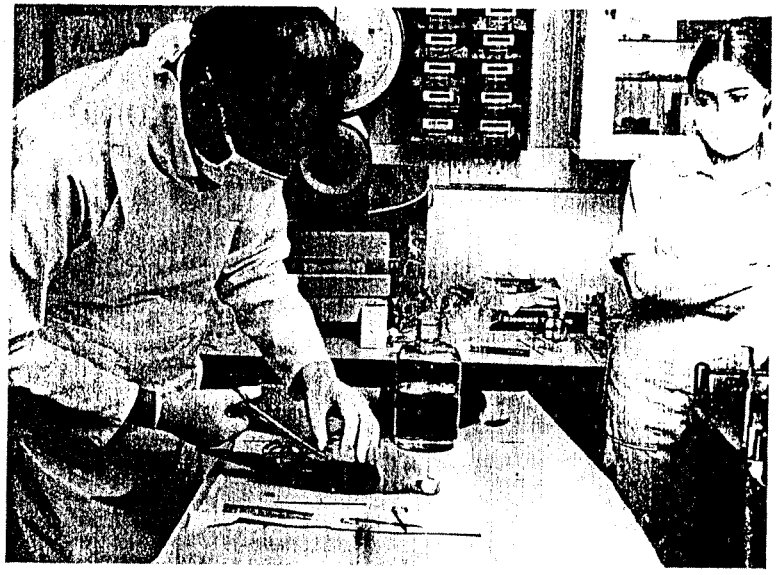


Figure 1: Post mortem examination of a Pink Pigeon (*Columba mayeri*). In recent years the species has been the subject of detailed clinical and pathological investigation, both on Mauritius and at the Jersey Wildlife Preservation Trust. (*Photo*: J. E. Cooper)

preliminary analysis of the breeding records and mortality data is presented here.

SOURCES OF DATA

Detailed records of the fate of all breeding attempts at the Government Aviaries and at the JWPT have been kept since the start of the captive breeding programme. Most of the Pink Pigeons that have died in captivity have been referred to John E. Cooper at the Royal College of Surgeons of England, where they have been examined post mortem (*Figures 1* and *2*). Others have been examined at the JWPT. Although the resulting data have not yet been fully analysed, use has been made of early findings. Relevant information from studies of the wild Pink Pigeons and those released at Pamplemousses are also discussed.

FINDINGS

MORTALITY OF JUVENILE AND ADULT PINK PIGEONS

More than a quarter of Pink Pigeons fledged at the Government Aviaries and the JWPT have failed to survive their first year. Mortality was relatively high

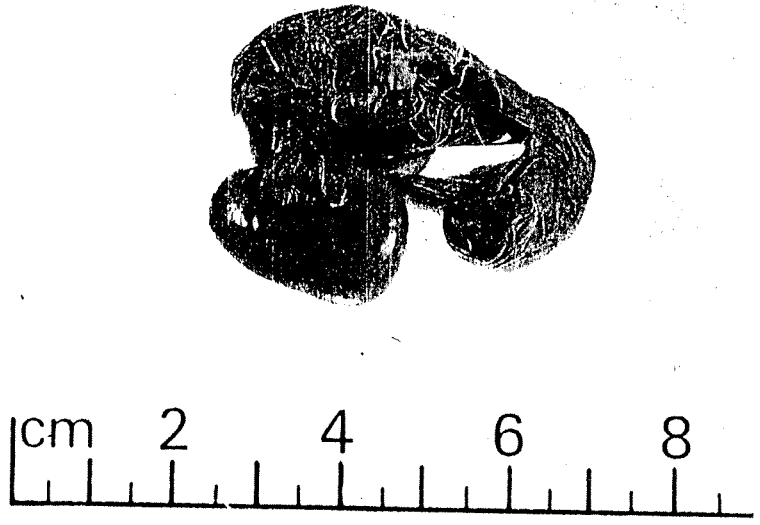


Figure 2: Embryos are examined carefully for developmental abnormalities as well as for the presence of infectious disease. The cause of death of this Pink Pigeon embryo was probably chilling. (*Photo*: J. E. Cooper)

during the first two months of independent life, but then dropped markedly (*Figure 3*). Many of the deaths during the second six months of life were the result of emaciation following increased intraspecific aggression in the aviaries holding groups of young birds (see below). *Figure 4* shows the age distribution of deaths in subsequent years. The maximum life span so far recorded is for a male trapped as an adult in 1976, which is still alive in its thirteenth year of captivity. Although a female trapped as an adult in 1977 also survives, female Pink Pigeons have tended not to live as long as males. Because wild-caught pigeons and members of each annual cohort of captive-bred birds still survive, it is impossible to calculate mean life spans accurately for males and females that live for more than one year. However, if only those pigeons hatched before 1 January 1981 are considered, and it is assumed that wild birds trapped as adults were one year old when caught, minimum mean life spans of 6.6 years for males and 5.2 years for females are obtained. The shorter lives of females may be in part a result of management aimed at maximizing egg production. The Pink Pigeons at JWPT live longer on average than those at the Government Aviaries and there is therefore a greater proportion of older birds in that population (*Figure 5*).

Factors associated with the deaths of fledged Pink Pigeons at the Government Aviaries and the JWPT, and those that were culled or died in quarantine at the Royal College of Surgeons, are shown in *Table 1*. In nearly 30 percent of cases there was no apparent cause of death. Thirty-five percent of deaths could be

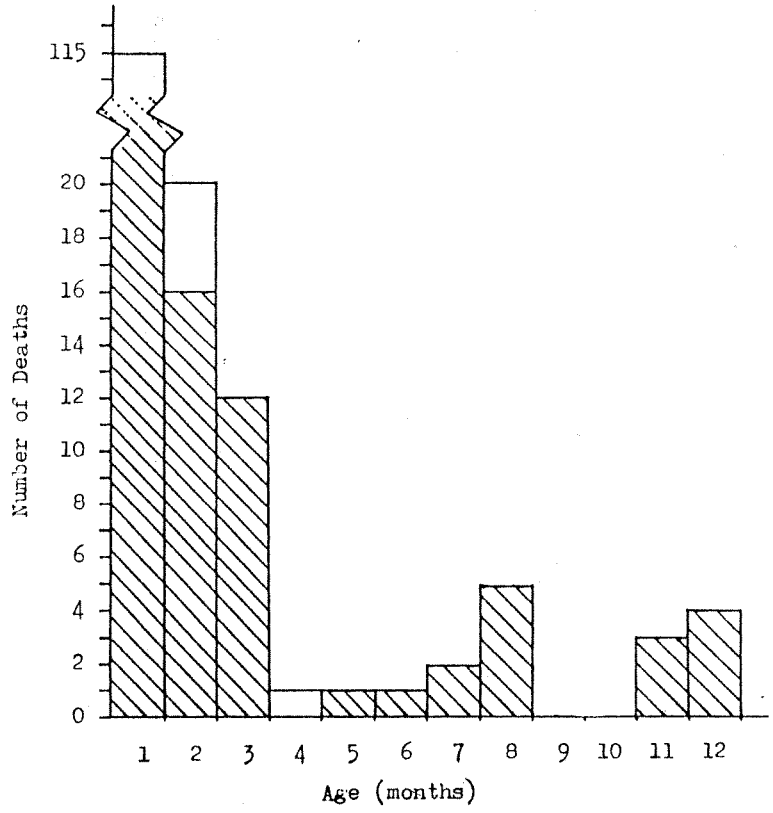


Figure 3: Age distribution of deaths of Pink Pigeons in their first year, at the Government Aviaries and at the Jersey Wildlife Preservation Trust.

attributed to nutritional or developmental defects, though many of the pigeons dying in an emaciated condition were the victims of intraspecific aggression. Infectious diseases were diagnosed as the cause of only ten deaths (12.7 percent), while faulty management and accidents accounted for more than 20 percent of the total.

Little is known of the life expectancy and mortality of adult Pink Pigeons in the wild. It has been suggested that feral cats (*Felis catus*) and mongooses (*Herpestes auropunctatus*) might kill some birds forced to feed on the ground by seasonal

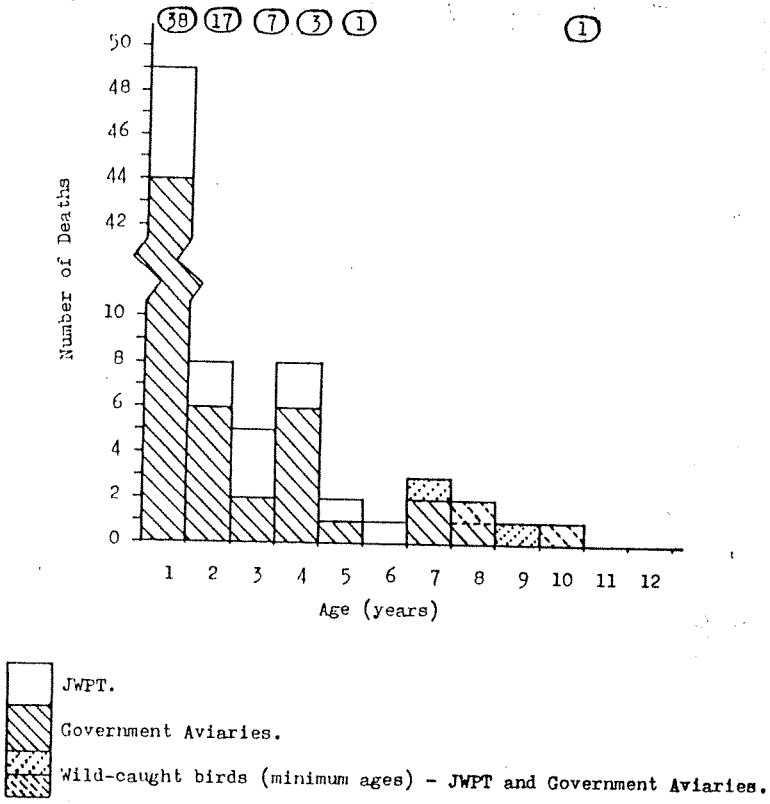


Figure 4: Age distribution of deaths of Pink Pigeons, post fledging, at the Government Aviaries and at the Jersey Wildlife Preservation Trust.

food shortages (Jones 1987). McKelvey (1976) reported an attack on a Pink Pigeon by a Peregrine Falcon (*Falco peregrinus*), but this must be a very rare occurrence as there have been only two other records of Peregrine Falcons on Mauritius. Pink Pigeons are killed during cyclones, or starve later because the trees have been stripped of fruits, flowers and leaves, but cyclones hit Mauritius on average only once every four years, and even then the Pink Pigeon habitat is not always adversely affected (Jones 1987). Because of its reputation for being poisonous, the Pink Pigeon has never apparently been hunted on a large scale, but birds have occasionally been shot in the past (Jones 1987). However, of the 22 Pink Pigeons released in Pamplemousses, up to 15 were killed or injured by intruders with catapults. Since 1976, eleven adult Pink Pigeons have been trapped for the captive breeding programme.

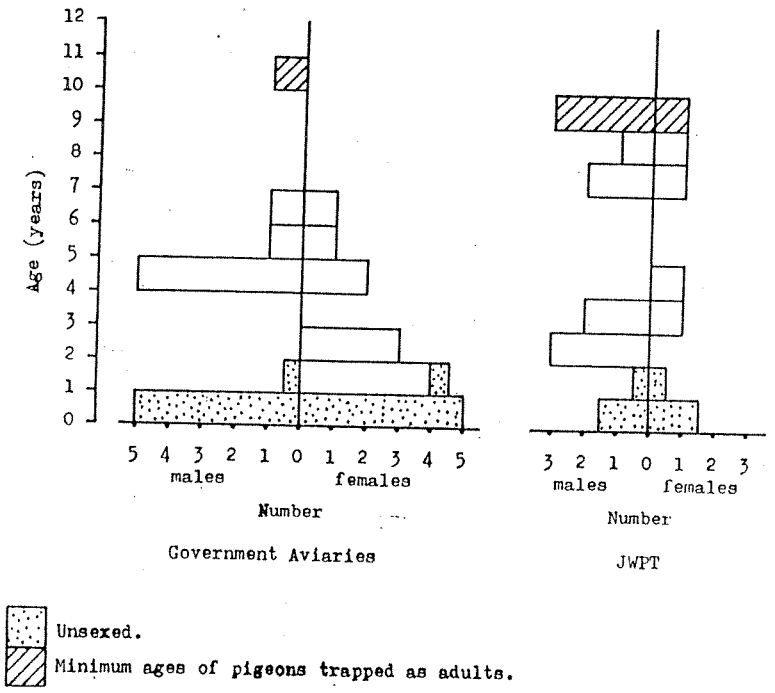


Figure 5: Age structure of the captive Pink Pigeon populations at the Government Aviaries and the Jersey Wildlife Preservation Trust on 31 December 1985.

NUTRITIONAL DISEASES

In the wild, Pink Pigeons eat the leaves, buds, flowers, fruit and seeds of a range of native and exotic plant species, and have also been reported to eat animals such as snails and tadpoles (Jones 1987). At the Government Aviaries, they are fed on a variety of grains and pulses obtained locally, and the birds supplement this diet with leaves and shoots from the trees growing in their aviaries. Due to local shortages, it has not always proved possible to maintain a varied diet, and as a result some pigeons have developed conditions caused by vitamin deficiencies.

Young Pink Pigeons fed on diets with a high proportion of millet have tended to grow slowly and to have a ragged appearance. The growing feathers sometimes lack pigment, and in severe cases debris accumulates in the corner of the gape, the eyelid margins become granulated, and an exudate causes them to stick together. These are signs of a pantothenic acid deficiency but hypovitaminosis A is also a possibility (Arnall & Keymer 1975; Scott *et al.* 1982). The condition is not expressed equally in all squabs fed on the same diet, and some do not appear to be affected at all. This suggests that some birds are genetically more susceptible to a shortage than others.

Juvenile Pink Pigeons kept without access to fresh leaves develop signs

Table 1: Causes of mortality of fledged Pink Pigeons at the Government Aviaries, the JWPT, and the Royal College of Surgeons (RCS).

Proximate or Contributory Causes	Govt. Aviaries	JWPT	RCS	Total No.	Total %
Unknown/Unidentified	17	6	0	23	29.1
Nutritional and developmental problems	19	2	7	28	35.4
Culled (leg deformities)	0	2	5		
Culled (cerebellar hypoplasia)	0	0	1		
Emaciated	5	0	1		
Emaciated/vitamin A deficiency	6	0	0		
Pantothenic acid deficiency	1	0	0		
Culled (perosis)	1	0	0		
Opisthotonus/fits	4	0	0		
Ataxia	1	0	0		
Articular gout	1	0	0		
Management and accidents	10	8	0	18	22.8
'Stress'	2	0	0		
Aortic rupture	1	0	0		
Circulatory failure	0	1	0		
Impaction of colon	1	0	0		
Gut stasis	0	1	0		
Self-mutilation	0	1	0		
Accident	0	1	0		
Infection following head injury	1	0	0		
Entangled in creeper	2	0	0		
Escaped	0	2	0		
Ruptured crop	1	0	0		
Haemorrhage post-vaccination	0	1	0		
Accidental overdose	1	0	0		
Culled (permanent luxation)	0	1	0		
Culled (fractures)	1	0	0		
Infectious disease	9	0	1	10	12.7
Unconfirmed Newcastle disease	4	0	0		
Diphtheritic cloacitis	2	0	0		
Unconfirmed coccidiosis	2	0	0		
Caseous air sacculitis	0	0	1		
Necrotic lesions in the liver	1	0	0		
TOTAL	55	16	8	79	

characteristic or suggestive of a vitamin A deficiency. These included the appearance of small white pustules in the buccal cavity and a watery discharge from the nostrils and eyes. In one case deposition of urates on the heart was noted post mortem, probably indicative of renal failure, possibly exacerbated by vitamin A deficiency. One young pigeon showing signs of vitamin A deficiency suffered fits and died in opisthotonus, and another had poor coordination and balance. When this second bird was culled as an adult, it was found to have cerebellar hypoplasia (Cooper *et al.* 1987). A squab which trembled continuously and had problems balancing died at the age of 14 days. Six Pink Pigeon squabs at the Government Aviaries had what appeared to be 'clubbed down' on hatching, usually a sign of riboflavin or zinc deficiency (Scott *et al.* 1982). The six were the offspring of one pair, and it is possible that a genetic defect inhibiting the assimilation of this vitamin was involved.

SKELETAL DEFECTS

'Inclined feet' has been a common skeletal defect in the captive Pink Pigeon populations. It has been noted in 18 pigeons at the Government Aviaries and one at JWPT. This condition expresses itself as an inward twisting of one or both feet, and first becomes noticeable when the young pigeon is about two weeks old. A mild case is difficult to detect and the bird is able to perch normally. However, in its severest form the feet are so badly twisted that the bird has to balance on its metatarso-phalangeal joints. It has not proved possible to correct the deformity by the application of splints to the birds' legs and feet.

Three Pink Pigeon squabs bred at the Government Aviaries have sustained numerous fractures with no apparent history of trauma. One of these died before fledging, but with intensive care the other two survived. All three were closely related, two of them siblings, so this condition may be genetic in origin.

Several Pink Pigeon squabs developed 'slipped wing', which occurs when the carpus is rotated outwards by the weight of the growing primaries. 'Splayed legs' has affected at least 12 squabs at the Government Aviaries. It develops if the legs are forced apart as the body rapidly gains weight. The incidence of 'slipped wing' was found to be higher in inbred Giant Canadian Geese (*Branta canadensis maxima*) than in outbred ones (Kreeger & Walser 1984), while 'splayed legs' is particularly common in some inbred strains of falcons. There may, therefore, be a genetic component to both these conditions.

Cooper *et al.* (1987) found that three out of six Pink Pigeons examined had bent sterna. This condition, which may affect a quarter of all captive-bred pigeons on Mauritius, involves the buckling of the sternal carina and varies from a barely discernible wave to a marked kink. Affected birds show no obvious disability.

VIRAL, BACTERIAL AND PARASITIC INFECTIONS

The only blood parasite so far identified in Pink Pigeons is *Leucocytozoon marchouxi* (Peirce *et al.* 1977). This species had previously been recorded from two other columbiforms on Mauritius, the introduced Spotted Dove (*Streptopelia chinensis*) and the Barred Ground Dove (*Geopelia striata*) (Peirce *et al.* 1977). The results from the screening of Pink Pigeon blood samples for parasites are summarized in *Table 2*. It is striking that *Leucocytozoon* was found in samples from six out of seven Pink Pigeons awaiting release at Pamplemousses, but that none of the five already released was infected. It is possible that the birds in the release aviary were more stressed and so had a demonstrable parasitaemia. One of the six infected birds survived in the botanical garden for two years after release. A body detected in a lymphocyte from one of the released birds could not be identified.

Coccidial oocysts and an ascarid egg were isolated from the intestinal contents of one of two Pink Pigeons culled at the JWPT (Flach 1984). Three Pink Pigeons have died at the Government Aviaries showing signs of coccidiosis, but the Government's Animal Health Laboratory failed to confirm this diagnosis. Three others examined post mortem at the Royal College of Surgeons showed a diphtheritic cloacitis, which was suspected to be due to *Trichomonas gallinae* (J. E. Cooper, unpublished data). One squab at the JWPT has died of trichomoniasis, and McKelvey (1976) noted the death of a squab with the same disease.

Table 2: Results of examinations of blood samples from Pink Pigeons for parasites.

No. examined	Origin	No. infected	Species	Reference
6	Government Aviaries	0	—	Cooper *et al* (in press)
2	Government Aviaries	0	—	J. E. Cooper (pers. comm.)
4	?	1	*Leucocytozoon marchouxi*	Peirce (1984)
5	Pamplemousses (free)	1	unidentified	J. E. Cooper (pers. comm.)
7	Pamplemousses (caged)	6	*L. marchouxi*	J. E. Cooper (pers. comm.)
2	JWPT	0	—	Flach (1984)
7	Government Aviaries	0	—	Animal Health Laboratory, Mauritius

Table 3: Additional records of potentially pathogenic bacteria recorded from Pink Pigeons from the Government Aviaries.

Date	No. examined	Tissued examined	Species identified	Source
Jul '80	1	liver	*Pasteurella multocida*	AHL
Jul '80	1	liver, lung & exudate	*Aerobacter aerogenes* *Streptococcus* sp.	AHL
May '81	1	liver	*Pasteurella gallinarum*	AHL
Aug '81	2	cloacal swab	*Salmonella typhimurium*	J. E. Cooper
Sept '81	1	liver	*Staphylococcus* sp. *Corynebacterium* sp.	AHL
		throat swab	*Staphylococcus* sp.	
		faeces	*Escherichia coli*	
Dec '81	1	cloacal swab	Coccobacillus	AHL
Jul '82	1	liver	*Corynebacterium* sp.	AHL

Note: AHL = Animal Health Laboratory, Mauritius.

There have been no records of trichomoniasis in the wild population, but the young from two nests at Pamplemousses are thought to have died from this disease. The females from both nests, which failed within two days of each other, were found with their pharynges virtually blocked by 'canker' two weeks later. Following the observation of flagellates (Reece, this volume) from buccal swabs, both pigeons were treated and made full recoveries.

Cooper *et al.* (1987) listed bacterial and fungal species isolated from throat and gut swabs from six Pink Pigeons originating from the Government Aviaries. Some of those identified are potential avian pathogens, for example *Pasteurella* spp., *Yersinia* sp. and *Aspergillus* spp. *Table 3* summarizes other records of bacteria isolated from Pink Pigeons. Bacterial infections that have been identified as a cause of death include one case involving a *Corynebacterium* sp. and two cases of coliform infection at the JWPT. Pneumonia was identified as the cause of death of one, possibly two, squabs at the JWPT and of one adult at the Rio Grande Zoological Park at Albuquerque, New Mexico.

None of the six pigeons culled at the Royal College of Surgeons in 1983 showed serum antibodies to Newcastle disease virus (paramyxoviruses 2–9, excluding 5) or to *Chlamydia psittaci* (Cooper *et al.* 1987). However, four Pink Pigeons which died in convulsions in 1985 were thought by Mauritius Government veterinary staff to have been suffering from Newcastle disease. At Albuquerque, four squabs died from *Herpesvirus* infections. This virus was found to be enzootic, though previously undetected, in the flock of Domestic Pigeons from which the foster-parents for Pink Pigeon eggs were drawn (Snyder *et al.* 1985).

Apart from the three squabs killed by maggots of the Tropical Nest Fly (*Passeromyia heterochaeta*), there is no evidence that insect parasites have caused any deaths, though it is probable that they act as vectors for some infections. A hippoboscid (*Ornithoctora plicata*) has been found on a Pink Pigeon squab in the wild and on adults at Pamplemousses. Simuliid flies are the normal vectors of *Leucocytozoon* species (Peirce *et al.* 1977), so it is possible that *Simulium ruficorne*, the only species recorded in Mauritius, feeds on the Pink Pigeon. Although suitable vectors for avian malaria are present, neither these parasites nor microfilariae have yet been identified in blood samples from Pink Pigeons. Pink Pigeons kept at Casela Bird Park in Mauritius, where a wide selection of

Table 4: The breeding success of Pink Pigeons at the Government Aviaries and the JWPT, contrasted with that reported for Domestic Pigeons.

	Pink Pigeons				Domestic Pigeons
	Mauritius 1977–86		Jersey 1977–86		USA
	No.	%	No.	%	%
No. of eggs	973		474		
No. (%) smashed	186	19.1	116/340	34.1	0 (?)
No. (%) fertile	415/742	55.9	101/254	39.8	82.4–88.3
Est. no. of fertile, unsmashed eggs	440		124		
No. (%) hatched	282	68.0	88	71.0	94.5–96.7
No. (%) fledged (30 days)	165	58.5	35	39.8	75.7–93.1
No. (%) to one year	96/158	60.8	26	74.3	
% of eggs fledged		17.0		7.4	60.2–79.1

Notes: Data for the Domestic Pigeon are from four years of the New Jersey Squab Breeding Contest and one year at the Chaffey Squab Breeding Experimental Station Contest (reviewed in Levi 1978). Data for the Pink Pigeon are from Jones *et al.* (1983), summaries in the journal *Dodo* 1977–1986 and unpublished information.

exotic species is on display, have been found infested with feather lice. These have not yet been identified.

'ADRENAL STRESS'

At the Government Aviaries, groups of juvenile Pink Pigeons are housed together to avoid socialization problems. However, if the groups are maintained for too long, the birds develop a dominance hierarchy (McKelvey 1976) and the subordinate birds may be continually harassed by the others. They then feed less or stop feeding altogether, rapidly lose weight, and may die from a variety of causes if they are not separated from the other birds (Jones *et al.* 1983). If a pair of adults is placed in an aviary, one of the birds, usually the female, may suffer in a similar manner if the pair proves incompatible. This can also happen with well-established pairs if only one bird is in breeding condition. As an example, a female placed in an aviary with a prospective mate was chased by the male, being frequently displaced from her perch. Although still outwardly healthy, she stopped feeding and lost 135g, 38 percent of her original weight, within 15 days. She was removed, and had to be hand-fed until strong enough to fend for herself. This condition is similar to that described as adrenal stress in Wood Pigeons (*Columba palumbus*) (see below).

BREEDING SUCCESS

Pink Pigeons had laid 973 eggs at the Government Aviaries and 474 at the JWPT by the end of 1986. Fertility was low when compared with that reported for the Domestic Pigeon (*Columba livia*) in the USA (Levi 1978) (*Table 4*), as was the hatchability of fertile, unbroken eggs and the proportion of squabs successfully fledged.

The limited data on wild Pink Pigeons suggest that they are no more successful at breeding than the captive ones, with less than 10 percent of the eggs surviving

Table 5: Rates of fledging and nest predation of wild Pink Pigeons compared with those of some other pigeon and dove species.

Species	No. of eggs	No. fledged	% eggs fledged	Overall % predation eggs	squabs
Pink Pigeon *Columba (Nesoenas) mayeri*—Mauritius	21–25	1	c. 4–5	(≤96)	
	51–59	7	c.12–14	c.85–88	0
	72–84	4	c. 5	c.80–95	
	100–120	≤8	≤7–8	(≤92)	
Feral Pigeon *C.livia* —England	812	384	47.3	18.7	c.5.4
Stock Dove *C.oenas* —Belgium	360	136	37.8	19.0	c.5.3
Wood Pigeon *C.palumbus* —England	1704	c.527	30.9	55.2	(≤11.2)
Collared Dove *Streptopelia decaocto*—Czechoslovakia	436	c.299	68.6	(≤2.8)	c.3.7
Turtle Dove *S.turtur* —England	621	c.242	39	34	(≤8)
Laughing Dove *S.senegalensis* —USSR	84	41	48.8	(≤28.6)	(≤17.8)
Ruddy Ground Dove *Columbina talpacoti*—Costa Rica	40	8	20.0	(≤50)	(≤30)
Cold-billed Ground Dove *C.cruziana*—Ecuador	477	c.263	55.2	(≤23.3)	(≤21.5)

Notes: Data for the Pink Pigeon are from McKelvey (1976, 1977), Temple (1978) and Jones (1987); where necessary the numbers of eggs have been estimated by assuming 1.5 to 1.75 eggs per clutch. Data for the other species are from Cramp (1985) and Ricklefs (1969) who refer to various original sources.

to produce fledged young. However, the main cause of failure is predation, which possibly accounts for the loss of at least 80 percent of all clutches (*Table 5*). Other known causes of failure in the wild are infertility and the destruction of nests during cyclones.

In the botanical garden at Pamplemousses, possibly as many as five out of nine nesting attempts failed due to predation by Common Mynahs (*Acridotheres tristis*), an introduced species common in the man-modified habitats but rare in the remnants of native forest. Apart from the eggs and squabs taken for the captive breeding programme, only one clutch of eggs is known to have been collected by humans and this is now in the Mauritius Institute (Jones *et al.* 1983).

Egg breakage

Captive Pink Pigeons tend to be clumsy on the nest and many eggs have been found cracked, dented or smashed. Eggs have also been pushed out of nests, often due to over-zealous incubation behaviour, for example when both parents try to sit at the same time. At the Government Aviaries, over a third of eggs left under Pink Pigeons have been damaged during the course of incubation (*Table 6*). This is partly due to inexperience; birds in their first year of laying at the JWPT broke 26 out of 58 eggs (44.8 percent), whereas those in their fourth year broke nine out of 44 (20.5 percent) (Rankine 1983). The difference is statistically significant ($X^2 = 5.557$, $P < 0.05$). In part to minimize such losses, both the Government Aviaries and the JWPT now foster eggs, under Barbary Doves (*Streptopelia 'risoria'*) on Mauritius and under doves and Domestic Pigeons in Jersey. The use of foster parents also enables the Pink Pigeon pairs

Table 6: Survival of Pink Pigeon eggs incubated by Pink Pigeons and by Barbary Doves at the Government Aviaries.

	Incubated by Pink Pigeons No.	%	Incubated by Barbary Doves No.	%	n	χ^2	P
No. of eggs	85		501				
No. (%) smashed	30	35.3	14	2.8	586	105.9	<0.001
No. (%) fertile	33/63	52.4	296/466	63.5	529	2.474	n.s.
Est. no. of fertile, unsmashedeggs	29		309				
No. (%) hatched	19	65.5	222	71.8	338	0.256	n.s.
No. (%) fledged	9	47.4	133	59.9	241	0.678	n.s.
No. (%) to one year	6	66.7	97	72.9	142	—	n.s.

to recycle more rapidly and so increases the production of eggs. The results obtained suggest that Barbary Doves are at least as successful at hatching Pink Pigeon eggs and raising the squabs as the Pink Pigeons themselves (*Table 6*). Fostering at the Government Aviaries has reduced the incidence of damage and displacement from the nest during incubation, but there is still appreciable loss (19 percent) during the first few hours before the eggs can be transferred. These losses include eggs laid directly off a perch. Rankine (1983) records thin and soft-shelled eggs at the JWPT and eleven eggs with very poor quality shells have been noted at the Government Aviaries, despite suitable sources of calcium being available.

The loss of eggs due to breakage in the nest appears to be rare in Domestic Pigeons, and it has never been recorded for wild free-living Pink Pigeons. It may have been the cause of one nest failure at Pamplemousses (Todd 1984), but predation could not be ruled out in that case.

Infertility

The percentage of infertile eggs laid by Pink Pigeons is about three times that found in Domestic Pigeons (*Table 4*). Preliminary findings suggest that inexperience and senility play a part, but they cannot account for the majority of infertile eggs. Rankine (1983) considered that failure to copulate successfully was a major cause of infertility, but this was difficult to substantiate. Spermatozoa from a testis smear examined in 1984 at the JWPT showed a number of abnormalities (J. E. Cooper, unpublished). It is not known whether other males are similarly affected. The presence of such abnormalities could account for the effect of inbreeding on fertility. Of 46 eggs laid by pairs including a bird with an inbreeding coefficient of 0.25, only 41.2 percent proved fertile. In contrast, the percentage of fertile eggs laid by brother-sister pairs or their equivalent kinship (kinship coefficient = 0.25) has been higher, though not significantly higher, than that of fertile eggs laid by nominally unrelated pairs, 67.1 percent and 57.5 percent respectively. At least 15 eggs laid at the Government Aviaries have lacked yolks, all but four of them laid by two females.

Infertile eggs have been found in the wild. Two out of ten Pink Pigeon eggs collected for the captive breeding programme proved to be infertile. One pair of pigeons released at Pamplemousses laid two clutches of infertile eggs.

Embryonic mortality

In the two captive populations, embryonic mortality accounts for the failure of

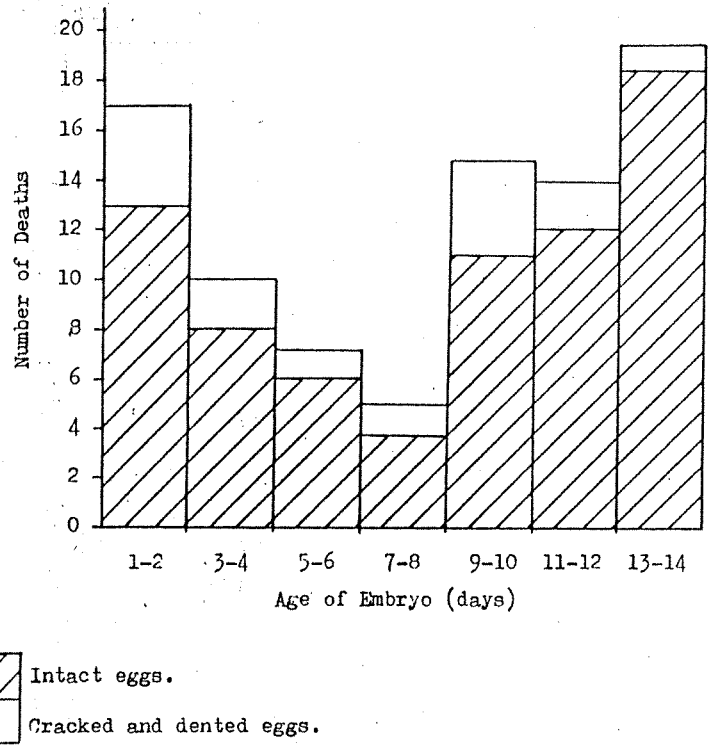


Figure 6: Age distribution of 87 embryo deaths in the captive Pink Pigeon population at the Government Aviaries.

a third of all fertile eggs. The age distribution of 87 embryo deaths at the Government Aviaries is shown in *Figure 6*. There are two peaks, one early and one late in incubation, a pattern similar to that described for the Domestic Pigeon (Riddle 1930) and the Domestic Chicken (*Gallus gallus*) (Gordon 1977). At the Government Aviaries, 39 percent of Pink Pigeon deaths occurred during the first six days and 56 percent during the last six days of the 14-day incubation period. Eighteen percent of embryonic deaths occurred during hatching, compared with 14 percent at the JWPT (Rankine 1983).

Eggs with minor cracks, dents or holes when removed from the parental nest have been repaired with nail-varnish. Over 70 percent of the fertile eggs among them died before hatching, probably from either bacterial infection or faulty water balance. No gross abnormalities have been detected when unhatched eggs have been opened to age the dead embryo, though detailed examination may reveal minor defects. The incidence of infectious disease in the egg is not known, while desertion has caused the loss of fewer than five eggs at the Government Aviaries.

Squab mortality

In the captive populations, 46.9 percent of Pink Pigeons hatched have died

before the age of 30 days. At the Government Aviaries, two-thirds (68.5 percent) of the squab deaths occurred within four days of hatching and 83.8 percent by the tenth day. A similar pattern of mortality is evident in the JWPT data (*Figure 7*).

Possible causes of the deaths of 156 Pink Pigeon squabs are listed in *Table 7*. In over a third of cases, the cause of death has not been identified. Faulty management techniques and accidents accounted for about a quarter of the deaths, while developmental problems and poor or incompetent parental care contributed about 17 percent and 12 percent respectively. Infectious disease apparently played a comparatively minor role although it must be stressed that full microbiological investigations were not made. The early peaks in mortality shown in *Figure 7* are largely accounted for by the deaths with no apparent cause, combined with the deaths of squabs that were weak at hatching and those poorly synchronized to their foster-parents on Mauritius, and with the deaths due to chilling at JWPT.

The deaths of squabs that were very weak at hatching, in some cases requiring to be helped from the shell, and which never improved, have been tentatively attributed to faulty development in *Table 7*, even though the possibly diverse causes of 'weakness' have not been identified. Of the other developmental defects which have proved fatal to squabs, the most common has been incomplete absorption of the yolk-sac. The exposed yolk-sac is vulnerable to damage and infection.

The other developmental defects are discussed below.

Deaths during foster- and hand-rearing

Sixteen Pink Pigeon squabs have died at the Government Aviaries because they were poorly synchronized with their foster parents' incubation cycle, and were either fed crop-milk adulterated with seeds or just seeds and water. If this happens, the squabs may suffer from intestinal blockage or peritonitis and will die if not treated promptly (Jones *et al.* 1983).

The foster doves cease feeding the young Pink Pigeon at about two and a half to three weeks if they fail to solicit food vigorously. Occasionally squabs will not have started feeding themselves by this stage and would starve if not hand-reared. Hand-rearing of these older squabs has ended in the deaths of six of them following crop rupture. Squabs used to be fed by syringing food directly into the crop via a plastic tube placed down the oesophagus (Jones *et al.* 1983), but this occasionally led to damage to the crop lining if the bird struggled or was inadvertently handled too roughly. This source of mortality has now been eliminated by the adoption of a shorter feeding tube.

INBREEDING DEPRESSION

The captive Pink Pigeons are descended from eleven birds from the wild. At no time since the first one was caught in 1976 has the wild population been estimated to comprise more than 30 birds (Jones 1987) and it is probable that some of the founder stock were related. The captive populations could therefore include many more inbred birds than those known. (For the calculation of kinship and inbreeding coefficients used in this paper, it has had to be assumed that no wild-bred Pink Pigeon in captivity was related to another.)

Early in the captive breeding programme, a large proportion of Pink Pigeons at the Government Aviaries were the young of a particularly productive pair.

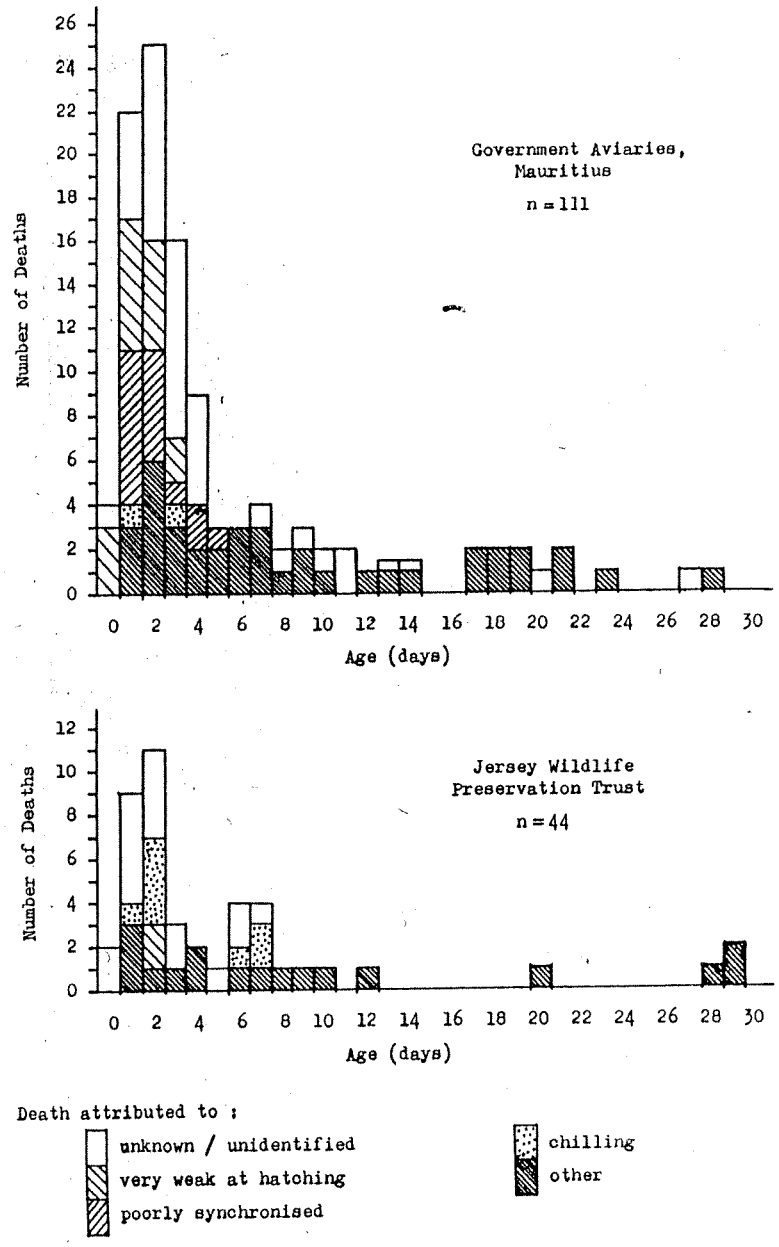


Figure 7: Age distribution of Pink Pigeon squab deaths at the Government Aviaries and at the Jersey Wildlife Preservation Trust.

Table 7: Causes of Pink Pigeon squab mortality at the Government Aviaries and the JWPT.

Proximate or Contributory Causes	Government Aviaries	JWPT	Total No.	Total %
Unknown/Unidentified	38	17	55	35.3
Management and accidents	39	3	42	26.9
Poorly synchronized with foster-parents	16	0		
Incorrect diet when hand-reared	11	1		
Ruptured crop	6	0		
Accident (fracture, entangled foot, etc.)	3	2		
Internal haemorrhage	3	0		
Developmental problems	19	7	26	16.7
Very weak at hatching	16	2		
Incomplete yolk-sac absorption	1	4		
'Spontaneous' fractures	1	0		
Ataxia	1	0		
Undersized and underdeveloped	0	1		
Incompetent parental behaviour	7	11	18	11.6
Fell from nest	4	1		
Chilling	2	8		
Crushed by (foster-)parent	1	1		
Injured by father	0	1		
Infectious diseases	5	6	11	7.1
Congested lungs/pneumonia	0	2		
Coliform infection	0	2		
Cloacitis	2	0		
? Coccidiosis	1	0		
Caseous lesions in intestines and lungs	1	0		
Corynebacterium infection	0	1		
Trichomoniasis	0	1		
Severe eye infection	1	0		
Predation, etc.	4	0	4	2.6
Black Rat (*Rattus rattus*)	1	0		
Larvae of Tropical Nest Fly (*Passeromyia heterochaeta*)	3	0		
TOTAL	112	44	156	

As a result, a number of pairs of siblings were allowed to breed. In *Table 8* and *Figure 8*, the fate of eggs from sib matings or their equivalent (kinship coefficient 0.25) is compared with that of eggs laid by pairs not known to be related. Eggs from pairs including a bird known to be inbred have been excluded. The fertility of eggs from related pairs was found to be higher than that of eggs from nominally unrelated pairs, though the difference is not significant at the 5 percent level. In contrast, the proportions of fertile, unbroken eggs that hatch, squabs that fledge, and fledglings that survive for one year, are all significantly lower for the inbred eggs. These results are not unexpected as the deleterious effects of inbreeding on normally outbreeding populations are now well documented (e.g. Wright 1977; Senner 1980). The possible presence of related birds in the founder stock and the unrecorded inbreeding which would have resulted could account for the relatively poor breeding results shown by the nominally unrelated pairs.

Table 8: The effect of inbreeding on the breeding success of the Pink Pigeons at the Government Aviaries.

	Nominally unrelated pairs		Sib matings or equivalent				
	No.	%	No.	%	n	χ^2	P
No. of pairs	23		17				
No. of eggs	592		191				
No. (%) smashed	110	18.6	41	21.5	783	0.598	n.s.
No. (%) fertile	263/457	57.5	96/143	67.1	600	3.773	n.s.
Est. no. of fertile, unsmashed eggs	277		101				
No. (%) hatched	194	70.0	58	57.4	378	4.744	<0.05
No. (%) fledged	117	60.3	24	41.4	252	5.747	<0.05
No. (%) to one year	88	75.2	11	45.8	141	6.875	<0.01

DISCUSSION

In the two major captive populations of Pink Pigeons, mortality has followed a pattern common to many species of bird, both wild (free-living) and captive (e.g. Lack 1954; Hillgarth & Kear 1981). However, the percentage of individuals dying at each stage of the breeding cycle has been higher than that found in most other studies.

A number of conditions affecting Pink Pigeons have been recognized. In some cases their probable causes can be inferred due to their similarity to known conditions in Domestic Pigeons or other well studied species. A few of those exhibited by Pink Pigeons appear to be solely genetic in origin, for example 'cleft tail feathers'; others such as 'clubbed down' and 'crooked toe deformity', are primarily thought to be the result of dietary deficiencies or poor management, although their individual expression may be influenced by the genetic background of the individual.

Nutritional deficiencies

Several nutritional problems have been diagnosed in the Pink Pigeons on Mauritius, and two of the most important of these have been pantothenic acid and vitamin A deficiencies. A deficiency of vitamin A may have been the cause of nervous problems in several birds. In chickens, vitamin A deficiency has been reported as causing degenerative changes in both the central and peripheral nervous systems resulting in ataxia and incoordination (Siegmund 1979; Gordon 1977). Although not necessarily fatal, a deficiency of vitamin A reduces the bird's viability and may leave it more susceptible to infections.

Vitamin A deficiencies have been largely avoided in recent years on Mauritius because the pigeons are now provided with maize on a regular basis. The original diet would in theory have met the vitamin A requirements of Domestic Pigeons (Levi 1978), and the foster Barbary Doves provided with the same diet as the Pink Pigeon have never shown signs of deficiency. It is therefore possible that both Domestic Pigeons and Barbary Doves, which usually feed on seeds low in vitamin A, are adapted to the low levels of this vitamin. Consequently they are likely to be very efficient at absorbing it whereas the Pink Pigeons which eat a wider range of foodstuffs, many of which are very high in vitamin A, do not have to have such efficient rates of absorption or metabolism.

The diet provided for the Pink Pigeons at the Government Aviaries may be too high in protein. This is suggested by the incidence of kidney lesions, including interstitial nephritis, recorded post mortem (Cooper *et al.* 1987) and the one case of articular gout. The occurrence of 'splayed legs' and 'slipped wing' may also be due to the same dietary imbalance, though these conditions have alternatively been attributed to calcium and phosphorus deficiencies (Kear 1973, 1978).

Although dietary deficiencies might have been having a general effect depressing the viability of the pigeons, this does not appear to be the case. Conditions caused by deficiencies, for example of vitamin A, have developed, but improving

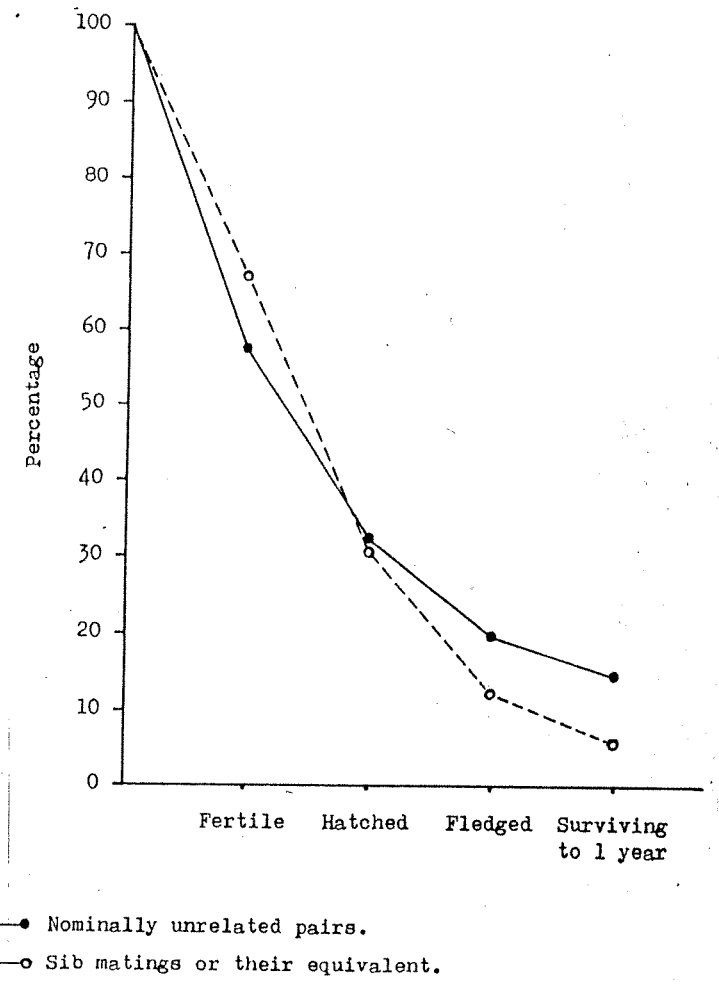


Figure 8: The breeding success of 23 nominally unrelated pairs of Pink Pigeons and 17 pairs of siblings or their equivalent (kinship coefficient = 0.25).

the diet has not led to a marked improvement in the breeding results, even though the incidence of these conditions has dropped significantly. There has also been great variation in fertility between pairs and in mortality between their offspring, even though all birds have been provided with the same diet.

Developmental conditions

A common skeletal deformity that has affected the Pink Pigeons has been 'inclined feet'—a condition that may be homologous to club foot. Jones *et al.* (1983) suggested that the condition was the result of shortened flexor tendons, because the foot is twisted even further inwards if an attempt is made to straighten the leg. Cooper *et al.* (1987) and Flach (1984) have described the condition post mortem. The main deformity identified was a rotation of the distal end of the tarsometatarsus causing an associated malpositioning of the tendons. Cooper *et al.* (1987) could find no evidence of bone disease in radiographs, but could not exclude the possibility that skeletal lesions at an early age played a part. Jones *et al.* (1983) speculated that 'inclined foot' was of genetic origin, but examination of the family tree of the captive Pink Pigeon population has failed to support this. 'Curled toe paralysis', a condition affecting poultry and other bird species, has similarities to 'inclined feet'. It is caused by riboflavin deficiency and is associated with enlargement of the sheaths of the sciatic and brachial nerves (Scott *et al.* 1982). The nerves of Pink Pigeons with 'inclined feet' have not yet been examined to establish the homology of this condition. However, none of the offspring of the pair which produced young with 'clubbed down' has developed 'inclined feet'.

The most common skeletal deformity is a bent or wavy sternum. The condition is well known in a range of bird species including the Domestic Pigeon. Levi (1977) considered that the deformity was the result of an unsuitable nest-substrate and an inadequate diet. He also noted that some breeds are more susceptible to the condition than others, suggesting that genetic factors are involved in its aetiology.

'Adrenal stress'

Subordinate birds in pairs or groups often feed less or stop feeding completely and die from inanition or secondary conditions. Murton *et al.* (1971) described an apparently similar cause of mortality in wild Wood Pigeons (*Columba palumbus*), in which subordinate birds lost weight and died from inanition and adrenal stress. Examination post mortem revealed hyperplasia of the cortical cells of the adrenal glands. The adrenal glands of the Pink Pigeons that died in the circumstances described above have not yet been examined in detail, so the possible homology of these conditions cannot be confirmed.

Breeding success

Jenkins *et al.* (this volume) attribute the high rates of infertility and mortality at all stages in the wild population of Hawaiian Crows (*Corvus hawaiiensis*) to exotic diseases, in particular to avian malaria and avian pox. There is, however, no evidence to date that infectious disease is a major factor reducing the breeding success of the Pink Pigeons.

In *Tables 5* and *9*, the breeding success of the wild population of Pink Pigeons is compared with that of some other pigeon and dove species. In the studies used for comparison, the percentage of eggs producing fledglings ranges from almost 70 percent in the Collared Dove (*Streptopelia decaocto*) to less than 10 percent in the Pink Pigeon. At less than 10 percent, the proportion of Pink

Table 9: Nesting success of wild Pink Pigeons compared with that of some other pigeon and dove species.

Species	No. of nests	No. of young fledged	% nests fledging young	Young fledging per nest	Young per successful nest
Pink Pigeon					
Columba (Nesoenas) mayeri	14	1	7.1	0.07	1.0
—Mauritius	c.35	0	0	0	0
	48	4	≤8.3	0.08	1.0(?)
	68	≤8	?	≤0.12	?
Stock Dove *C.oenas* —East Germany	399	c.519	c.73	1.3	1.78
Laughing Dove *Streptopelia senegalensis*—South Africa	619	c.433	?	0.7	?
—Botswana	672	c.591	?	0.88	?
Mourning Dove *Zenaida macroura*—USA	249	c.213	52.2	0.86	1.64
—USA	204	c.274	69.7	1.34	1.93
Ruddy Ground Dove *Columbina talpacoti*—Costa Rica	21	8	23.8	0.38	1.60
Cold-billed Ground Dove *C.cruziana*—Ecuador	283	(263)	56.5	c.0.93	c.1.64

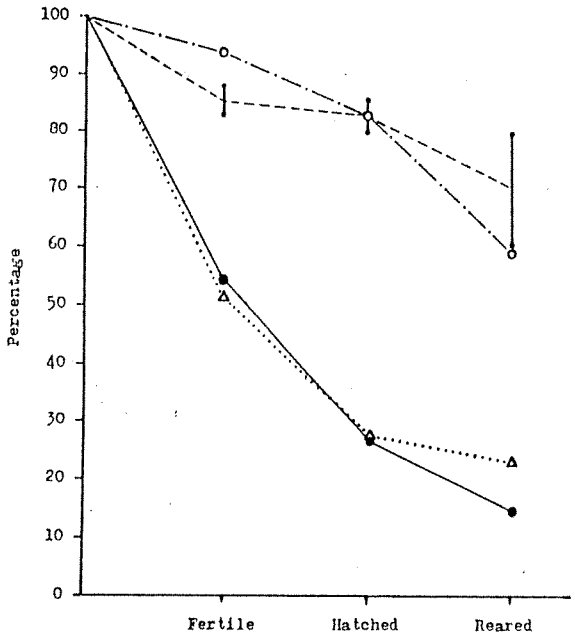
Notes: Data for the Pink Pigeon are from McKelvey (1976, 1977), Temple (1978) and Jones (1987). Data for the other species are from Cramp (1985) and Ricklefs (1969) who refer to various original sources.

Pigeon nests fledging young is also low. With the exception of the Ruddy Ground Dove (*Columbia talpacoti*), the other species for which figures are available fledge young from over 50 percent of their nests. Predation is a major cause of nest failure in some of the other studies, but in no case where detailed figures are provided does it approach the level suffered by the Pink Pigeons. Pink Pigeons might be expected to be especially vulnerable to mammalian predators having evolved on an island with none, even though they do have a nest distraction display (McKelvey 1976; Jones 1987).

Observations and some experimental evidence support the suggestion that the introduced Long-tailed Macaque (*Macaca fascicularis*) is the main nest-predator (McKelvey 1976, 1977; Jones 1987). McKelvey, for example, reported the loss of 40 out of 48 nests to macaques during 1976. Although there is no direct evidence, Ship Rats (*Rattus rattus*) probably destroy some clutches as well. They are known nest-predators (Atkinson 1978) and have been recorded taking the eggs of other Mauritian bird species (Jones 1987). The only extant native nest-predator is the Mauritian Cuckoo-shrike (*Coracina typica*), which was reported to have taken four out of 48 clutches of Pink Pigeon eggs in 1976 (McKelvey 1977).

The incidence of infertile eggs has been greater than might be expected and occurs about three times more frequently than in Domestic Pigeons (*Table 4*). The difference may be even greater since Levi (1977) considered that only 3 percent to 5 percent of Domestic Pigeon eggs were infertile and that the numbers reported were too high because they included eggs which failed due to early embryonic death.

The prevalence of embryonic death in Pink Pigeons is also exceptionally high compared with that recorded in Domestic Pigeons, in which less than 5 percent of fertile eggs died (Levi 1977). Although these data came from squab breeding



●——● Pink Pigeon. Data from populations at the Government Aviaries and JWPT. 'Reared' refers to birds reaching an age of 30 days.

|----| Domestic Pigeon. Ranges cover results from four years of the New Jersey Squab Breeding Contest and one year at the Chaffey Squab Breeding Experimental Station Contest. 'Reared' refers to marketable birds (25 - 35 days old) (reviewed in Levi 1978).

o—·—o Feral Pigeon. Data excluding predated nests adapted from Murton & Clarke 1968. 'Reared' refers to birds fledged.

Δ·····Δ Hawaiian Goose. Data from captive population at the Wildfowl Trust, 1962 - 1972 (Kear & Berger 1980).

Figure 9: Breeding success of the Pink Pigeon compared with that of Domestic and Feral Pigeons (*Columba livia*) and Hawaiian Geese (*Branta sandvicensis*).

contests and so might be expected to be inflated, this does not seem to be the case. Comparable figures were obtained by excluding the figures for predated nests from data on Feral Pigeons (also *C. livia*) in Murton & Clarke (1968) (*Figure 9*). The Pink Pigeon results are similar to those recorded for an inbred population of anothor endangered island species in captivity, the Hawaiian Goose (*Branta sandvicensis*) at The Wildfowl Trust, England (Kear & Berger 1980).

A deficiency of either vitamin A or riboflavin, both of which have been suspected in squabs at the Government Aviaries, reduces the hatchability of chickens' eggs (Scott *et al.* 1982) and may account for some Pink Pigeon embryo mortality.

The prevalence of squab mortality is far higher than that found in the Domestic

Pigeon squab breeding contests which Levi (1978) reports as ranging from 6.9 percent to 24.3 percent *(Table 4)*.

Squabs less than five days old, which are not being fed properly by their foster-parents, have proved difficult to rear by hand. Many of the early attempts ended in failure, probably because the high carbohydrate content of the artificial diets used reversed the osmotic gradient in the gut causing dehydration (Jones *et al.* 1983). Mammalian milk compares well with crop milk as a source of protein, fatty acids and some vitamins, but it contains lactose. Pigeons do not produce lactase and mammalian milk should therefore not be fed to squabs (*contra* Jones *et al.* 1983), since it may ferment in the gut. A shortage of manganese, which birds require in greater quantities than mammals, may be another cause of failure to hand-rear young squabs (Jones *et al.* 1983).

Inbreeding depression

If an ultimate cause of the poor breeding results is to be identified, inbreeding depression is the most likely candidate. The Pink Pigeons have exhibited many of the effects of inbreeding depression described for other species, such as poor parental behaviour, decreased fertility, low hatchability of fertile eggs, poor survival of young, and increased susceptibility to a wide range of apparently unrelated diseases, both infectious and non-infectious (Soulé 1980; Senner 1980; Ralls *et al.* 1980). These deleterious effects are, however, not confined to those Pink Pigeons known to be inbred. It is therefore probable that some, if not all, of the pigeons taken from the wild were related. As the wild population is small and has recently declined in numbers, it may also be suffering from the effects of inbreeding, though these would be masked to a large extent by the high level of nest predation.

In *Figure 9*, the breeding success of the Pink Pigeons at the Government Aviaries and the JWPT is compared with that of the Hawaiian Geese at The Wildfowl Trust between 1952 and 1972. In the first ten years, the latter population was highly inbred, all birds being descended from just three founder birds. However, over the next five years four males from Hawaii were introduced (Kear & Berger 1980). For the first ten years breeding success was worse than that of the Pink Pigeons, but with the arrival of the new males, it improved significantly. It is therefore only by coincidence that the composite results match the breeding success of the Pink Pigeon so closely. However, the fact that the breeding success of the Pink Pigeons has been depressed in a similar pattern to that shown by a population known to be highly inbred supports the hypothesis that unrecorded inbreeding is reducing the viability of the captive birds.

In an investigation of the breeding records of a herd of captive Dorcas Gazelles (*Gazella dorcas*), Ralls *et al.* (1980) found that inbred calves had died due to premature birth, inanition and a variety of miscellaneous medical problems and infections, none of which had caused the death of non-inbred calves. The situation is not so clear cut in Pink Pigeons. The only causes of death to which inbred squabs succumbed in significantly higher numbers than expected were 'weakness' and being fed on an unsuitable artificial diet. These are related since in many cases weak squabs needed to be hand-fed. There is no obvious correlation between inbreeding and particular causes of death of fledged Pink Pigeons.

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Maintenance and Breeding of the Pink Pigeon *Nesoenas mayeri* in Captivity.

By C.R. Lind
Bird Staff, Jersey Wildlife Preservation Trust.

Introduction

The Pink pigeon *Nesoenas mayeri* has been the subject of an intensive captive breeding programme at the Jersey Wildlife Preservation Trust since 1977. During this period over 100 birds have been hatched and successfully reared. Methods of housing the birds as well as hatching and rearing young pigeons have been refined over this period and will be discussed in this paper.

A three year study carried out at the Trust into the breeding behaviour of the pink pigeon was undertaken in 1987 and the data gathered have provided an insight into the breeding requirements of this species. This has been a great help in formulating the Trust's current methodology for breeding the pink pigeon.

Accommodation

Pink pigeons have been housed at the Trust in a wide variety of aviaries. Some of these have been purpose built and others modified to accommodate pigeons. Experience has shown that provided a few basic criteria are met, pigeons can be housed and will breed in almost any aviary which provides both an outside flight and a sheltered inside area, the latter preferably heated if the birds are to be bred throughout the year.

The height of the aviary appears to be the single most important criterion . Ideally aviaries should be three metres or more in height. The pigeons will usually select the nesting site located at the highest point in the aviary. The provision of nesting sites in high points in the aviary and in particular in the inside areas appears to offer the birds a greater feeling of security and they are less disturbed by routine servicing of the aviary.

Many aviaries housing pigeons at the Trust are adjacent to one another. These aviaries are constructed with adjoining doors which can be opened to allow the free movement of birds between aviaries. These aviaries are used for breeding and would normally contain one pair of pigeons in two adjoining aviaries. This allows a large aviary space for each pair but, more importantly, it allows for the pair of birds to be easily separated should the male become overly aggressive towards the female. Housing pairs of pigeons in adjacent aviaries does not appear to cause

problems in most instances but Bell and Hartley (1988) have documented cases where the males of adjacent pairs have spent large amounts of time involved in 'aggressive' displaying to each other. This appears to be at the expense of normal nesting behaviour as the pairs involved built poor quality nests and failed to brood eggs properly. For this reason it is probably better to isolate pairs of pigeons if the birds are to be left to hatch and rear their own eggs.

Food and Feeding

The diet of the pink pigeon in the wild is comprised predominantly of fruits, flowers and leaves (McKelvey, 1976; Jones *et al.*, 1983). At the Trust the pigeons are fed on a wide variety of food items but the bulk of the feed is comprised of a mixture of various fruits and vegetables.

As a base, a dry mixture of wheat, commercial layers pellets, and a general purpose insectivorous food are combined. This makes up approximately 30% of the total feed. Much of this mixture is left in the bowls by the pigeons, the exceptions being young birds and brooding birds. As many of the pigeons are foster reared and are fed on wheat for the first 4 to 6 weeks whilst with the foster birds it takes a short period of time for them to change over to the regular pigeon diet. During this transition period they eat a greater proportion of the dry mixture than the adult birds. With nesting pairs, the bird which is not brooding will eat the bulk of the fruit and vegetable from the food dishes leaving only the dry mix for the brooding bird when it comes off the nest.

The remaining 70% of the feed is made up from a selection of fruits and vegetables. Some of these are offered regularly while others can only be given when seasonally available. Those items offered on a regular basis include apple, pear, grape (both white and black) and lettuce. Originally carrot had been offered on a daily basis but much of this was left in the dishes or discarded on the floor.

The fruit and vegetables are offered cut into small pieces (0.5 cm. cubed).The lettuce is cut into pieces which are slightly larger. The mixture is then placed in bowls on top of the dry mixture. A number of supplements are then added to the feeds. Vionate, a powdered multi-vitamin and mineral supplement, is added to the feed on a daily basis. Vitamin D_3 and vitamin E (alpha-tocopherol) in a powdered form is added to the feeds on alternate days. A small amount of finely grated egg is then added to the top of each feed. In the past the branches of Contorted Willow (*Salix tortuosa*) had been offered as a supplement to the regular feed. As most of the aviaries housing pigeons are well planted with a variety of shrubs, many of which are avidly eaten by the pigeons, it was felt unnecessary to continue this.

The feeds are provided in 11 cm. diameter ceramic bowls with a bowl provided for each pigeon. Providing individual bowls for each bird allows for the feeds to be placed in different parts of the aviary which can help to eliminate confrontation between pigeons kept in groups.

Breeding

The breeding display and nesting behaviour of the pink pigeon is similar to other columbiformes and has been discussed in detail by McKelvey (1976) and Bell and Hartley (1988). Although breeding is seasonal in the wild, the pigeons at the Trust will breed throughout year. Problems can be encountered during cold periods when the temperature falls below 10° C.. Without heated accommodation females may lose interest in breeding. Males, however, will still show an interest and with the females not responding to the displaying male, will often become aggressive. It is important therefore that any breeding pairs together during the winter months are carefully monitored.

1. Pairing

It has previously been suggested that the skin of the cere and around the eye are a vivid red colour when the bird is in optimal breeding condition (Jones *et al.*, 1983). Although the colour of the skin of the cere and around the eye does appear to change from the usual pink to a vivid red at certain times of the year this does not appear to indicate a greater desire to breed in the birds. Pigeons which do not exhibit this vivid red colour appear as willing to breed as those that do. In the past, problems have been encountered with some males which have exhibited the vivid red colour. When an attempt was made to pair these individuals with females, the males were overeager and would attempt to drive the female to nesting sites without the proper cooing and bowing display which usually precedes this. This usually resulted in the eventual battering of the female.

The general method of mixing a pair of pigeons now used at the Trust involves placing a new bird, either male or female, into an aviary with a previously established bird and mixing the pair together immediately. It has proven better to put males into aviaries which contain established females rather that the other way around. In the past the birds were placed in the same aviary but were separated with visual access for the first few days before mixing. This method resulted in a lower rate of successful pairings than the method now used. It appears that males given visual access to females will display and that the female may respond but without being able to copulate with the submitting female the male soon becomes frustrated. On mixing these birds, the male having displayed to the female on numerous occasions prior to mixing will immediately attempt to drive the female to a nesting site. Females will not usually respond to this driving until the male has performed the bowing and cooing display and copulated with the submitting female.

Mixing pigeons as described above appears to work with the vast majority of birds but a few males will attempt to drive the female immediately upon mixing,

thereby bypassing the bowing and cooing display. In situations like this, successful pairings have been achieved by mixing these aggressive males with more than one female at a time. Usually two females are placed in an aviary and left for a couple of days to ensure that they are compatible. The male is then placed in the aviary and mixed immediately. Males mixed using this method show a dramatic change in behaviour, usually going a number of days before beginning to display to the females. At this point the birds must be regularly monitored because once the male pairs with a female, that female will begin to chase the remaining female(s).

If a male persists in aggressively driving a female(s) even when mixed with more than one at a time, the birds should be separated as soon as possible. With problem males such as this, isolating the bird from visual contact with females for a period of time before repairing has often proved effective.

Once a pair has been successfully mixed they will ususally remain compatible for 3 to 4 months. This is independent of the number of eggs layed. Pairs at the Trust which have been allowed to sit full term on their clutches without hatching the eggs do not appear to stay compatible any longer than pairs which have their eggs pulled immediately after laying although the latter appear to be under more stress due to the greater number of breeding cycles within the same time period.

2. Nesting

All aviaries for pink pigeons at the Trust are provided with both nest platforms and nest boxes.The nest platforms are 25.5 cm. x 25.5 cm. with a wire mesh bottom. The mesh on the bottom should not be larger than 1.5 cm. sq. to prevent eggs falling through. Nest boxes are 25.5 cm. x 25.5 cm. x 25.5 cm. with a 7 cm. lip at the front. These are usually placed around the aviary such that each platform or box is in a sheltered location as high up as possible. The most favoured nesting sights are almost always those platforms or boxes located in the highest corner of the inside area of the aviary. Pigeons have nested outside but only in circumstances where the outside flight provides a sheltered area considerably higher than any provided in the inside area.

The provision of nest material is one of the most important aspects of breeding the pink pigeon. A constant supply of fresh nesting material is crucial to promoting proper reproductive behaviour in the birds. Initiation of broodiness in the female is brought about by the male carrying nest material (Lehrman, 1958). Fresh material is usually added to the aviaries on a weekly basis. The nesting material supplied to the birds consists of twigs of various sizes. Twigs 20 cm. or less in length and under 0.3 cm. in diameter appear to be preferred. A large amount of the material which the birds carry to the nest platform will be discarded over the edge and builds up on the ground. The pigeons appear to ignore this discarded material but will reuse it if it is redistributed throughout the aviary.

3. Incubation & Rearing

Table 1. Averaged daily weights for Pink Pigeon squabs at the Trust

Day	Weight	Day	Weight
1	13.4g	12	145.3g
2	22.2g	13	155.6g
3	32.9g	14	165.5g
4	45.1g	15	171.4g
5	59.1g	16	176.3g
6	73.4g	17	179.8g
7	86.3g	18	181.7g
8	99.0g	19	187.2g
9	110.1g	20	191.7g
10	124.0g	21	193.0g
11	135.6g		

Avg. fledge weight = 207.4g

Pink pigeons lay a clutch of two eggs over a three day period with the eggs being laid on the first and third days. The incubation period is 14 days but there is some variation, with a range of 13 to 16 days. Chipping usually occurs 24 hours prior to hatching and usually begins early in the morning.

The female will begin to sit tightly on the nest two to three days before laying the first egg of the clutch. During this period the male will often be seen sitting with the female, spending progressively longer periods on the nest until the laying of the second egg (Bell and Hartley, 1987). At this point the male will take over the brooding of the eggs during the day with the female brooding through the night. This pattern will continue until the eggs begin to chip at which point the birds will begin to brood the eggs together.

Using this change of brooding behaviour as an indicator of egg hatching has proved accurate in most cases. The birds will also appear much more agitated once the egg(s) have started to chip. At the Trust no attempt has been made to check squabs until they are at least 7 days old. As long as the parent birds continue to brood it can be assumed that the squab(s) are alright. It is often difficult to determine if the eggs have hatched but experience has shown that if an egg has successfully hatched the shell will be discarded over the edge of the nest within 24 hours of hatching. Examination of these shell fragments should indicate if these are the result of a successful hatching.

Squabs are usually brooded continually for the first 7 days after which they will be left unbrooded for increasingly longer periods until fledging (Bell and Hartley, 1988). Fledging usually occurs 26 to 30 days after hatching with the squab fledging at approximately 66% of adult weight.

Parent reared squabs at the Trust are removed from the parent birds shortly after fledging. Leaving squabs with the parent birds past fledging increases the

probability of parental aggression towards the squab. Removing the squab will also allow the parent birds to begin another reproductive cycle. In most cases it is desireable to minimize the time between reproductive cycles in an effort to maximize the output from a pair of pigeons.

4. Foster Rearing

At the Trust both domestic pigeons and Javan doves (*Streptopelia 'risoria'*) have been used to foster pink pigeon eggs and squabs, but Javan doves have proved easier to work with. Even though domestic pigeons are able to brood both eggs from a clutch, they are more aggressive, which leads to a greater chance of egg damage when removing and replacing eggs in the nest. Doves can only brood one egg at a time due to their smaller size. The incubation period for domestic pigeons is 18 days which is 4 days longer than that for pink pigeons. This must be compensated for when substituting pink pigeon eggs for domestic pigeon eggs. The Javan doves have a 14 day incubation period, the same as the pink pigeon, and therefore no compensation is necessary. For these reasons Javan doves are now the chosen foster species at the Trust.

The majority of pink pigeons produced at the Trust are foster reared. There are a number of reasons for using this method with the pink pigeon. Removing clutches of eggs from a pair of pigeons will result in replacement clutches being laid. Through utilizing this method of multi-clutching the reproductive output of the pairs of pigeons can be greatly increased. This also allows much greater control of the genetic composition of the captive population as any pair of birds can be effectively bred regardless of their parental abilities.

The use of foster birds also allows regular monitoring of eggs and squabs. With respect to eggs, this allows data to be collected on initial egg weights, water loss during incubation period, and monitoring of embryo development. This has also proved valuable in cases where eggs have been damaged by either the parent of foster birds and have had to be repaired.

In the case of squabs, regular monitoring of growth and development is possible when foster birds are used. At the Trust all fostered squabs are weighed daily for the first 21 days after hatching. The daily weights are compared with averaged weights for that given day which allows for an accurate assessment of the squabs' growth. If the growth is found to be below average measures can be taken to correct this. This has resulted in a very low rate of mortality in squabs reared under fosters. Since the beginning of 1987 the mortality in pre-fledged squabs has been less than 20%. Table 1. shows a list of the average daily weights for the first 21 days after hatching of fostered squabs at the Trust.

Foster birds at the Trust are housed in cages 86.4 cm. long, 78.4 cm. deep and 61 cm. high. Each cage is provided with two perches, one spanning the length and one the width of the cage. A wooden nest box is also provided, the design of which is described later in this paper. The bottom of the cage is lined with

newspaper which is changed daily. The foster birds use this newspaper as nesting material, tearing it into strips to line the bottom of the nest box.The cages containing the pairs of foster birds are cleaned daily and the food and water changed. The birds are fed a mixture of wheat and maize and a commercial pigeon grit is also offered. A general avian multi-vitamin is given daily in the drinking water.

The most important consideration in managing a colony of foster birds for brooding eggs and rearing pink pigeon squabs is synchronization. Pairs of foster birds must be closely synchronized with pairs of pink pigeons if they are successfully to rear any squabs which hatch. Fostered eggs must hatch within a given time frame, which is based on the initiation of brooding in the foster birds. The ideal situation is one in which the pair of pink pigeons and the pair of foster birds lay eggs on the same day. In this situation the egg will hatch when the foster doves are expecting and are producing the necessary crop milk to feed the squab. As both the pigeons and doves lay 2 eggs over a 3 day period, pink pigeon eggs can be set under the foster doves anytime during this three day laying period. In fact experience has shown that pink pigeon eggs set under doves up to 2 days after the doves have layed their second egg will be successfully reared.

At the Trust every effort is made to avoid artificial incubation and hand rearing when dealing with the pink pigeon. Two major problems have been encountered in the past with hand rearing this species. Firstly, it is difficult to produce a suitable artificial crop milk to feed to the young squabs for the first week to ten days. Attempts in the past to hand rear squabs from the egg on an artificial crop milk have led to compaction of the gut, resulting in the death of the squab. More success has been achieved from hand rearing squabs which have been fed by either their parents or foster doves for at least 5 days. In these cases the squabs have been fed on soaked seed (maple peas or wheat) and there has been no attempt to feed an artificial crop milk.The second problem arising from hand-rearing is the development of abnormal behaviour in the pigeons. This is possibly the result of imprinting on the person rearing the squab and has caused serious problems with the daily management and breeding of these birds. Pink pigeons hand-reared at the Trust in the past have shown aggressive behaviour towards keepers as well as a lack of proper breeding behaviour.

In the past an unacceptable number of pigeon squabs developed what Jones *et al.*,(1983) refered to as inclined feet and it was felt that this may be a consequence of inbreeding in the pink pigeon population. Post mortems on a number of pigeons exhibiting this condition (Cooper *et al.*, 1988) showed a rotation of the distal tarsometatarsus. Birds raised at the Trust with this condition showed no apparent relationship to specific parent birds or a specific geneology. This led to the belief that it may be a developmental problem related to poor husbandry techniques. This resulted in the design of a special nest box to be used with the foster dove colony.

This nest box consists of an open fronted wooden box and a wire mesh insert which is placed in the base of the box. The box is 20 cm. x 20 cm. x 20 cm.

with an open front with a 5 cm. lip. The wire mesh insert is constructed from 1 cm. sq. heavy gauge mesh with the edges bent down to create a platform which will sit 4 cm. above the base of the box. This platform is then hammered down to form a concave depression making sure that at its lowest point it is still approximately 1 cm. above the base of the nest box.

The foster doves will cover this mesh insert with strips of newspaper when nesting, which is encouraged as the newspaper acts as a cushion while brooding the eggs. This newspaper must be removed, however, once the hatched squab is 3-4 days old and the mesh kept clear of newspaper until the squab fledges. The wire mesh provides a surface which the squabs can grip, preventing the situation where a closed foot could rotate and possibly causing a malformation of the legs. This has resulted in the elimination of inclined feet in the pink pigeons bred at the Trust since initiation of this procedure in 1987.

Pink Pigeons reared under foster doves fledge at about 26 days of age. The birds are usually left in with the foster pair until it has been confirmed that they are regularly feeding themselves. At this point they are removed and placed in an aviary. If there are other young pigeons of a similar age thay can be put together in the same aviary. These should be birds under 8 weeks of age. Attempts to mix birds older than this usually results in aggression between the birds, often resulting in the loss of condition or death of an individual(s). The best results combining young pink pigeons into groups at the Trust have been achieved by taking a number of individuals straight from the foster parents and mixing them together in an aviary. In some cases this can only be achieved by leaving some pigeons in with the foster birds until other pigeons have matured to the stage at which they can be removed from their foster parents. Removing a fledged pigeon(s) from the foster birds and placing it in an aviary on its own with the intention of introducing newly fledged pigeons at a later date usually results in aggression by the established bird towards the introduced bird(s).

There are two major advantages in mixing young pigeons in groups. Firstly this minimizes the aviary space required to house the birds. Secondly, and of more importance, sexing of the birds is much easier with a group. Pink pigeons can be kept in a group until the birds reach sexual maturity at about 8 months of age. At this point males can be seen displaying to females and fighting with other males. As birds within a group will all differ slightly in age this will happen gradually. Those birds which exhibit signs of sexual maturity can be removed from the group and paired with a suitable mate or rehoused depending on the requirements of the collection.

Conclusion

Since the initiation of the captive breeding program for the pink pigeon a variety of methods for both housing and breeding the species have been attempted. Experience, however, has shown that breeding success can be achieved by

meeting a few essential criteria. An effort has been made in this paper briefly to outline some of the methods employed at the Trust which have proved important to housing and breeding the pink pigeon. It should be stressed that these are generalized and exceptions are often found. For this reason it is always desirable to maintain as much flexibilty as possible in housing and breeding the pink pigeon.

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HUSBANDRY

Rearing methods

In order to achieve the desired rapid growth of the captive population, extensive use of cross-fostering under domestic pigeons or doves will be necessary, particularly from under-represented founder lines. Parent rearing should be encouraged in part from well-represented founder lines.

In fertility

What appears to be a high rate of infertility may give a false impression of the actual situation. This centres around the correct identification of infertile eggs from fertile eggs in which the embryos have died within the first 72 hours. It is highly possible that at present these very early dead embryos show as infertile eggs or candling and are recorded as such. Means of determining early dead embryos from truly infertile eggs need to be established and protocols circulated to all holders.

High early mortality (within first few days 0-7)

Seeming high rates of early mortality probably reflect management rather than inbreeding depression (figures on mortality 0-7 days).

Diet

It is considered that there are no serious dieting problems which manifest themselves in the captive population at present. Some diet analysis will however be carried out by the New York Zoological Society. The reliance of seeds as a high proportion of the diet against a larger proportion of fruit and leaves might merit some further investigation.

NEW YORK

a) Canary pellets 75%
b) Greens, rice, soft feed 25%
c) Mix seed garnish

JERSEY

a) Fruit: greens 75%
apple, pear, grape

b) Dry matter 25%

Wheat	70%
Corn	10%
Layer's pellet	10%
Soft feed	10%

c) Graded egg garnish

BLACK RIVER

a) Maize 60%
b) Wheat 20%
c) Mix Millet 20%
d) Unlimited access to greens
e) Fruits provided based on limited availability

Disease

Disease does not appear to be a major factor in mortality at present.

A reference collection exists fro Mascarene Island fauna post mortem material. This is maintained at the Royal College for Surgeons of England by Mr. J.E. Cooper. The majority of pink pigeons which have died in captivity are now located in this collection along with the post mortem reports. It is now recommended that copies of these reports are now forwarded to the International Studbook keeper as well as all subsequent reports. It may be desirable to develop a protocol for pigeon necropsies outlining or highlighting areas of specific interest to pink pigeon mortality.

Some base line data on haematology clinical chemistry exists for the pink pigeon, see Cooper et al 1987 E.J. Flach and J.E. Cooper (unpublished). More data should be collected wherever possible.

Screening and quarantining of birds when moved between locations and in particular when returned to Mauritius will continue to play a major role in reducing the risk of the spread of infectious disease.

J.E. Cooper to supply protocol for screening (review screening for other avian species in Guan Rail).

Co-ordination of the overall population

The International Studbook will be a major tool in managing the entire captive population. Regional studbooks for the various areas are required for the effective management of these subpopulations. A North American regional studbook already exists and one needs to be created for the British Isles and the rest of Europe, Mauritius and any other areas i.e. Asia as necessary.

Within North America the programme should become an S.S.P. and in the British Isles and the rest of Europe an E.E.P.

For the effective management of the global population, International and Regional studbook keepers and co-ordinators will need to meet periodically. During such meetings goals for the next period of the programme should be established. For example

the number, if any, of birds required for the release from outside Mauritius should be established.

Identification

All birds both in captivity and in the wild must be banded with numbered metal rings. It is recommended that the numbers be prefixed by a letter or letters perculiar to the collection in which the specimen was bred (i.e. J = Jersey, Ju = Jurong, NY = New York).

D.N.A. Finger Printing

Continued work on D.N.A. fingerprinting of the pink pigeon extending this to the entire population will bring benefits to furthering our understanding of the founder contribution to the population. It may help clarify the relationship between the current captive population, largely descended from birds trapped in 1976 and 1977, the remaining wild population. In particular how those birds recently brought into captivity from eggs harvested from the wild should be handled in the genetic analysis.

Protocol for collections for collection of material

i.e. dead embryos or post mortem - Mike Bruford

Expansion of the population - new locations

One of the current problems in the captive population is that too few locations holding the species are breeding successfully. New locations taking the species should received good husbandry guidelines in advance of receiving the birds. It is hoped that this might assist in bringing about successful reproduction in the shortest time.

New locations should be selected on the basis of previous experience with Columbiforms and commitment to the programme. New locations should take on a population of at least three pairs and at a minimum two pairs in order to give them some flexibility in their management.

Potential for growth of the captive population and associated problems:

There is the potential for female pink pigeons to lay in excess of 30 eggs in any 12 month period. If a high percentage of these can be hatched and reared the rate of recruitment to the population can be considerable. The population at the J.W.P.T. has achieved an average yearly rate of grwoth of 80% per year.

Past history of the captive population of this species has shown, however, that limitations in the facilities of the collections handling them can severly reduce this potential production by increasing mortality in a number of ways.

A large number of eggs being laid within a short time period can quickly over stretch the capacity of a foster parent. This ties up many of the available foster pairs in brooding and rearing young, decreasing the number of foster pairs available to breed new eggs. This reduces the chance of foster pairs being synchronised with laying pairs of pink pigeons. The effect of this is a tendency for a large percentage of squabs to hatch under unsynchronised fosters which are then liable to feed these squabs leading to a high rate of mortality in the first week of life. A lack of synchronised fosters also results in more eggs having to be left under parent birds. Where pink pigeons are left to brood and rear young, particulary where two eggs are left with them, there is a high rate of mortality in young under a week of age.

Where large numbers of young are reared adequate holding areas are necessary to ensure an optimal survival rate. Over crowding in Mauritius for example has led to high rates of mortality, up to 78% in some years, in pigeons under a year of age, therefore, without adequate holding facilities the high rate of mortality in young pigeons will severely reduce the potential output.

This points to a need to closely manage breeding pairs of pink pigeons within collections to avoid producing more eggs than a given facility can handle. In the past large numbers of eggs had been taken from some individuals resulting in an over representation of some founders. It is now apparent that unless breeding birds are important in increasing representation of under represented founders, it is not desirable to produce large numbers of young from pairs of pink pigeons. In fact the number of offspring should be restricted to two to three young from each pair to maximise the number of birds which are bred. In respect to female survivorship it is also undesirable to allow breeding for prolonged periods during which they lay an excessively large number of eggs.

Founders

The founder representation of the captive population is unequal. Certain wild caught individuals have proved to be extremely difficult to breed in captivity while others have reproduced freely which has led largely to this situation. In a number of cases the few offspring produced from those 'difficult' birds have in turn not bred well. The majority of the potential founding birds were removed from the wild in 1976 and 1977 and therefore any surviving birds must be considered to be coming towards the end of their reproductively active lives.

Five birds brought into captivity died without contributing to the population.

Of the 11 founders three are under represented and their contribution is in danger of being lost from the population. Four specimens have roughly the correct proportion of representation while four are over represented.

In order to preserve the genetic material of the three under represented founders a number of specimens have been identified as priority birds from which to breed. Irrespective of age, conditon

and post breeding history region's efforts should be made as a matter of urgency to breed from these priority birds.

Founder number 1 is in particular danger of being lost. It is recommended that he be moved from Casela to Jersey along with two of his surviving offspring, 174 from Casela and 178 which is at present in the released population.

It is recommended that the other living under represented founder, Studbook No. 37, be moved from Jurong to Jersey. Surviving offspring of 37 are present at Jersey (114) and at Brownsville (106).

No. 174 and 178 included above under Founder No. 1 are also important for 37.

Founder 132 is currently not represented outside Mauritius. Two living descendants remain there, 206 and 252. It is recommended that one of these two be moved to Jersey.

Eleven founders - birds that have contributed to captive population.

S.B. No.

1 M
Captire 1976
Present Loc. Casela (Mauritius) 1977
Representation 1.8750
No. of living descendants 5
First generation

3 M
Captive 1976
Present loc. Black River 1976
Representation 32.4378
No. of living descendants 152

4 M
Captive 1976
Died 16.8.85
Representation 7.7965
Living descendants 33

5 F
Captive 1977
Died 14.2.85
Representation 29.1878
Living descendants 146

6 M
Captive 1977
Present loc. Jersey
Representative 11.8427
Living descendants 62

9 M
Captive 1977
Present loc. Jersey
Representative 23.6583
Living descendants 130

10 F Captive 1977
Died 28.5.85
Representation 11.7664
Living descendants 123

13 M Captive 1977
Present loc. Jersey
Representation 17.4125

37 F Captive 1979
Present loc. Jurong 1.3.87
Representation 5.5
Living descendants 20
First generation offspring 28
(14 x SB No. 1 also under represented
14 x 81

132 M Captive 1981
Died 18.8.85
Representation 4.4840
Living descendants 27
First generation - only 2 survive
SB Nos. 206 F
252 M

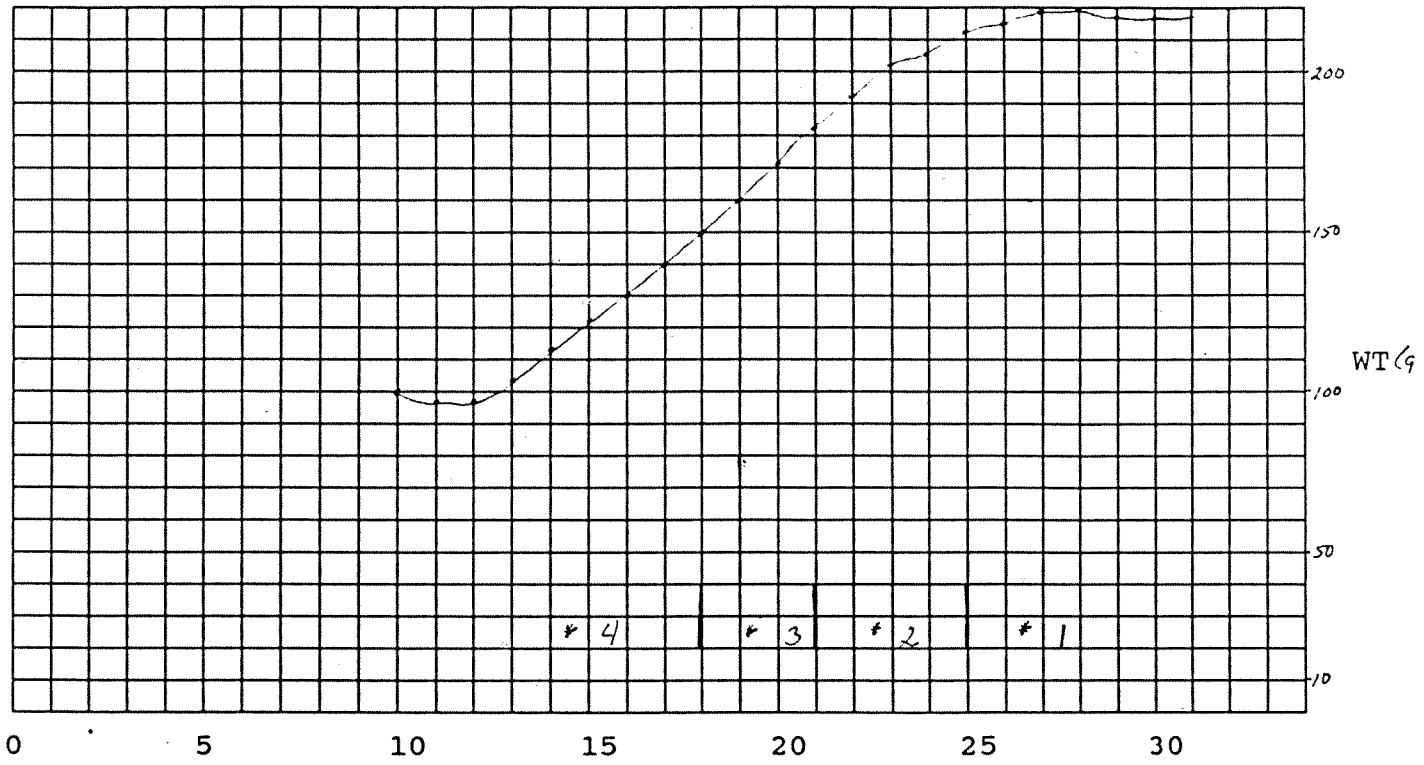
Hand-rearing.

Kurt. - to put together.

This method of rearing should not receive too much emphasis.

SPECIES *MAURITIUS PINK PIGEON* INCUBATION *15 DAYS*

BROODER TYPE	TEMP.	WTS.	DAYS
ISOLETTE	*88-90°*	*100* THRU *130 g*	*10-12* THRU *16*
ISOLETTE	*84-86*	*130* THRU *160*	*16* THRU *20*
MEDIUM BROODER / BOX CAGE	*82-84*	*160* THRU *200*	*20* THRU *25*
BROODER BOX CAGE	*80-82*	*180-200* THRU ⇒	*25* THRU ⇒



(*NO. OF HANDFEEDS)

DIETS	ITEMS
1	*20 g. CANARY PELLETS; 10g BABY CEREAL; 110 ml. H_2O; 1g $CaCO_3$*
2	*PINK PIGEON MIX; GREENS; MIXED VEGGIES*
3	*ADULT PINK PIGEON DIET*
4	
5	
6	
7	
8	

MAURITIUS PINK PIGEON

A. Brooder Set-Up:

(Squab is removed from foster parents at approximately ten days or 100 grams. Brooder Room Keeper should be in contact with Prop Keeper in regard to moving of squab.) After weighing, the squab is placed in an isolette in a bowl lined with a piece of Nomad matting and stick nest. Initially, the temperature is set at 88°. Temperature is then gradually lowered over a week or so to 84°. After approximately seven to ten days in the isolette, the squab can be moved to a large box cage set up with proper perching, etc. At first, temperature should be maintained at 82-84°. Once fully feathered and eating on its own, the temperature can be lowered to 80°. (See General Information (F): Brooder Box Cage)

B. Diet:

Squab is fed a liquid diet consisting of:

20 gms. canary pellets
10 gms. baby cereal
110 m. H_2O
Pet Drop once a day and $CaCO_3$

Ingredients are mixed until soupy. It is then heated and fed at 105°. Diet is made fresh for every feed. The diet is strict until weaning.

C. Feeding Procedure/Weaning:

Initially, squab is fed four times a day; up to 30cc at each feed. The actual amount given is determined by examining crop size. Although the crop may not always empty out before next feed, there should always be a significant decrease in crop size between feeds. (Crop should always be empty at first a.m. feed. See Health.) The squab is fed through a drilled-out syringe fitted with 1-2 inch cat catheter on the tip. Feeding involves positioning bird's beak

between fingers. (Frequent touching of the squab's beak for the first few days facilitates the feeding procedure since the squab will be used to having its beak handled.) The squab will open its mouth readily and the feeding catheter can then be inserted above and behind the tongue. It is important to feed from the bird's left side because the opening to the bird's crop is on the right side of its throat. The opening to the lungs is on the left. It is, therefore, necessary to aim the food past that opening to avoid getting food into the lungs. The food is squeezed in, stopping once or twice to give the bird a chance to breathe. Feeding should end when the crop is plump and soft; before it is bulging and tight. After feeding, the squab's beak and surrounding area should be cleaned off with a damp towel to prevent any spilled food from forming a crust. At approximately 188-190 gms. (almost three weeks of age) the squab will become difficult to feed, struggling and refusing the syringe. This is an indication to begin cutting back on hand feeds. At this point, a food pan consisting of pink pigeon mix and cooked egg, as well as a water pan should be introduced. Weaning the squab is done by first cutting out one hand feed and encouraging squab to feed from pan while carefully monitoring weight. If there is no significant weight loss (less than 10 gms.) over a couple of days, another feed can be cut. This reduction in the number of hand feeds is done gradually over a couple of weeks. As the squab begins to show more interest in the food pan, it will become more difficult to hand feed. Continued weight gain at this point is a good indication that the bird is beginning to eat on its own. At approximately four to six weeks of age (230-250 gms.), squab should be off all hand feeds and eating well on own.

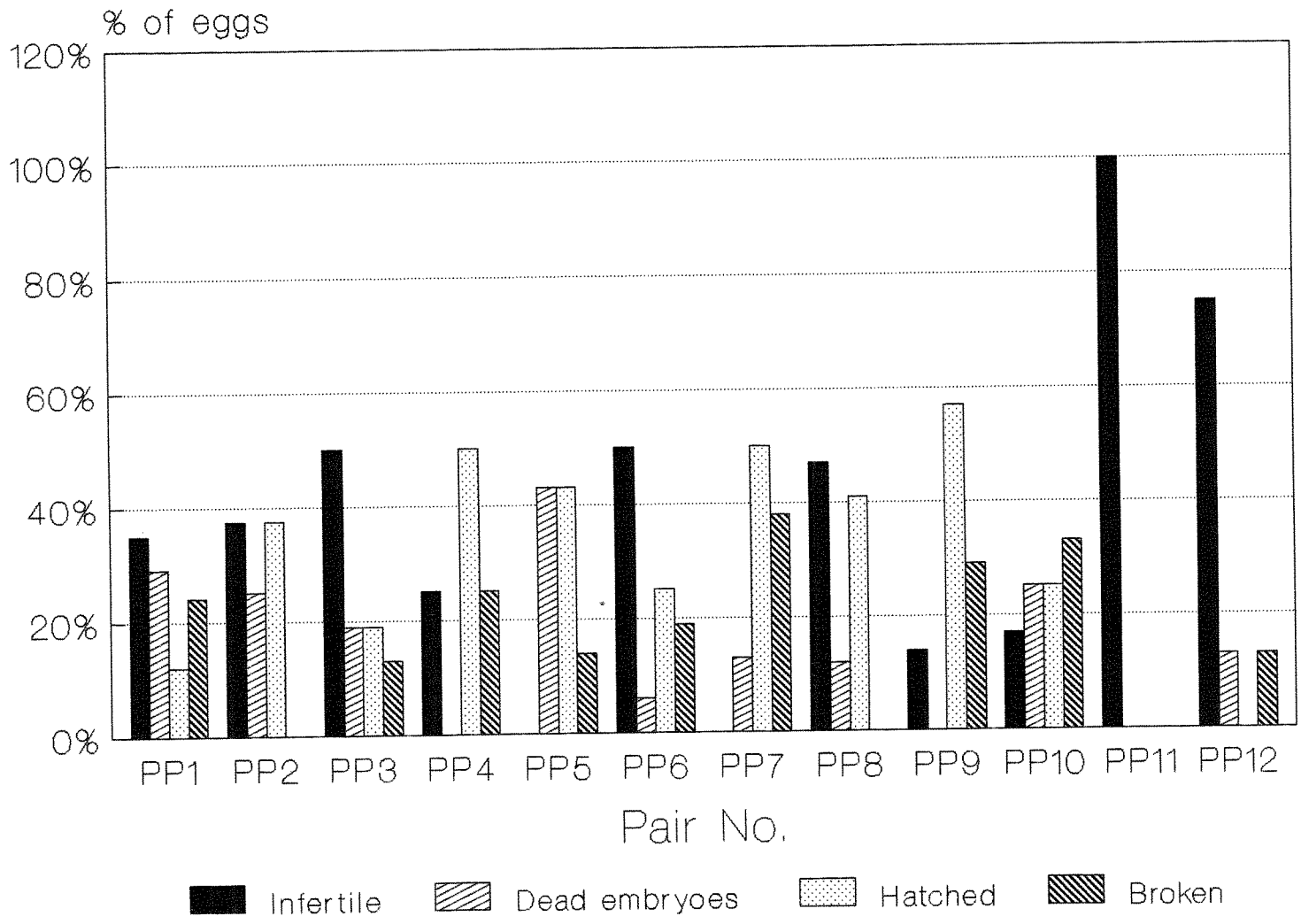
D. Growth:

Initial weight gains are within 10% of body weight. After approximately three weeks, weight gains are less, leveling off at approximately 230-240 grams.

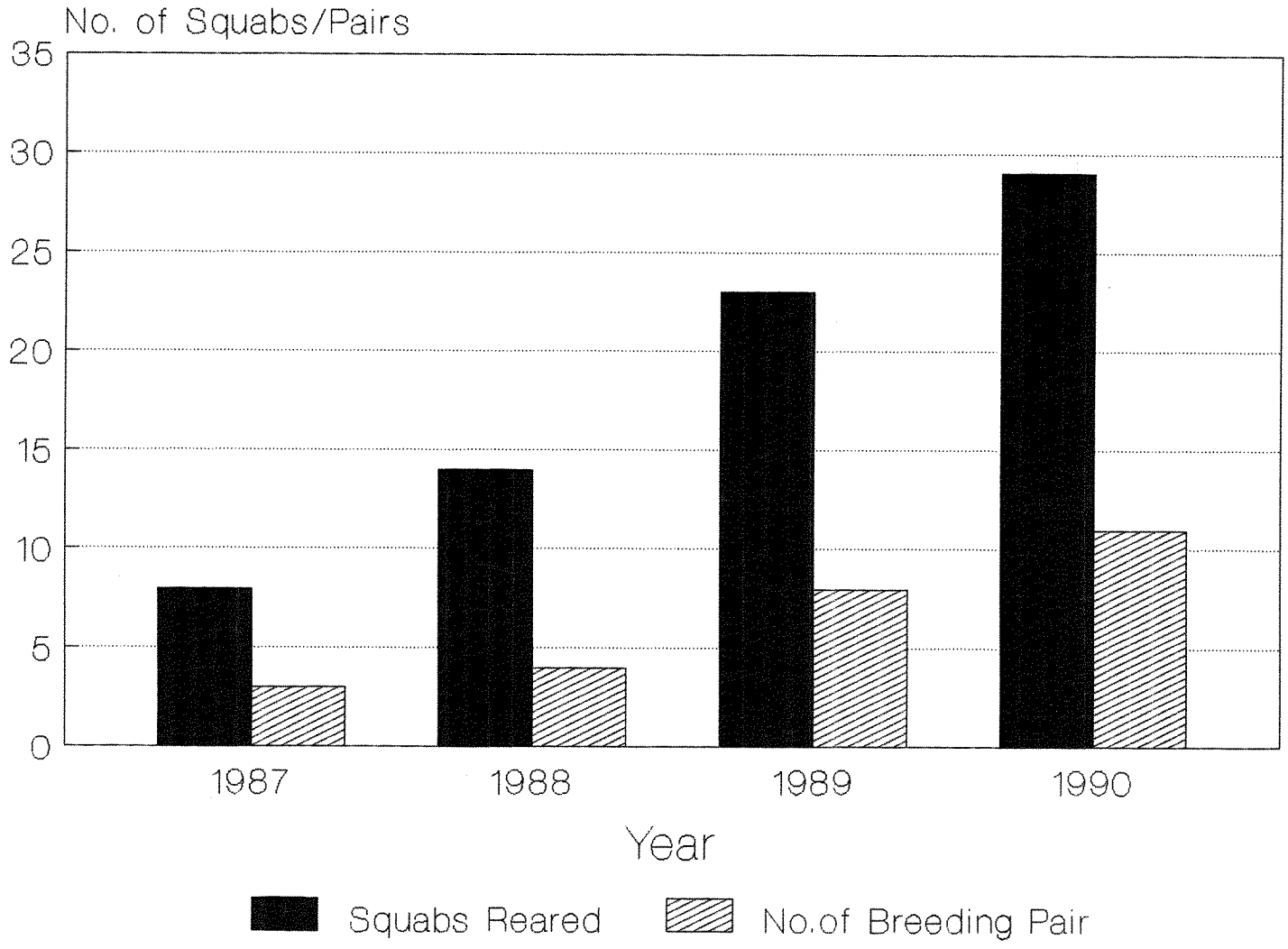
E. Health:

Special note should be made of crop size before and after each feed. Crop should always be empty at first a.m. feed. If it is not, the squab should not be fed and the vets notified. A tight, hard crop that does not decrease at all in size between feedings could indicate crop stasis that can be caused by a number of medical problems. Other symptoms such as lethargy, regurgitating food, discharge from nose or eyes, should be reported. Special note should also be made of any problems with feet (such as curled or crossed toes).

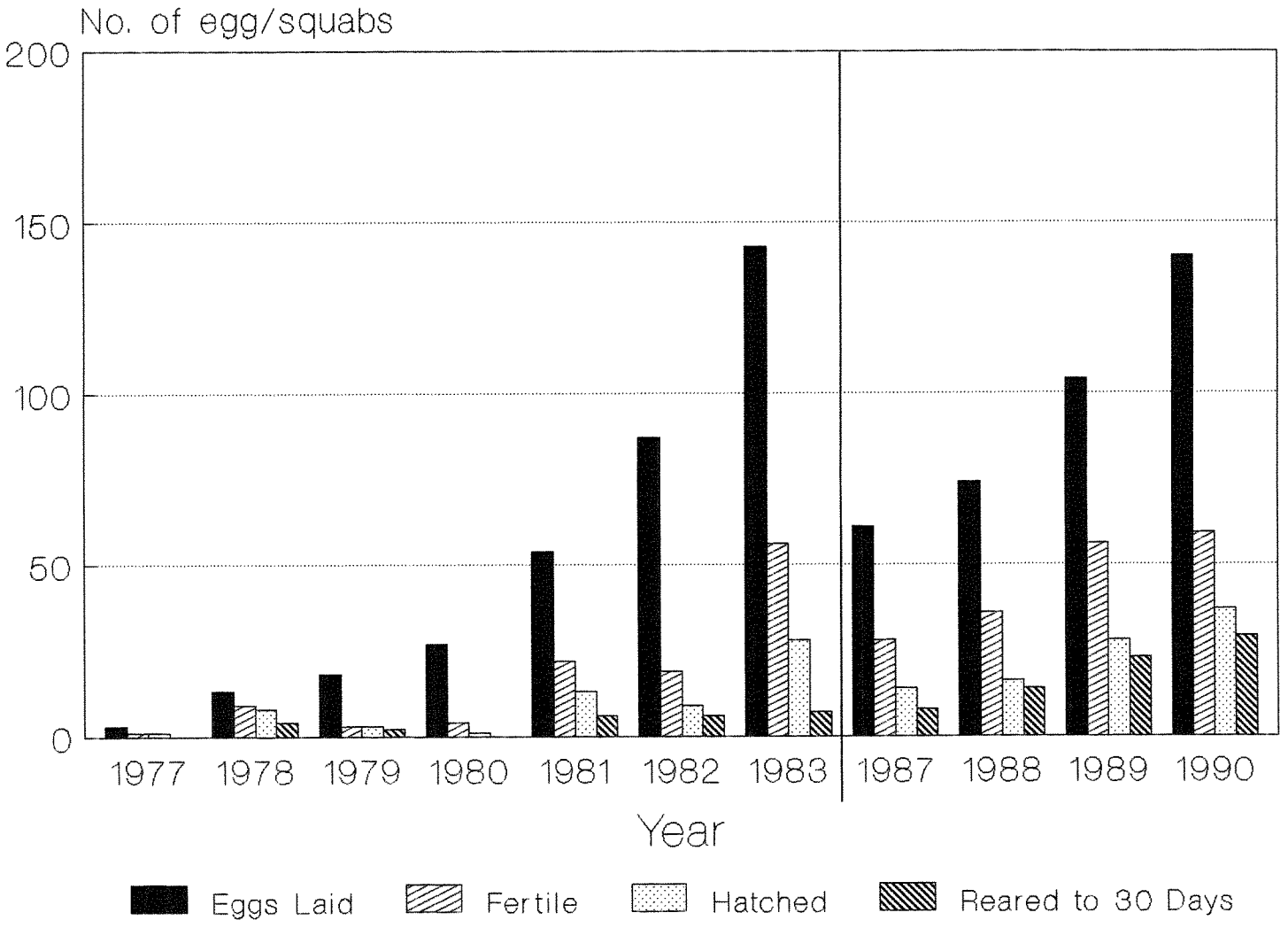
Egg results per pair of Pink Pigeon for 1990



Number of squabs reared per year and number of contributing pairs



Yearly Breeding Results for the Pink Pigeon at J.W.P.T.



Dodo, J. Jersey Wildl. Preserv. Trust 26: 93–98, 1989.

THE EFFECTS OF MULTIPLE CLUTCHING ON THE SIZE, FERTILITY AND HATCHABILITY OF THE EGGS OF THE PINK PIGEON *Nesoenas mayeri* at the Jersey Wildlife Preservation Trust

By C. R. LIND
Bird Section, Jersey Wildlife Preservation Trust.

Introduction

Since initiation of the captive breeding programme for the Pink pigeon *Nesoenas mayeri* at the Jersey Wildlife Preservation Trust in 1977, the greatest success in breeding has been achieved through the use of foster doves to hatch and rear the pigeon squabs (Jones *et al.*, 1983). Fostering pigeon eggs has greatly improved the productivity of breeding pairs of pink pigeons by allowing multiple clutching. This, however, creates an unnatural stress by causing the birds to lay more eggs than would be laid in a natural situation. At the Trust, pink pigeons have laid up to 21 clutches in a year using this technique.

A number of studies have suggested that egg quality is strongly correlated with parental condition (Meathrel and Ryder, 1987; De Laet and Dhondt, 1989). Egg quality, as described by such factors as egg size, weight, and composition, has been closely linked to hatchability and chick survival rates (Schifferli, 1973; Ricklefs *et al.*, 1978; Quinn and Morris, 1986). Resource availability and the stress imposed by egg laying and rearing the subsequently hatched chicks are suggested in all of the above studies as the two main factors influencing egg quality.

This paper is an attempt to assess the possible effects of multiple clutching on egg quality in the pink pigeons at the Trust. Egg quality in this study is defined by three criteria; initial egg weight, fertility, and hatchability.

Methods

The data for this study were taken from egg records which are kept on all eggs laid by pink pigeons at the Trust. The data cover a period from April 1987 to September 1990, and represent approximately 300 eggs. Any eggs which were broken either by parent or foster birds, or abandoned by the fosters were excluded from analysis.

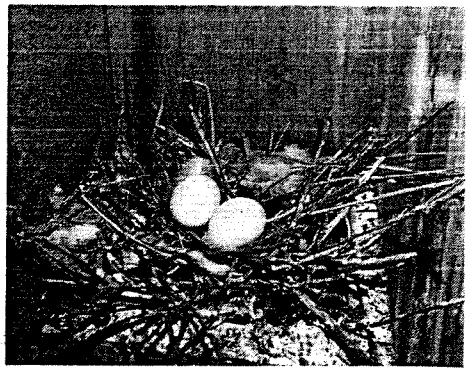


PLATE 1 *C. REESE LIND*
A clutch of pink pigeon (*Nesoenas mayeri*) eggs.

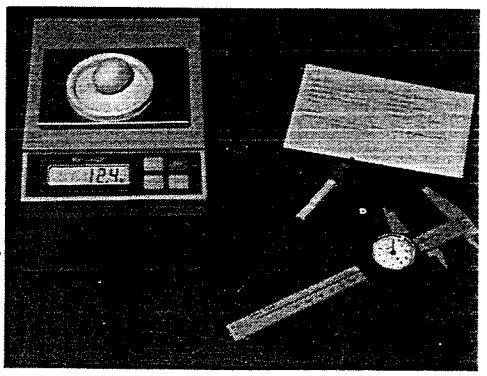


PLATE 21 *C. REESE LIND*
Recording morphometric data on pink pigeon eggs.

The pink pigeons at the Trust will breed throughout the year; as a result of this, breeding is not confined to a discrete season or seasons. For this reason the use of clutches in this study refers to the clutches laid by a female during a particular pairing. It is unusual for pigeons to be paired more than once in a year, and in the few instances where this has happened, there has been a rest period of at least four months prior to the pairing.

Initial egg weight was used as an indicator of egg size. This was available for most eggs as the majority were removed from the parent birds within hours of laying. These were then weighed before being set under foster birds. In some cases however, eggs were not removed immediately and initial weights could not be obtained through weighing. For these eggs, initial weights were calculated using a formula described by Hoyt (1979):

$$W = K_w * LB^2$$

where W is initial egg weight, L is egg length and B is egg breadth. K_w is a species specific constant calculated to be 5.41×10^{-4} (S.D. = 3.06×10^{-6}) for pink pigeons from a sample of eggs with known initial weights.

The total number of fertile eggs was calculated as the total number of eggs which hatched plus the total number of eggs in which the embryos died. Fertility is represented as the percentage of fertile eggs of the total number of eggs laid, excluding broken eggs, by all pigeons for each clutch. The number of fertile eggs reported in this study is probably an underestimate of the actual number. Eggs were candled to determine fertility, with fertile eggs being those which showed a developing embryo. In most cases an embryo could not be seen until it was at least 72 hours old. Any embryos dying before this stage of development would not be detected and the eggs would have been recorded as infertile.

Hatchability is defined as the number of fertile eggs which developed full term and hatched. This is equivalent to the number of fertile eggs minus the number of eggs in which the embryos died during development. Hatchability is represented as the percentage of hatched eggs of the total number of fertile eggs laid by all pigeons for each clutch.

Analysis

Data were grouped by clutch for analysis. Only the first ten clutches were used since the number of pigeons laying more than ten clutches during any one pairing was too small to allow testing. To test for a correlation between clutch number and initial egg weight, fertility, and hatchability, a Spearman Rank correlation test was used. All probabilities were one-tailed with alpha set at 0.01.

Results

The number of clutches laid by pairs of pigeons was highly variable, with the mean being 5.4 (S.D. = 3.3) with a range from 1 to 14. The majority of clutches (77%) contained two eggs with the remaining clutches containing just one egg.

Initial egg weights varied greatly with a mean of 14.7g (S.D. = 1.3), and a range from 8.6g to 17.6g (see Fig. 1). In most cases (66%) the first egg was lighter than the second with a mean percent difference in weight of 3.9%. No significant correlation was found between initial egg weight and the number of clutches laid ($r_s = 0.38$, $N = 10$, $p > 0.01$).

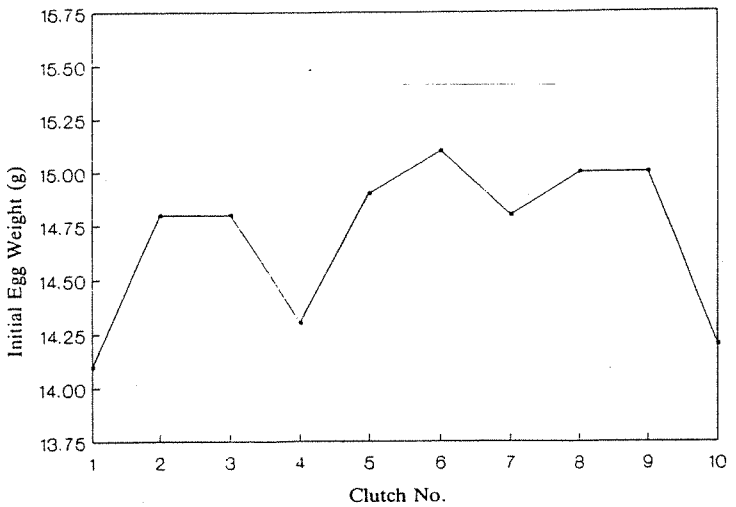


Fig. 1 The effect of the number of clutches laid on initial egg weights.

There was no significant correlation between number of clutches laid and egg fertility ($r_s = 0.43$, $N = 10$, $p > 0.01$). There was a high degree of variability in fertility as shown in Fig. 2.

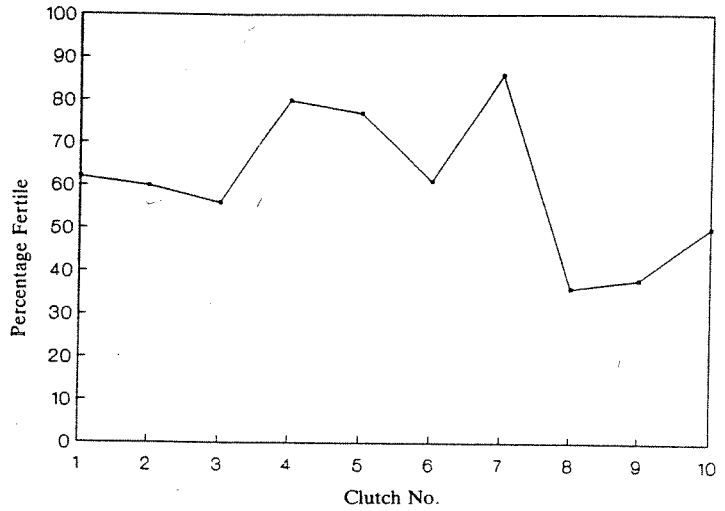


Fig. 2 The effect of the number of clutches laid on the percentage of fertile eggs laid.

The greatest effect of multiple clutching was seen with hatchability. The percentage hatchability for the first two clutches laid was 90%, but then dropped sharply to 40% for the third clutch with the data showing a much smaller degree of variation over the remaining clutches (see Fig. 3). The exception to this was clutch eight which showed a 0% hatchability. There was a strong negative correlation between hatchability and the number of clutches laid ($r_s = 0.73$, $N = 10$, $p > 0.01$) though this was not significant at the chosen level of alpha.

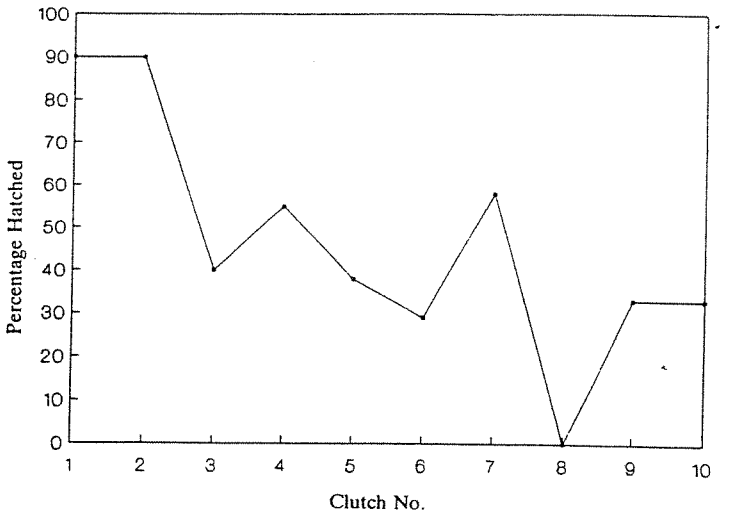


Fig. 3 The effect of the number of clutches laid on the percentage of fertile eggs hatched.

Discussion

The results of this study indicate that egg size and fertility show no significant correlation to the number of clutches laid, and that multiple clutching at the Trust does not appear to affect these measures of egg quality. However, there was a strong negative correlation between hatchability and the number of clutches laid. Although at a significance level below that chosen for this study, this relationship cannot be ignored and must be taken as a possible indication of a trend towards decreasing hatchability with an increase in the number of clutches laid.

The data used in this study were not assessed for the possible effects that long term multiple clutching might have. Continued harvesting of large numbers of eggs from a female over successive years may adversely affect egg quality as defined for this study. This could not be tested because of the small sample sizes.

Over the period the data for this study were collected, the practices for breeding pink pigeons at the Trust gradually changed. Due to changing demographics in the population, more pairs of pigeons are being bred with fewer eggs being taken from each pair. Additionally, pigeons are usually only bred from once and then exported. The only instance in which a bird or pair of birds would be bred from over an extended period, with a large number of eggs being taken, would be in the case of genetically under-represented individuals. Although this now happens infrequently, the findings of this study indicate that a different approach to harvesting a large number of eggs from a pair of pigeons may yield better results. If hatchability is adversely affected by the number of clutches laid it may be more effective to break a breeding session up into shorter periods, giving the birds a rest period between sessions to regain condition. The length of each session and the number of eggs taken would depend on the amount of stress imposed on the birds by the separations and subsequent remixings. A balance would have to be met between minimizing the stress associated with egg laying and that associated with separation and repairing. It is interesting to note that hatchability decreased sharply after the second clutch (see Fig. 3). At the Trust two clutches of eggs can be obtained from the pigeons in a short period, usually three to four weeks, but separation of the birds at this point would not be feasible. At present the pairings usually last from two to four months and it should be possible to rest birds after a two month session with little disruption.

Acknowledgements

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SOME OBSERVATIONS ON POLYMORPHISM IN THE ST. VINCENT PARROT *Amazona guildingii*

By PAUL J. BUTLER
Caribbean Programme Director, RARE Center for Tropical Bird Conservation.

Introduction

The St. Vincent parrot *Amazona guildingii*, first described by Vigors in 1837 and named *Psittacus guildingii*, in honour of the then local Pastor Rev. Lansdown Guilding, is endemic to the East Caribbean nation of St. Vincent and The Grenadines. Subsequently reclassified as *Chrysotis guildingii*, and later *Amazona guildingii*, it is now confined to the remaining isolated stands of primary forest, where, numbering less than five hundred individuals, it is threatened with extinction.

PLATE 1 *PHILLIP COFFEY*
St. Vincent parrot *Amazona guildingii*.

I.U.C.N./C.B.S.G. Working Group on Permanent Animal Identification

Final Report on Transponder System Testing and Product Choice as a Global Standard for Zoological Specimens

Transponders offer a technology for unobtrusive permanent individual animal identification applicable to most vertebrates and some invertebrates. Registration of the unique identification number with the International Species Information System (ISIS) would provide the world's zoos with an important technique for following individual animals throughout their life.

Because there were several products available, a Working Group was formed at the 1989 CBSG meeting to assemble and evaluate information on transponders. At the 1990 CBSG meeting in Copenhagen, substantial information was presented on the applications and standardization of transponders for permanent identification of non-domestic animals. Previous reports have addressed issues such as central registration, medical concerns, and limited read-ranges (see CBSG News, Vol. 1, Nos. 2, 3). However, due to the lack of consistent information available to the Working Group, a recommendation as to which system should be recommended as a global standard could not be made.

At the Copenhagen meeting, it was recommended that the CBSG urge all concerned parties to postpone their selection of a specific transponder system until the competing systems could be independently evaluated. This side-by-side evaluation, conducted by members of the Working Group, has been completed and a recommendation can now be made that is independent of the manufacturer's performance claims. The criteria for evaluating the systems were: (1) product performance, (2) commercial availability by January 1, 1991, (3) international distribution, and (4) price.

Table 1. Results of Transponder System Tests

Manufacturer	Manufacturer's Suggested Read-Range	Actual Read-Range (Mean ± SE)
Destron/I.D.I.	5.0 cm	2.6 ± 0.1 cm
A.V.I.D.	5.8 cm	5.2 ± 0.1 cm
Destron/I.D.I.		
small	11.4 cm	5.6 ± 0.6 cm*
medium	29.2 cm	12.9 ± 0.2 cm
large	38.1 cm	16.4 ± 0.4 cm*
Trovan/A.E.G.	15.0 cm	10.7 ± 0.4 cm

*Actual Read-Range calculated from only five readings due to battery problems in the reader. Statistical analysis by ANOVA for repeated measures of the read distances for the four similar-sized products ($F = 91.3$, $P = 0.001$). The Trovan had a greater read distance than the small Destron/I.D.I. and A.V.I.D. products ($P = 0.01$).

Product performance was evaluated by reading implants against a measured grid background. All systems were

Table 2. Transponder system costs (all values in $U.S.)

Manufacturer	Reader	Transponder Plain	Transponder Sterile	Commercial Availability	International Distribution
A.V.I.D.	1,250.00	8.50	N/A	Yes	No
Destron	815.00*			No*	Yes
Small		5.50	11.25	Yes	Yes
Medium		7.75	N/A	Yes	Yes
Large		8.25	N/A	Yes	Yes
Trovan/A.E.G.	837.00	N/A	5.85	Yes	Yes

*New Dual Coil Reader was used for this test. Other, shorter reading readers are available. N/A = Not Available.

Transponders...

calculated. In each instance, the transponders were placed flat on a table top in an orientation parallel to the reader. Although this orientation produced the shortest read-range for all systems, it most closely approximates the actual orientation of the transponder in most implanted specimens. System testing was recorded on videotape and copies are available upon request from Dr. Blumer. The original transponder system manufactured by Destron/I.D.I. was also included in the testing to illustrate the improvements made in the development of the current systems.

In addition to the findings listed in Tables 1 and 2, several other considerations were made by the Working Group:

1. Medium (3 x 18 mm) and large (3.5 x 29 mm) transponders would not be acceptable in the majority of specimens. Therefore, product choice should be based on the performance/price of small transponders (app. 2 x 11 mm).

2. Most experience with transponders has been based on bulk-packed implants which were sterilized by the user and required re-use of the implanter needle. The availability of pre-packaged, sterile transponders packaged in needles will result in easier and less traumatic use of these systems.

Based upon the criteria listed above, the Working Group has chosen the **Trovan/A.E.G. transponder system** as the preferred system for the development of a global standard. These findings will be forwarded to numerous international authorities (CITES, EEC, USFWS, etc.) along with the recommendation that they adopt similar standards. The Trovan/A.E.G. system can be purchased from:

North America:

International Infopet Systems
31264 La Baya Drive, Suite A
Westlake Village, CA 91362, USA
Telephone: (818) 707-9942; (800) 463-6738
Telefax: (818) 707-9947
Contact: Lindy Harton

Europe:

Euro I.D.
Grossbuellesheimer Str. 56
5350 Euskirchen 16
West Germany
Telephone: (02251) 7 11 25
Telefax: (02251) 7 34 88
Contact: Mr. Usling

For additional information, contact:

Dr. Evan S. Blumer
Fossil Rim Wildlife Center
P. O. Drawer 329
Glen Rose, TX 76043, U.S.A.
Telephone: (817) 897-3147
Telefax: (817) 897-3785

Paul van den Sande
Royal Zoological Society of Antwerp
Koningin Astridplein 26
B-2018 Antwerpen,
Belgium
Telephone: 03-231-16-40
Telefax: 03-231-00-18

News Bites...

Conservation Biology Program Established

The Connecticut Chapter of The Nature Conservancy has established a Conservation Biology Research Program. The program is open to Masters and Ph.D. candidates interested in conducting basic research on endangered species, communities, habitat, and ecosystems. The program also is intended to advance the conservation of biological diversity within the state of Connecticut. For more information, contact Beth Lapin, Director of Science and Stewardship, The Nature Conservancy, 55 High Street, Middleton, CT 06457, USA.

Bat Captive Action Plan Survey

Nina Fascione, Philadelphia Zoo (U.S.), was asked by the CBSG Chiroptera Planning Group to conduct a survey of North American bat collections. The goal of the survey is to determine the amount of space available for bats and which species are currently being maintained. These data will be used for strategic planning purposes in order to make the most effective and productive use of available space. She will collaborating with Dr. Chris West, Bristol Zoo (U.K.) who is conducting a similar survey of European zoos. In addition, there is an AAZPA Chiroptera Taxon Group being formed which will be chaired by Reg Hoyt, Phoenix Zoo (U.S.). The purpose of this group will be to organize captive propagation and husbandry efforts for Chiropterans in the North American region. Holders of Chiroptera are encouraged to participate in this survey. Please contact: Nina Fascione, Research Associate, Philadelphia Zoological Garden, 34th St. & Girard Ave., Philadelphia, PA 19104. Ph: 215) 243-1100.

Giant Clam Poaching in Indonesia

The IUCN Mollusc Specialist Group intervened earlier this year as part of an effort to improve protection for one of the last remaining healthy populations of the Giant Clam, *Tridacna gigas*, in Indonesia. The population lies in the proposed Teluk Cenderawasih Marine Conservation Area in Indonesia, on a reef which has been nicknamed 'Tridacna Reef'. In the latter part of 1989, it was discovered that clams were being taken illegally on a regular basis by a Japanese fishing vessel in partnership with a local company. The adductor muscle was being exported to Asia, and the less valuable mantle being sold to a local crocodile farm as food. From the numbers of dead shells left and reports of the amount of adductor muscle being collected, it was estimated that well over 1,000 old, large individuals had been taken.

When the alarm was raised, a number of international conservation bodies sent letters of intervention to the Governor of Irian Jaya and to the Director General of Forest Protection and Nature Conservation. Alison Kay wrote on behalf of the IUCN Mollusc Group. The situation seems to have eased, although until the area has full protection and enforcement as a Marine Conservation Area, the clams will still be vulnerable.

Action Plans...

Interaction Between Captive and Field Conservationists

Part of the official SSC mandate to CBSG is that it be the primary link between the global captive community and the other SSC Specialist Groups. Moreover, CBSG Global Captive Action Plans are being developed as joint endeavors between CBSG and the relevant SSC taxonomic Specialist Groups. However, it is also very appropriate and constructive for field conservationists to be appointed as advisers to Regional Taxon Advisory Groups for issues of husbandry and problems that emerge as largely regional in nature. It will be useful to expand representation from the captive community on SSC taxonomic Specialist Groups. While such representation is good on some Specialist Groups, it is very limited on others. The CBSG will encourage other Specialists Groups to add more captive community representatives.

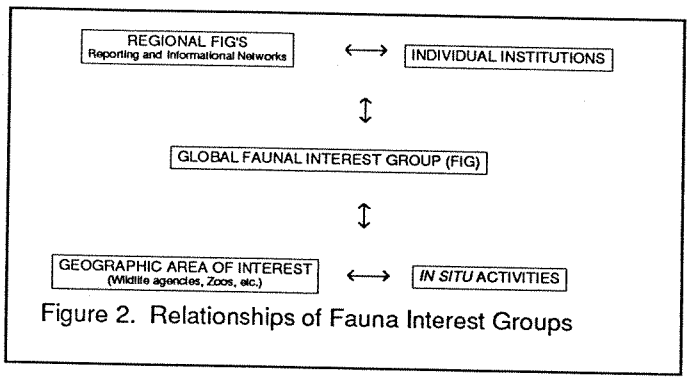

Figure 2. Relationships of Fauna Interest Groups

Agenda for Regional Conservation Coordinators Committee Meeting

Following is the tentative agenda for the CBSG Regional Conservation Coordinators committee meeting to be held in Singapore on 26 September 1991.

1. Studbook Issues
   - Standardization of Regional Studbooks
   - Relationship of Regional and Global Studbooks
   - Coordination of Numbers Assigned
   - Computerization (Convertability to SPARKS or ZSM).
   - Archives and ISIS
2. New Software Development (e.g., SPARKS II)
3. Training of studbook keepers and species coordinators
   - Regional responsibilities and programs
   - Standardization
   - Studbook Keeper/Species Coordinator Manual
4. Global Captive Action Plans
   - Systematic Formation of Global Action Plan Groups; linkage to SSC Taxonomic Specialist Groups
   - Schedule of Action Plan Workshops
   - Interaction of Global Action Plan Groups with Regional Taxon Advisory Groups (TAG's)
5. Regional Taxon Advisory Groups (TAG's)
   - Initiation in and Coordination among Regions
   - Functions
6. Global Programs and Masterplans for Individual Taxa
   - Guidelines (Biological and Organizational) for Interaction of Regional Programs.
   - Plans for/Selection of More Trial and Model Programs
7. Fauna Interest Groups (FIG's)
   - Relationship of Global and Regional
8. Core Activities of CBSG Office

Recommendations for Standardized Transponder Implantation Sites

Following is a report on recommended implantation sites for transponders prepared by Susan B. Elbin, Curatorial Intern, Animal Management Services, New York Zoological Park, Bronx, New York 10460:

Our goal in establishing standard implant sites for a range of species is to simplify transponder implantation and scanning. We have considered the responses of the TAGs, FIGs, SSP coordinators, and studbook keepers. In our recommendations, we have considered all of the responses received and have adopted many of them. We welcome any additional comments or suggestions from the international community. A global list of standardized implantation sites (Table 1) and a list of species that do not fit the general guidelines (Table 2) are also presented.

Fish

We agree with the single response for implant site in fish: base of dorsal fin for fish longer than 29 cm; coelomic implantation for fish shorter than 30 cm.

Amphibians

Two of the three responses for amphibians agreed on using the lymphatic cavity site. It has been observed that coelomic implantation in a gravid female can lead to expulsion of the eggs through the wound. Therefore, we recommend lymphatic implantation.

Reptiles

Each Taxon advisory group reported and justified implantation sites according to order as follows: chelonians - hind limb socket; crocodilians - anterior to nuchal cluster; lizards (large:> 12.5 cm snout to vent length) - lateral, anterior to inguinal region (left), lizards (small: <12.5 cm snout to vent length) - coelomic cavity (because of delicate skin); snakes - nape of neck (left). We recommend using the animal's *left* side for transponder implantation for the sake of agreement with the other Taxa.

Birds

Most people selected either the pectoral muscle (subcutaneous) or the base of the neck for implantation in birds (81%, n=26 responses). There were not many responses for small birds. One group recommended *no* transponders be used (pink pigeon). Additional discussion should be encouraged for this species. A pattern emerged that reflected the size of the bird well as the handling method. We recommend implanting large and/or heavy birds that are typically restrained by more than one person to be implanted dorsally at the base of the neck for ease of scanning while handling. Smaller or more tractable birds (i.e. vultures) should be implanted on the *left* breast muscle. We recommend implantation on the left side for consistency across classes.

Mammals

Most people agree that either the area at the base of the ear or the area between the shoulder blades is the best site for transponders in mammals (70%, n=69 responses). These two regions are well defined, protected from impact, and will not cause irritation that would encourage the animal to pick or rub the spot.

Adult size of the animal should be used to determine proper implantation site. We suggest using the face of the scanner to estimate a mammal's (relative) size. If the intrascapular area, e.g. from the backbone to the shoulder blade, is less than or equal to the diameter of the scanner (17 cm), the animal is considered to be small to medium-small. If the intrascapular area is greater than or equal to the diameter of the scanner (>17 cm), then the animal is medium-large to large.

Transponders in large to medium-large mammals should be placed behind the left ear at the base. Transponders in small to medium-small sized mammals should be placed between the shoulder blades, since the region behind the ear will often not accommodate a transponder chip. If the animal cannot be implanted in either of theses two locations, an alternate site (always on the *left* side) will be used and included in a list of exceptions.

We recommend that the same side (e.g. the animal's left side) *always* be used for transponder implants, regardless of site chosen. This reduces any possible confusion or interference that may arise with implantation of reproductive implants and reduces the scanning area to one-half of the animal. We suggest, then, that *reproductive* implants with microchips should always be implanted on the animal's *right* side.

Table 1. Global implantation site recommendations for different classes of vertebrates. All transponders should be inserted on the animal's left side when applicable.

Fish:
Large (>30 cm): left base of dorsal fin
Small (<30 cm): coelomic cavity

Amphibians:
Lymphatic, cover wound with skin bond

Reptiles: (by order and body size; size measurement is snout to vent length of adult lizard)
Chelonians: (left) hind limb socket
Crocodilians: anterior to nuchal cluster
Lizards (large,>12.5 cm snout to vent): (left) inguinal region
Lizards (small,< 12.5 cm snout to vent): intercoelomic cavity
Snakes: nape of neck (left)

Birds: (size measurement is mass of adult bird)
Large (>1.5 kg and/or long-legged) - dorsally at juncture of neck and body
Medium to small (<1.5 kg) - on pectoral muscle.
Note: all Psittaciformes = left pectoral muscle; all New World and Old World vultures = base of neck; all other Falconiformes = pectoral muscle

Mammals:(size measurement is distance between back bone and shoulder blade of adult mammal)
Large, medium-large (> 17 cm)- behind left ear, at base
Small, medium-small (<17 cm) - between shoulder blade, left of center

Table 2. Exceptions to global implantation site recommendations.

Species	Implant Site	Comments
Elephant	Main caudal fold parallel to tail on left side	
Hyrax	Intralumber, left of center	Thick skin on neck makes implantation difficult
Loris	Intralumbar, left of center	Dermal shield makes scapular implantation difficult

PROPOSED
IUCN RESOLUTION STATEMENT ON
ANIMAL GENETIC RESOURCE BANKING
FOR SPECIES CONSERVATION

Captive Breeding Specialist Group Annual Meeting
Singapore, September 29, 1991

PROBLEM STATEMENT

The IUCN holds that the successful conservation of species requires integrated management efforts to sustain available genetic diversity. These efforts include programs to protect and manage animal populations within their natural, native habitat (*in situ* conservation) and supporting programs that manage individuals, gametes and/or embryos outside of natural environments (*ex situ* conservation).

The IUCN recognizes that, although habitat protection is the most desirable approach for conserving biological diversity, supportive *ex situ* programs are essential in many cases. For example, such programs can deal effectively with short-term crises and with maintaining long-term potential for continuing evolution.

The IUCN further recognizes that the efficiency and efficacy of *ex situ* conservation can be increased many fold by applying recent advances in reproductive technology. These include assisted or 'artificial' breeding and the low temperature storage (banking) of viable animal germ plasm, namely spermatozoa, embryos and oocytes. Germ plasm banks: 1) offer a high degree of security against the loss of diversity and, therefore, entire species from unforeseen catastrophes; 2) minimize depression effects of genetic drift and inbreeding; and 3) provide a powerful method for managing the exchange of genetic diversity among populations. Other conservation benefits include banks of serum, DNA and cultured cell lines from germ plasm donors which permit studies on disease status, detection of microbial antibodies, pedigree determination, taxonomic status, geographical substructure and cellular physiology.

The IUCN also recognizes that the establishment of a genetic resource bank must, through basic research, be matched by the development of technologies for its use as a genuine and practical conservation asset.

The development of genetic resource banking programs is hampered by the lack of guidelines for establishing such banks and for integrating them with overall conservation programs. As yet, no single organization with a role in the international coordination of conservation efforts has provided guidance.

RECOMMENDATION

The IUCN regards development of genetic resource banks as an essential component of integrated conservation programs. Therefore, the Captive Breeding Specialist Group recommends that a formal process be developed to formulate global guidelines to establish, operate, use and review animal genetic resource banking programs for species at risk. The framework for international coordination of this type of program must be based upon agreements to cooperatively manage such species for demographic security and genetic diversity.

To achieve this recommendation, a Coordination Committee under the auspices of the Captive Breeding Specialist Group and others to be identified will:

a) Coordinate animal genetic resource banking activities within the Species Survival Commission and among regional captive propagation groups. This will be accomplished by integrating the genetic resource banks directly into the framework of population viability assessments and conservation Action Plans. These activities require an expert resource network to provide advice on all technical matters.

b) Establish guidelines for identifying taxa, species or populations that would benefit from genetic resource banks. These guidelines should be detailed and assist in the development of strategic Action Plans for conserving targeted animal populations. The single most important consideration is to ensure that there is a defined conservation goal that requires the collection and storage of biological materials. This requires that an integrated plan for a goal-orientated conservation program be established prior to initiating banking activities.

c) Establish a globally-standardized, record-keeping database for cataloging, managing and pooling data on banked materials. It will be essential that these biological materials are linked to individually identifiable source animals.

d) Provide expert technical advice to the appropriate taxon groups to assist in developing animal genetic resource Action Plans. The primary responsibility for developing Action Plans resides with those groups with specific responsibilities for *in situ* and *ex situ* conservation of specific taxa, species and populations. These groups should be encouraged by the Coordination Committee to include genetic resource banks as an integral component in their strategic conservation planning. The Coordination Committee will support the appropriate taxon groups to integrate information on: reproductive and genetic histories of *ex situ* and *in situ* populations; efficiency of reproductive technologies; areas requiring further research; types of biological materials requiring storage; appropriate protocols for banking biological materials; primary and secondary repository sites; strategies for using banked materials; and sources of funding.

e) Provide a mechanism for approval and periodic review of animal genetic resource banking Action Plans.

DRAFT

Cryopreservation and Banking of Animal Germ Plasm for Species Conservation: An Imperative for Action by the Captive Breeding Specialist Group

W.F. Rall, J.D. Ballou and D.E. Wildt
National Zoological Park, Smithsonian Institution
Washington, DC 20008-2598 USA

SUMMARY

Conservation efforts for rare animal species currently focus on programs to protect populations in natural habitat (in situ) and in captivity (ex situ). The ultimate aim of both approaches is to maximize both global biodiversity and genetic diversity. The systematic cryopreservation and banking of germ plasm from free-living and captive populations provide new opportunities to control and manage bio- and genetic diversity. Despite the widely acknowledged benefits of this approach, the development of genetic resource banking programs is hampered by the lack of a mechanism to integrate this activity with other conservation activities.

We propose that the CBSG act immediately to provide leadership for international coordination. The CBSG should assume responsibility for developing programs that encourage germ plasm banking as an integral component of in situ and ex situ conservation efforts. Specifically, the CBSG should: 1) draft and seek adoption of an IUCN Position Statement on the role of germ plasm banking in management and research programs to conserve endangered species; 2) establish a Genetic Resource Banking Oversight Committee to formulate global guidelines for the establishment, operation and review of animal genetic resource banking programs; and 3) develop a formal process that would assist the development of Genetic Resource Banking Action Plans. It is likely that extensive regional and international planning is required to establish and operate such banking programs and ensure the ultimate utility of the banked materials.

INTRODUCTION

Increasing numbers of species face extinction in their native habitat usually as a result of the direct or indirect actions of man. The survival of a species in the wild is thought to depend on a secure native habitat that is sufficiently large to support a population meeting certain genetic and demographic requirements (Soule 1987). Most of the important requirements are related to the properties and characteristics of the population as a whole, such as its size, life-history characteristics and the nature of the gene pool contained therein. The latter, especially genetic variations (i.e. polymorphism) within populations or communities of individuals, plays an important role in many of the critical biological processes related to species conservation, including

extinction (Ehrlich and Ehrlich 1981), inbreeding depression (Ralls et al. 1988), speciation (Templeton 1989) and natural selection (Frankel and Soule 1981). The loss of biological resources as embodied in species resulting from aeons of evolutionary adaptations is recognized as a major international concern. For this reason, it is generally recognized that every possible avenue should be taken to conserve bio- and genetic-diversity (Wilson 1988).

Conservation efforts consist of both: 1) '_in situ_' conservation programs that protect and manage animal populations within their natural, native habitat; and 2) '_ex situ_' conservation programs that remove individuals, gametes or embryos from wild populations for controlled breeding and management in captivity. Although habitat protection is acknowledged to be the most efficient approach for conserving bio-and genetic-diversity, for some species, _in situ_ conservation alone can not be relied upon to ensure the long-term viability of species at risk (Conway 1988, Soule 1991). Continued human population growth and the biopolitical, environmental and social consequences of that growth require _ex situ_ approaches as critical components of integrated conservation (McNeely et al. 1990).

Currently, _ex situ_ efforts for animal species at risk of extinction focus on captive propagation (Soule et al. 1986, Foose et al. 1986). The immediate goal of such programs is to manage populations of a species so as to retain maximum genetic diversity. Ultimately, such captive populations would serve as a source of individuals for release into restored habitat or to infuse genetic diversity into inbred, free-living populations. This can be accomplished only if a significant fraction of the overall genetic diversity existent in the wild population is incorporated into and retained by the captive population. Most captive breeding programs seek to maintain 90% of the captive population's initial genetic diversity for 200 years (Ballou 1991), as recommended by Soule et al (1986). Unfortunately, the world's zoos and bioparks do not have sufficient capacity to house the numbers of animals needed to meet the habitat crisis facing wild animals. For example, estimates suggest that space currently is available in North America for only about 100 mammalian species in populations large enough to meet the required genetic and demographic goals (Conway, 1987). This compares to the 815 mammalian species estimated by Soule et al. (1986) that would require captive propagation programs during the next 200 years.

UTILITY OF GENETIC RESOURCE BANKS FOR IN SITU AND EX SITU CONSERVATION PROGRAMS

The efficiency and efficacy of captive breeding can be increased many-fold by applying recent advances in reproductive biotechniques (Wildt 1989, 1991). Perhaps the most important advance is germ

plasm cryopreservation or the low-temperature storage and banking of spermatozoa, embryos and oocytes. Germ plasm cryopreservation currently plays an important role in domestic livestock agriculture, especially in the international movement of disease-free, genetically-superior individuals. The development of banks of cryopreserved germ plasm for nondomesticated species offers many important advantages for conserving and managing the genetic diversity within existing populations. Specifically, an animal genetic resource bank:

1. Reduces the number of animals that must be maintained in captivity by extending the generation interval of a species indefinitely. Thus, the genetic diversity of a founder does not die with the animal, but remains viable and available for use in future generations.

2. Provides a high degree of security against the loss of diversity or entire species from epidemics, natural disasters and social/political upheavals.

3. Serves a vital, interactive role between <u>in situ</u> and <u>ex situ</u> conservation programs. Such interactions prevent unintended selection pressures in captivity, preserve new diversity resulting from natural evolutionary processes in free-living populations, and permit 'infusions' of genetic diversity into fragmented populations suffering from genetic drift or inbreeding depression. This strategy also eliminates the need to remove additional animals from the wild or introduce captive animals into wild free-living populations.

4. Provides a method for improving food production and the economy of local communities by inter-species hybridization with domesticated species (e.g. hybridization of rare species of cattle with domesticated breeds).

5. Allows ready access to systematic collections of rare biological specimens for research in conservation biology or other 'life' sciences.

The importance of germ plasm resource banks for conserving the genetic diversity of wild fauna has been recognized since the first reports of successful cryopreservation of spermatozoa (Polge et al. 1949) and mammalian embryos (Whittingham et al. 1972). Over the past two decades, reports of various public- and privately-sponsored task forces have stressed the need for germ plasm repository programs to be established for conservation purposes. These include:

1. Conservation of Germplasm Resources: An Imperative. National Research Council, National Academy of Sciences, Washington DC, USA, 1978.
2. Animal Genetic Resources: Conservation and Management.

Proceedings of the FAO/UNEP Technical Consultation, FAO Animal Production and Health Paper No. 24, Rome Italy, 1981.
3. Animal Germplasm Preservation and Utilization in Agriculture. Council for Agricultural Science and Technology, Report No. 101, September 1984, Ames, Iowa, USA.
4. U.S. Strategy on the Conservation of Biological Diversity. Interagency Task Force Report, U.S. Agency for International Development, Washington DC, USA, 1985.
5. Technologies to Maintain Biological Diversity. U.S. Congress, Office of Technology Assessment, Report OTA-F-330, U.S. Government Printing Office, Washington DC, USA, 1987.
6. Research Priorities for Single Species Conservation Biology. A workshop sponsored by the U.S. National Science Foundation, Washington, DC, 1989.

STATEMENT OF THE PROBLEM

Despite all the publicity directed at the issues of declining habitat, species extinction, loss of genetic diversity and the potential contributions of germ plasm banking, it is remarkable that no organized programs exist to sample, evaluate, cryopreserve, maintain and use germ plasm from wild animal species. Furthermore, there are no guidelines for establishing such germ plasm banking programs or integrating them with other conservation programs. As yet, no single organization with a role in the international coordination of conservation efforts has provided guidance or oversight.

There are several organizational and procedural matters that must be addressed before the full potential of genetic resource banks can be realized for international conservation purposes. We propose that the CBSG immediately provide a leadership role to remedy the lack of international oversight and coordination. The CBSG should assume responsibility for developing programs that encourage germ plasm banking as an integral component of in situ and ex situ conservation efforts. Specifically, the CBSG should: 1) draft and seek adoption of an IUCN Position Statement on the role of germ plasm banking in management and research programs to conserve endangered species; 2) establish a Genetic Resource Banking Oversight Committee to formulate global guidelines for the establishment, operation and review of animal genetic resource banking programs; and 3) develop a formal process that would assist the development of Genetic Resource Banking Action Plans. Other important elements of these overall activities include the coordination of activities within the Species Survival Commission to identify species conservation programs that would benefit from germ plasm banking, and assisting efforts to secure sources of funding for international germ plasm banking activities. Discussion of each of these critical needs follows.

ENCOURAGE INTERNATIONAL GERM PLASM BANKING ACTIVITIES

Germ plasm banking activities can best be encouraged by education programs to inform the public, conservation managers and conservation researchers of the benefits resulting from the systematic banking of genetic resources. Examples of current applications and the conservation and research benefits of germ plasm banking can be drawn from type-culture collections of microorganisms and cell cultures (Colwell 1976, Edwards 1988), the commercial cattle breeding industry (Seidel, G.E. 1990) and banks of embryos from genetically-defined strains of laboratory rodents (Mobraaten 1981).

Ongoing international programs for the ex situ conservation of plant genetic resources provide a useful model (Cohen et al. 1991). Efforts for developing collections of crop germ plasm are well advanced. International coordination of crop germ plasm conservation is provided by the International Board for Plant Genetic Resources (IBPGR) and the Consultative Group on International Agricultural Research (CGIAR). At present, 14 major agricultural research centers have been established in developing regions, each developing base collections of germ plasm for the major food crops. Funding for these activities is approximately US$300 million per year. Comparable efforts for domestic animal species are modest. Currently there is no 'International Board of Animal Genetic Resources' to coordinate international efforts to conserve agriculturally-important sources of animal germ plasm. However, the Food and Agriculture Organization (FAO) of the United Nations has established an initiative to establish germ plasm banks in developing regions. Coordination of FAO and wild animal conservation and germ plasm banking activities would be best provided through the CBSG.

IUCN POSITION STATEMENT ON ANIMAL GENETIC RESOURCE BANKING

One method of highlighting the potential benefits of active genetic resource banking programs is to seek an official position statement by the IUCN. The statement should be drafted jointly by the CBSG and the Chairman of the Species Survival Commission (SSC) of the IUCN. Information and review of the statement should be solicited from other SSC Specialist Groups prior to submission to the IUCN for approval. We suggest that the statement emphasize the importance of coordinated in situ and ex situ conservation programs for endangered species. The role of germ plasm banking in preserving important sources of genetic diversity and in providing a means for moving genetic diversity between captive and free-living populations should be stated. The CBSG should be designated to be responsible for oversight of germ plasm banking activities within the Species Survival Commission. Finally, the CBSG should be directed to coordinate and review international aspects of banking programs for nondomesticated animal species.

FORMULATE GLOBAL GUIDELINES FOR THE ESTABLISHMENT, OPERATION AND REVIEW OF ANIMAL GENETIC RESOURCE BANKS

A key factor to ensuring the success of animal genetic resource banks (GRBs) is to ensure that they are established using rigorous scientific criteria and state-of-the-art technology. Because limited resources are available, difficult choices will need to be made on which species can derive the maximum benefit from this approach. At present no guidelines exist to assist in formulating action plans for establishing and operating a genetic resource bank.

To assist the CBSG in developing such guidelines, we suggest the following sequence as a first attempt to address many of the important issues. This working plan was modified from one suggested recently by one of us (Rall 1992).

GENETIC RESOURCE BANKING OVERSIGHT COMMITTEE

STEP 1. The first step in establishing integrated GRBs is to establish a GRB Oversight Committee under the auspices of the CBSG. This committee should be composed of 8 to 15 members. The composition must include one or more experts from each of the following areas: 1) cryobiologist; 2) reproductive physiologist; 3) population biologist; 4) geneticist; 5) veterinarian; 6) in situ conservation biologist; 7) ex situ conservation manager; and 8) the chairmen of regional cryopreservation task force committees. Furthermore, the chairmen (or their representative) of all SSC specialist groups should serve as ad hoc members.

STEP 2. The second step is to define the responsibilities of the committee and formulate a formal process for establishing GRBs. We propose five basic missions for the GRB Oversight Committee:

1. Coordinate GRB activities within the SSC and regional propagation groups. The GRB Oversight Committee would assist SSC taxon Specialist Groups, regional taxon advisory and captive propagation groups achieve their goals of conserving rare species. This can be accomplished by integrating the consideration of GRBs directly into the framework of strategic planning processes of population viability assessment and conservation action plan (PVA/CAP) workshops. These activities require that an expert resource network be established to provide advise on all technical matters related to GRBs and their utility.

2. Establish guidelines for identifying candidate taxa, species or populations that would benefit from a GRB program. These guidelines should be detailed and assist in the development of strategic GRB Action Plans for conserving specific animal populations. The single most important consideration is to ensure that there is a defined conservation goal that requires the collection and storage

of biological materials. This requires that a integrated plan for a goal-oriented conservation program be established prior to initiating banking activities. We list three scenarios below to illustrate our proposed process.

3. Provide expert technical assistance to the appropriate taxon groups to assist in the development of GRB Action Plans. This would include identifying institutions with an interest in providing long-term repository storage space or local/regional assistance in collecting and preserving material. Furthermore, the GRB Oversight Committee would work with the CBSG, the SSC Financial Development Officer and other interested organization to identify sources for supporting international GRB activities. Proposals for funding might be submitted individually or jointly with these and other organizations to private foundations, national research granting agencies and multinational organizations.

4. Provide a mechanism for the review of proposed GRB Action Plans. Plans that meet recommended requirements should be approved formally by the CBSG. (Formal 'sanction' may assist in the securing of external funding.)

5. Develop a periodic review process for individual GRB programs. This would be best accomplished by shared responsibility with the appropriate regional GRB Task Force Committee. For example, the annual reports of individual GRBs could be presented by the chair of the appropriate regional GRB Task force for review of recent progress, problems and future directions of banking activities.

THREE SCENARIOS OF APPROPRIATE GENETIC RESOURCE BANKING PROGRAMS

Scenario 1. An ongoing captive propagation program seeks to increase safety and management options for maintaining genetic diversity in a population, and achieve the same goals with fewer animals. We propose that such a population would be a candidate for a GRB program if the following minimum requirements are met:

a. Populations in captivity and/or the wild must be potentially viable by demographic and genetic criteria. This information is best obtained from a recent population viability assessment (PVA).

b. Ongoing captive propagation (e.g. SSP, EEP), studbook and conservation research programs have been established for the candidate animal population(s).

c. The current level of success of captive breeding must be sufficient to provide reasonable assurance that GRB-associated reproductive biotechniques will be successful.

d. Animals with known genetic backgrounds should be available to serve as founders of a GRB.

e. Sufficient numbers of 'surplus' females and males must be available to act as recipients to demonstrate the viability of cryopreserved germ plasm and serve as a source of material for

research and protocol development.

f. The effects of potential restrictions on the importation and exportation of animals and animal products must be evaluated.

g. And other factors as appropriate for the specific candidate species or population.

Scenario 2. An animal population has declined to low numbers (<100) and is expected to recover slowly. The population is expected to lose heterozygosity rapidly (>0.5% per generation and be subjected to genetic drift. A propagation/management plan has been initiated with the goals of protecting current levels of genetic diversity, preventing the loss of diversity in specific elderly founders and increasing the size of the population. We propose that such a population would be a candidate for an emergency GRB program if the following minimum requirements are met:

a. The populations must be potentially viable by demographic and genetic criteria. This information is best obtained from a recent population viability assessment (PVA).

b. There is a reasonable expectation that captive propagation will be successful. For example, a taxonomically-related species or subspecies has been successfully bred in captivity.

c. There is a reasonable expectation that GRB-associated reproductive techniques (e.g. germ plasm collection and cryopreservation, artificial insemination, embryo transfer) will be successful. For example, these procedures have been successfully applied in a taxonomically-related species or subspecies.

d. And other factors as appropriate for the specific candidate species or population.

Scenario 3. A free-living population has declined rapidly and satisfies the 'critical' or 'endangered' categories of the Mace-Lande criteria for threatened taxa (Mace and Lande 1991). Factors leading to the decline have been identified and a management plan has been initiated to maintain the population at low numbers (<2000) for many generations (5 to 20) before an increase in population size is expected. The population remains at risk to a further rapid decline that may reduce genetic diversity to unacceptable levels. One management goal is to develop a secure ex situ program to provide a reinfusion of genetic diversity in the event of a future decline. We propose that such a population would be a candidate for a GRB program if the following minimum requirements are met:

a. There is a reasonable expectation that GRB-associated reproductive techniques (e.g. germ plasm collection and cryopreservation, artificial insemination, embryo transfer) will be successful. For example, these procedures have been successfully applied in a taxonomically-related species or subspecies.

b. Animals with known or identifiable genetic backgrounds should be available to serve as founders of a GRB.

c. Sufficient numbers of 'surplus' females and males must be available to act as recipients to demonstrate the viability of cryopreserved germ plasm and serve as a source of material for

research and protocol development.

d. And other factors as appropriate for the specific candidate species or population.

DEVELOPMENT OF ACTION PLANS FOR GENETIC RESOURCE BANKS

STEP 3. The primary responsibility for developing GRB Action Plans properly resides with those groups with specific responsibilities for in situ and ex situ conservation of specific taxa, species and populations (e.g. taxon Specialist Groups, Taxon Advisory Groups and regional captive propagation groups). These groups should be encouraged to include the development of GRBs as an integral component in their strategic conservation planning (e.g. Captive Action Plans, Taxon Action Plans). The first step in the process occurs when a group identifies a specific conservation goal for a taxon, species or population that requires the collection and storage of biological materials. The needs and characteristics of the candidate animal population(s) would be evaluated in terms of the requirements listed in the appropriate scenario listed above. If analysis of these factors suggest that conservation efforts would be enhanced or ensured by a GRB program, the group would petition the CBSG of their intent to develop such an action plan.

The GRB Oversight Committee would review the petition and, if approved, would assist the conservation group in organizing a working session meeting to further evaluate the conservation needs and develop a detailed action plan. The role of the Oversight Committee would be to identify technical experts who can assist in this effort. The specific goals of the meeting would be to:

1. Assemble and evaluate available information on the life-, reproductive- and genetic histories of ex situ and in situ populations of interest. Much of this information would be available for recent propagation/management (e.g. SSP, TAG) and PVA materials.

2. Evaluate the efficiency and efficacy of reproductive technologies for the candidate species, such as artificial insemination, embryo transfer, in vitro fertilization, gamete and embryo cryopreservation and collection of spermatozoa, oocytes and embryos. Areas requiring further research or development would be identified.

3. Identify the types of biological material requiring storage. It should be noted that a wide variety of different biological materials might be cryopreserved and stored depending on the goals and needs of the conservation program (see Table 1).

4. Specify the appropriate protocols for banking activities. These include:

a. The criteria used to select material(s) for accession, determine the quantity of material from each donor and identify

appropriate uses of the material.

b. Procedures for collection, processing, cryopreservation, shipping, thawing and other treatments. The minimum quality control standards for each process and overall viability would be identified.

c. The appropriate repository equipment, facilities, security and management systems that ensure the ultimate utility of the banked materials would be identified.

d. If any of the above items are unknown, specific areas requiring further research should be identified.

5. Determine the location of the primary repository for storage of cryopreserved materials and secondary backup sites.

6. Develop strategies for the use of banked materials in breeding and conservation research programs.

7. Identify sources of funding for the GRB Action Plan.

If analysis of the these factors indicates that a GRB program would benefit conservation, the petitioning organization would prepare a written Action Plan for developing a GRB program.

REVIEW AND APPROVAL OF PROPOSED ACTION PLAN FOR A GENETIC RESOURCE BANK

STEP 4. Identifying the appropriate authority for reviewing GRB Action Plans is complicated by the overlapping purviews of national, regional and international organizations and their animal propagation/management programs. We suggest that the proposed GRB Oversight Committee is the most appropriate organization because of the very nature and responsibilities of the CBSG. First, by definition, genetic resource banking programs represent a form of ex situ captive propagation. Second, GRB activities are international in that technical experts and populations of most rare species are located on several continents. Third, GRB programs require integration with other in situ and ex situ conservation programs. However, in many cases, regional cryopreservation task force committees will play an important role in regional coordination and development of these programs. In those cases, we propose that the GRB Action Plan be reviewed by both the regional banking authority and CBSG GRB Oversight Committee. After approval, the plan would be implemented and collection, storage and use of biological materials can begin.

CONCLUSION

The development of animal Genetic Resource Banks offers unique opportunities to control and manipulate the effects of time in the management and conservation of rare species. The ideas proposed

here are intended to help stimulate discussion about the process on a formal basis. Many important questions remain to be resolved, including the translation of banking germ plasm into live offspring. However, many recent reports of successes using artificial breeding techniques indicate the potential of reproductive biotechnology. The further development of strategies proposed here will ensure that GRBs are not merely an interesting idea or static warehouses of biological materials but facilitators for conservation.

Table 1. Biological Materials for Germ Plasm Banking and Conservation Research.

Material Type	Long-term Storage Conditions	Examples of Potential Uses
Sperm, oocytes	below -130°C[a]	Controlled breeding; international shipment; gene banking
Embryos	below -130°C	Control of generation interval and gene flow; population amplification; international shipment
Cell lines	below -130°C	Genetic and physiological research
DNA		Molecular biology:
-Isolated	dried, 4°C[b]	Sequence detection and identification (e.g. by PCR)
-Isolated and frozen tissues	below -60°C[c]	Pedigree determination; genomic and mitochondrial libraries
Serum, plasma	below -60°C	Disease status (detection of microbial antibodies and disease organisms); endocrine status (measure hormones or hormonal metabolites)
Urine, milk	below -60°C	Endocrine and health status (measure hormonal and other metabolites)

[a]Liquid nitrogen refrigerator.
[b]Refrigerator or cold room.
[c]Low-temperature mechanical refrigerator.
[from Rall 1992, with modifications]

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COLUMBA (NESOENAS) MAYERI

PINK PIGEON

CONSERVATION VIABILITY ASSESSMENT

REPORT

SECTION 5

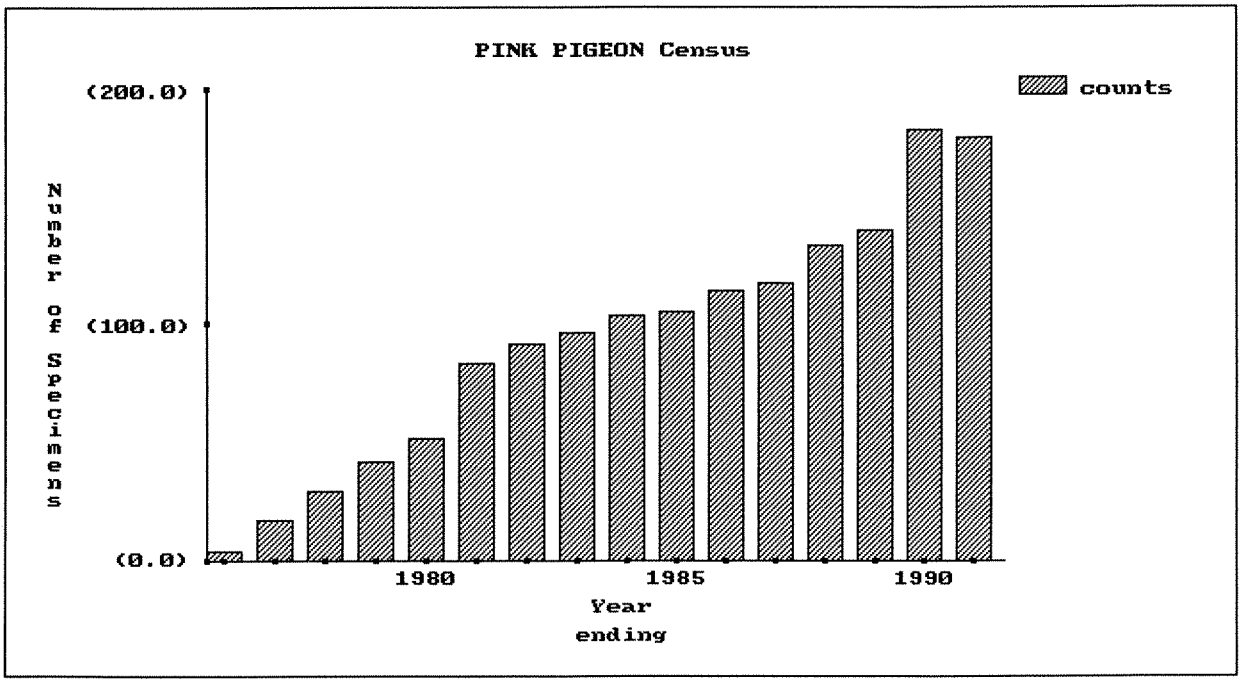
STUDBOOK ANALYSIS

Census Report

PINK PIGEON Studbook

Taxon Name: **NESOENAS MAYERI**

Year	Specimen Counts		Lambda	
1991	70.55.55	(180)	0.98	.
1990	72.55.56	(183)	1.15	.
1989	69.51.20	(140)	1.11	.
1988	62.49.22	(133)	1.12	.
1987	58.42.17	(117)	1.10	5 yr ave.
1986	58.43.13	(114)	1.10	.
1985	56.42.7	(105)	1.09	.
1984	54.42.7	(103)	1.09	.
1983	50.40.6	(96)	1.08	.
1982	45.37.9	(91)	1.08	10 yr ave.
1981	44.32.7	(83)	1.13	.
1980	25.22.4	(51)	1.14	.
1979	20.16.5	(41)	1.16	.
1978	16.12.1	(29)	1.20	.
1977	9.7.1	(17)	1.41	15 yr ave.
1976	3.1.0	(4)	1.38	.



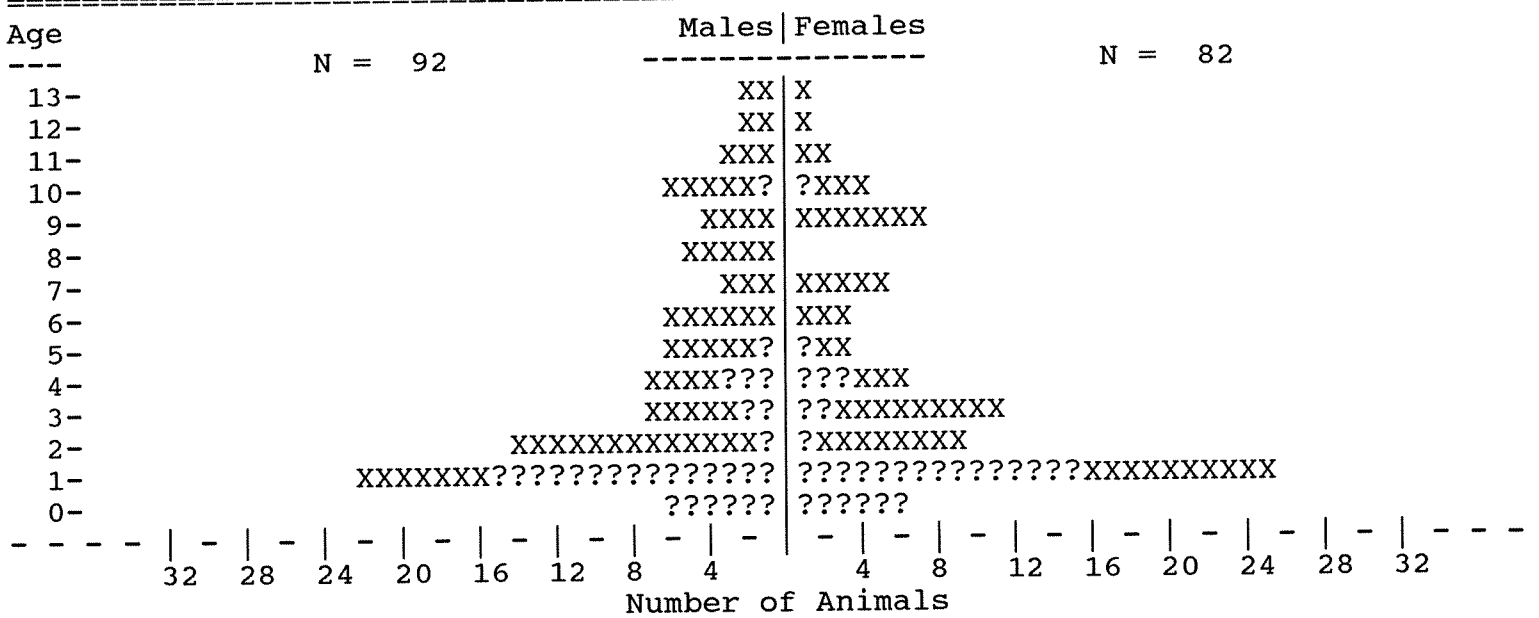
Compiled by: K. Taynton / C.R. Lind thru Zoo Outreach Organization
International Studbook

ISIS/SPARKS
31 Mar 1991

Age Pyramid Report

Restricted to: PINK PIGEON Studbook
Status: Living by 13 Oct 1991

Taxon Name: **NESOENAS MAYERI**



X >>> Specimens of known sex...
? >>> Specimens of unknown sex...
5 Male Specimens of unknown age...
1 Female Specimens of unknown age...

Taxon Name: **NESOENAS MAYERI**

Age Class	Fecundity [Mx]... Male	N	Female	N	Mortality [Qx]... Male	N	Female	N
0- 1	0.21	154.0	0.27	149.5	0.57	323.0	0.59	312.9
1- 2	0.58	104.1	1.02	95.2	0.15	114.4	0.19	104.3
2- 3	0.43	79.6	0.86	67.7	0.12	84.5	0.12	73.1
3- 4	0.55	65.1	0.47	51.1	0.11	68.0	0.14	55.1
4- 5	0.43	50.7	0.55	40.0	0.04	52.1	0.12	41.7
5- 6	0.27	42.9	0.28	32.4	0.05	44.0	0.06	33.3
6- 7	0.33	33.3	0.34	23.9	0.10	35.9	0.14	25.8
7- 8	0.20	27.5	0.03	18.3	0.07	29.3	0.00	18.3
8- 9	0.05	20.1	0.09	16.6	0.11	22.0	0.09	17.4
9-10	0.00	14.1	0.21	9.6	0.07	14.9	0.00	9.6
10-11	0.00	8.3	0.00	4.5	0.12	8.5	0.22	4.6
11-12	0.00	4.1	0.00	1.8	0.22	4.6	0.00	1.8
12-13	0.00	1.9	0.00	0.7	0.00	1.9	0.00	0.7
13-14	0.00	0.4	0.00	0.0	0.00	0.4	0.00	0.0
14-15	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
15-16	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0

T = 2.871	T = 2.514	30 day mortality: 45%
Ro = 0.918	Ro = 1.114	(283 out of 634)
lambda=0.97	lambda=1.04	
r = -0.030	r = 0.043	

14 specimens of unknown age ignored...

477 birth events to known age parents tabulated for Mx...
[29 parents (includes WILD) not found in data set ignored...]

468 death events of known age tabulated for Qx...

WARNING: Values with small sample sizes (N) warrant less confidence...

INTERNATIONAL STUDBOOK

Fecundity & Mortality Report

PINK PIGEON Studbook

Report End Date:
17 Apr 1991

Restricted to:
Locations: U.S.A.

Taxon Name: **NESOENAS MAYERI**

Age Class	Fecundity [Mx]... Male	N	Female	N	Mortality [Qx]... Male	N	Female	N
0- 1	0.07	21.2	0.31	18.0	0.61	51.4	0.66	46.3
1- 2	0.47	21.1	0.45	20.1	0.09	22.8	0.05	20.3
2- 3	0.59	20.3	0.80	20.1	0.14	21.9	0.05	20.8
3- 4	0.51	16.8	0.56	15.3	0.00	16.8	0.18	16.9
4- 5	0.32	15.5	0.40	12.5	0.00	15.5	0.00	12.5
5- 6	0.35	14.2	0.05	11.0	0.00	14.2	0.09	11.7
6- 7	0.37	9.6	0.24	8.2	0.22	11.5	0.17	8.7
7- 8	0.14	7.1	0.09	5.5	0.00	7.1	0.00	5.5
8- 9	0.00	5.5	0.00	5.0	0.17	6.0	0.00	5.0
9-10	0.00	4.4	0.00	2.3	0.00	4.4	0.00	2.3
10-11	0.00	2.5	0.00	0.0	0.00	2.5	0.00	0.0
11-12	0.00	2.0	0.00	0.0	0.00	2.0	0.00	0.0
12-13	0.00	1.3	0.00	0.0	0.00	1.3	0.00	0.0
13-14	0.00	0.4	0.00	0.0	0.00	0.4	0.00	0.0
14-15	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
15-16	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0

T = 3.132	T = 2.355	30 day mortality: 59%
Ro = 0.856	Ro = 0.812	(56 out of 95)
lambda=0.95	lambda=0.92	
r = -0.050	r = -0.088	

93 birth events to known age parents tabulated for Mx...

78 death events of known age tabulated for Qx...

WARNING: Values with small sample sizes (N) warrant less confidence...

Fecundity & Mortality Report

PINK PIGEON Studbook

Report End Date: 17 Apr 1991

Restricted to: Locations: JERSEY CHESTER PAIGNTON HAYLE CHARD WALSRODE

Taxon Name: **NESOENAS MAYERI**

Age Class	Fecundity [Mx]... Male	N	Female	N	Mortality [Qx]... Male	N	Female	N
0- 1	0.18	33.3	0.33	32.1	0.60	77.7	0.58	71.9
1- 2	0.83	22.2	1.19	22.6	0.18	25.7	0.22	24.9
2- 3	0.41	16.0	0.84	16.0	0.14	17.4	0.19	18.1
3- 4	0.22	13.9	0.46	13.0	0.07	14.4	0.15	13.6
4- 5	0.46	10.9	0.51	9.9	0.09	11.7	0.17	11.8
5- 6	0.26	9.5	0.34	9.0	0.10	10.0	0.11	9.1
6- 7	0.69	8.7	0.57	7.1	0.11	9.4	0.23	8.5
7- 8	0.45	8.9	0.00	6.0	0.00	8.9	0.00	6.0
8- 9	0.09	5.3	0.25	6.1	0.09	5.7	0.22	6.9
9-10	0.00	2.4	0.30	3.3	0.30	3.3	0.00	3.3
10-11	0.00	2.4	0.00	1.9	0.38	2.6	0.50	2.0
11-12	0.00	1.2	0.00	1.0	0.57	1.8	0.00	1.0
12-13	0.00	0.6	0.00	0.7	0.00	0.6	0.00	0.7
13-14	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
14-15	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0

T = 3.179	T = 2.397	30 day mortality: 54%
Ro = 0.917	Ro = 1.135	(81 out of 150)
lambda=0.97	lambda=1.05	
r = -0.027	r = 0.053	

123 birth events to known age parents tabulated for Mx...

122 death events of known age tabulated for Qx...

WARNING: Values with small sample sizes (N) warrant less confidence...

BRITISH ISLES & EUROPE

Fecundity & Mortality Report

Report End Date: 17 Apr 1991

Restricted to: PINK PIGEON Studbook
Locations: BLACK RIV CASELA JURONG PLAINE LI

Taxon Name: **NESOENAS MAYERI**

Age Class	Fecundity [Mx]... Male	N	Female	N	Mortality [Qx]... Male	N	Female	N
0- 1	0.28	80.8	0.26	84.3	0.60	170.6	0.60	175.9
1- 2	0.54	50.0	1.36	41.1	0.18	55.4	0.25	47.1
2- 3	0.40	39.2	0.98	27.5	0.11	40.9	0.12	29.2
3- 4	0.67	31.9	0.38	20.9	0.16	33.4	0.11	22.7
4- 5	0.49	23.3	0.67	15.6	0.04	23.9	0.18	16.4
5- 6	0.11	18.3	0.44	11.5	0.05	18.9	0.00	11.5
6- 7	0.11	13.9	0.00	7.6	0.00	13.9	0.00	7.0
7- 8	0.05	10.4	0.00	5.9	0.09	11.4	0.00	5.9
8- 9	0.06	8.3	0.00	5.5	0.11	9.3	0.00	5.5
9-10	0.00	6.3	0.00	4.0	0.00	6.3	0.00	4.0
10-11	0.00	3.0	0.00	2.6	0.00	3.0	0.00	2.6
11-12	0.00	0.9	0.00	0.8	0.00	0.9	0.00	0.8
12-13	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
13-14	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0

T = 2.373	T = 1.987	30 day mortality: 41%
Ro = 0.756	Ro = 1.074	(144 out of 348)
lambda=0.89	lambda=1.04	
r = -0.118	r = 0.036	

231 birth events to known age parents tabulated for Mx...

253 death events of known age tabulated for Qx...

WARNING: Values with small sample sizes (N) warrant less confidence...

MAURITIUS & JURONG

Fecundity & Mortality Report

Restricted to: PINK PIGEON Studbook
Locations: BLACK RIV
Dates: 01/01/1981 <= date .and. date <= 31/12/1981

Report End Date: 31 Dec 1981

Taxon Name: **NESOENAS MAYERI**

Age Class	Fecundity [Mx]... Male	N	Female	N	Mortality [Qx]... Male	N	Female	N
0- 1	0.67	8.9	0.52	6.7	0.76	28.1	0.82	26.4
1- 2	1.40	2.1	8.09	2.4	0.36	2.8	0.55	3.6
2- 3	2.15	2.6	4.06	2.0	0.00	2.6	0.00	2.0
3- 4	2.73	3.3	1.09	0.9	0.00	2.1	0.71	1.4
4- 5	5.36	0.6	0.00	0.0	0.00	0.2	0.00	0.0
5- 6	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
6- 7	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0

T =	2.785	1.260
Ro =	1.949	1.103
lambda=	1.27	1.08
r =	0.240	0.078

30 day mortality: 48%
(36 out of 75)

58 birth events to known age parents tabulated for Mx...

47 death events of known age tabulated for Qx...

WARNING: Values with small sample sizes (N) warrant less confidence...

BLACK RIVER SHOWING HIGH RATE OF MORTALITY

IN SQUAB LESS THAN OR EQUAL TO 1 YEAR OF AGE.

Compiled by: K. Taynton / C.R. Lind thru Jersey Wildlife Preservation Trust
International Studbook

ISIS/SPARKS
18 Apr 1991

Fecundity & Mortality Report

Restricted to: PINK PIGEON Studbook
Locations: JERSEY
Dates: 01/01/1987 <= date .and. date <= 31/12/1990

Report End Date: 31 Dec 1990

Taxon Name: **NESOENAS MAYERI**

Age Class	Fecundity [Mx]... Male	N	Female	N	Mortality [Qx]... Male	N	Female	N
0- 1	0.24	18.7	0.50	18.0	0.45	32.2	0.44	30.6
1- 2	2.48	5.1	3.60	5.6	0.36	7.0	0.44	8.0
2- 3	0.76	0.7	3.33	1.5	0.00	0.7	0.00	1.5
3- 4	0.41	1.2	3.85	0.8	0.00	1.2	0.00	0.8
4- 5	1.16	1.7	0.00	0.0	0.00	1.7	1.00	1.0
5- 6	0.83	3.0	3.03	0.3	0.00	3.0	0.00	0.3
6- 7	2.60	2.3	3.08	0.7	0.33	3.0	0.80	1.3
7- 8	1.55	2.6	0.00	0.0	0.00	2.6	0.00	0.0
8- 9	0.31	1.6	1.85	0.8	0.00	1.6	0.00	0.8
9-10	0.00	0.1	0.61	0.8	1.00	1.0	0.00	0.8
10-11	0.00	0.6	0.00	0.9	0.00	0.6	1.00	1.0
11-12	0.00	0.5	0.00	0.0	0.00	0.5	0.00	0.0
12-13	0.00	0.3	0.00	0.0	0.00	0.3	0.00	0.0
13-14	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
14-15	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0

T = 3.710	T = 1.868	30 day mortality: 30%
Ro = 3.169	Ro = 3.661	(24 out of 79)
lambda=1.36	lambda=2.00	
r = 0.311	r = 0.695	

75 birth events to known age parents tabulated for Mx...

39 death events of known age tabulated for Qx...

WARNING: Values with small sample sizes (N) warrant less confidence...

JERSEY RESULTS AFTER REVISED HUSBANDRY.

GENETIC ANALYSIS
PINK PIGEON - STUDBOOK POPULATION

FOUNDER ALLELE REPRESENTATION

Founder	Retention	%Representation		Target		Difference	
		with unk	w/o	with unk	w/o	with unk	w/o
1 ML	0.881	1.170	1.174	3.440	4.862	2.270	3.688
3 ML	1.000	20.525	20.589	3.440	4.862	-17.085	-15.727
4 M	0.997	4.997	5.013	3.430	4.847	-1.567	-0.165
5 F	1.000	18.384	18.442	3.440	4.862	-14.944	-13.580
6 ML	0.998	7.493	7.517	3.440	4.862	-4.053	-2.655
9 ML	0.956	15.316	15.364	3.440	4.862	-11.876	-10.502
10 F	0.941	7.480	7.503	3.236	4.573	-4.245	-2.931
13 ML	0.993	11.043	11.078	3.440	4.862	-7.603	-6.216
37 FL	0.946	3.261	3.271	3.440	4.862	0.180	1.591
14 M	0.866	5.349	5.366	2.979	4.210	-2.370	-1.155
132 M	0.764	2.807	2.815	2.630	3.717	-0.176	0.902
240 MLU	0.000	0.000	0.000	3.440	0.000	3.440	0.000
324 ULU	0.000	0.000	0.000	3.440	0.000	3.440	0.000
320 ULU	0.000	0.000	0.000	3.440	0.000	3.440	0.000
389 FLU	0.000	0.000	0.000	3.440	0.000	3.440	0.000
390 MLU	0.000	0.000	0.000	3.440	0.000	3.440	0.000
P340 M U	0.500	0.311	0.000	1.720	0.000	1.410	0.000
586 ULU	0.000	0.000	0.000	3.440	0.000	3.440	0.000
587 FLU	0.000	0.000	0.000	3.440	0.000	3.440	0.000
589 FL	0.000	0.000	0.000	3.440	4.862	3.440	4.862
590 FL	0.500	0.311	0.312	3.440	4.862	3.130	4.550
592 UL	0.000	0.000	0.000	3.440	4.862	3.440	4.862
593 ML	0.881	0.932	0.935	3.440	4.862	2.509	3.927
609 ML	0.000	0.000	0.000	3.440	4.862	3.440	4.862
610 ML	0.741	0.621	0.623	3.440	4.862	2.819	4.239
614 UL	0.000	0.000	0.000	3.440	4.862	3.440	4.862
618 FL	0.000	0.000	0.000	3.440	4.862	3.440	4.862
620 UL	0.000	0.000	0.000	3.440	4.862	3.440	4.862
621 UL	0.000	0.000	0.000	3.440	4.862	3.440	4.862
638 ULU	0.000	0.000	0.000	3.440	0.000	3.440	0.000

GENETIC SUMMARY	LIVING DESCENDANT POPULATION		POTENTIAL	
	with unknowns	w/o	w/ unkn	w/o
Number of founders:	15	14	30	21
Mean retention:	0.864	0.890	0.969	0.979
Founder genomes surviving:	12.963	12.464	29.068	20.568
Founder Equivalents:	7.676	7.629	29.686	20.929
Founder Genome Equivalents:	5.261	5.228	29.068	20.568
Fraction of wild gene diversity retained:	0.905	0.904	0.983	0.976
Fraction of wild gene diversity lost:	0.095	0.096	0.017	0.024
Mean inbreeding coefficient:	0.083			

GENETIC ANALYSIS - STUDBOOK POPULATION OF PINK PIGEON (*Nesoenas mayeri*)
30/03/91

FOUNDER ANALYSIS

Founder representation in each living animal:

1	3	4	5	6	9	10
13	37	14	132	589	590	592
593	609	610	614	618	620	621

Founder contributions

1.8750	33.0308	8.0471	29.7808	12.1261	24.5056	12.0062
17.8844	5.2500	8.5240	4.4846	0.0000	0.5000	0.0000
1.5000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000

Fractional contributions

0.0117	0.2058	0.0501	0.1855	0.0755	0.1527	0.0748
0.1114	0.0327	0.0531	0.0279	0.0000	0.0031	0.0000
0.0093	0.0000	0.0062	0.0000	0.0000	0.0000	0.0000

Number of living descendants

5	155	34	149	65	133	126
97	19	64	27	0	1	0
3	0	2	0	0	0	0

GENETIC SUMMARY	**LIVING DESCENDANT POPULATION**		**POTENTIAL**	
	with unknowns	**w/o**	**w/unkn**	**w/o**
Number of founders:	15	14	30	21
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Mean inbreeding coefficient:	0.083			

GENETIC SUMMARY OF POPULATION

Descendant population mean kinship:	0.1904
Gene diversity:	0.9048
Founder Genome Equivalents:	5.2509

Current Founder Contributions

Int. Stud.	Black River	Jersey	N. America	Internat.
1	1.9	0.0	1.0	1.8
3	17.4	12.4	10.6	32.4
4	6.3	2.8	1.0	7.8
5	14.5	12.4	10.6	29.6
6	2.2	11.5	1.4	11.8
9	6.1	16.2	6.9	23.6
10	4.8	4.7	7.8	11.7
13	6.7	11.7	2.1	17.4
37	2.8	1.0	2.1	5.5
14	4.5	2.2	3.5	8.5
132	4.9	0.0	0.0	4.8

FOUNDER ANALYSIS FOR *NESOENAS MAYERI* STUDBOOK DATA... **JERSEY**

19/04/1991

3	4	5	6	9	10	13
37	14					

Founder Contributions

12.4273	2.7500	12.4273	11.5302	16.2180	4.7325	11.7177
1.0000	2.1875					

Fractional contributions

0.1657	0.0367	0.1657	0.1537	0.2162	0.0631	0.1562
0.0133	0.0292					

Number of living descendants

73	9	73	57	69	62	58
3	14					

Number of Founder Equivalents = 6.4074

FOUNDER ANALYSIS FOR *NESOENAS MAYERI* STUDBOOK DATA... **NORTH AMERICA**

19/04/1991

Founder studbook numbers in parentheses indicate UNKNOWNs.
Negative founder studbook numbers indicate wild or unknown founders that mated with the (positive studbook #) animal to produce CB offspring.

1	3	4	5	6	9	10
13	37	14	(-340)			
Founder contributions						
0.5000	9.9995	1.0000	9.9995	0.3749	5.1874	4.1248
0.8749	2.7500	3.6875	0.5000			
Fractional contributions						
0.0128	0.2564	0.0256	0.2564	0.0096	0.1330	0.1058
0.0224	0.0705	0.0946	0.0128			
Number of living descendants						
1	39	2	39	5	32	32
6	11	26	1			

Number of Founder Equivalents (without unknowns) = 5.5465
Number of Founder Equivalents (with unknowns) = 5.6866

FOUNDER ANALYSIS FOR *NESOENAS MAYERI* STUDBOOK DATA... **BLACK RIVER**

19/04/1991

Founder studbook numbers in parentheses indicate UNKNOWNS.

1	3	4	5	6	9	10
13	37	14	132	(240)	(324)	(320)
(389)	(390)	(586)	(587)	589	590	592
593	609	610	614	618		

Founder contributions

1.8750	17.7448	6.2965	14.4948	2.2499	6.0965	4.7213
6.6947	2.7500	4.5855	4.4840	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.5000	0.0000
1.5000	0.0000	1.0000	0.0000	0.0000		

Fractional contributions

0.0250	0.2366	0.0840	0.1933	0.0300	0.0813	0.0630
0.0893	0.0367	0.0611	0.0598	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0067	0.0000
0.0200	0.0000	0.0133	0.0000	0.0000		

Number of living descendants

5	71	27	65	12	47	47
42	8	33	27	0	0	0
0	0	0	0	0	1	0
3	0	2	0	0		

Number of Founder Equivalents (without unknowns) = 7.7075
Number of Founder Equivalents (with unknowns) = 7.7089

COLUMBA (NESOENAS) MAYERI

PINK PIGEON

CONSERVATION VIABILITY ASSESSMENT

REPORT

SECTION 6

DISEASE

IBIS 130: 57–64

Clinical and pathological studies on the Mauritian Pink Pigeon *Columba mayeri*

J. E. COOPER*, J. R. NEEDHAM†, K. APPLEBEE**¶ & C. G. JONES††

*Department of Pathology, Royal College of Surgeons of England, 35–43 Lincoln's Inn Fields, London WC2A 3PN; †The Microbiology Laboratories, 56 Northumberland Road, North Harrow, Middlesex HA2 7RE; **Animal Care Unit, Royal College of Surgeons of England, 35–43 Lincoln's Inn Fields, London WC2A 3PN; ††Forestry Quarters, Black River, Mauritius

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Six Pink Pigeons *Columba = Nesoenas mayeri* from the captive breeding project on Mauritius which showed a range of physical abnormalities were examined clinically and *post mortem*. Significant findings included a pedal deformity in several birds and cerebellar hypoplasia/aplasia in another. Parasites were not detected and none of the birds showed serum antibodies to Newcastle disease virus, Paramyxovirus or *Chlamydia psittaci*. The results are of relevance to the captive breeding and management of this endangered species.

The Pink Pigeon *Columba mayeri* formerly *Nesoenas mayeri* is the rarest pigeon in the world (King 1981). In the wild it is confined to Mauritius where fewer than 20 individuals exist (Todd 1984). Captive breeding projects were established on Mauritius in 1976 (McKelvey 1976) and at the Jersey Wildlife Preservation Trust (JWPT) in 1977 (Hartley 1977, Jeggo 1977, 1979, Durrell & Durrell 1980): both have proved successful and captive individuals have been released into suitable sites on Mauritius (ICBP 1984). Concern has been expressed, however, over the viability of some of the pigeons produced and, in particular, the appearance within the captive colonies of 'inclined feet' and other physical defects. In this paper studies of six surplus birds are reported.

Materials and methods

Six pigeons were flown from Mauritius to London and imported under licence. They were kept in an approved quarantine room and fed on a staple grain diet supplemented with insectivorous bird food, chopped fruit and assorted foliage, a diet similar to that used on Mauritius (Jones *et al.* 1983). The history accompanying the birds stated that four (international numbers 0077, 0097, 0103 and 0118) exhibited pedal abnormalities. Another (0061) had shown 'co-ordination problems' while 0020 had very slightly inclined feet and had produced 14 fledged young, two of which also showed the abnormality.

Clinical procedures

On arrival the birds were clinically examined and weighed. Buccal and cloacal swabs and faeces were taken. After three days the birds were re-weighed, bled from the brachial (basilic) vein and further swabs taken. After another five days the procedures carried out on Day 3 were repeated but, in addition, three pigeons were anaesthetized with 25 mg kg^{-1} ketamine hydrochloride ('Vetalar': Parke Davis)

¶Present address: Animal Unit, Guy's Hospital Medical School, London SE1.

intramuscularly and blood samples were taken for clinical chemistry. After a further seven days the other three birds were anaesthetized and bled in the same way.

The pigeons were killed after another 10 and 9 days. Each bird was anaesthetized with intravenous alphaxalone-alphadolone ('Saffan': Glaxovet)—initially 12 mg kg^{-1}, then an overdose. Further blood was taken and serum prepared.

Post mortem examination

A full gross examination of each bird was carried out and whole body radiography performed using a dental X-ray machine. Swabs of lower intestine were taken for bacteriological culture, a range of tissues for histopathological examination and intestinal contents for parasitological analysis. The legs of all birds were removed, photographed, radiographed and dissected. Some were prepared by removal of excess flesh, using *Dermestes* beetles, and subsequent treatment with acetone and hypochlorite. Following examination all carcases and tissues were catalogued and stored in the Mascarene Collection at the Royal College of Surgeons of England (Cooper & Jones 1986).

Laboratory investigations

Faeces and intestinal contents were examined microscopically for parasites. Buccal, cloacal and intestinal swabs were examined fully for bacteria and fungi as described elsewhere (Cooper *et al.* 1986) but with the addition of two Sabouraud dextrose agar plates and a Lowenstein Jensen agar slope. The Lowenstein Jensen slope was incubated for 10 weeks at 37°C. Two Sabouraud agar plates were incubated at 37°C for seven days, another at 22°C for up to 21 days. One buccal swab was placed in 0·8 ml of glucose mycoplasma growth medium and treated as described by Needham (1979). Colonies of bacteria were identified following standard techniques (Cowan 1974) and API systems (API Laboratory Products Ltd, Basingstoke, Hants), fungi using colonial morphology and appearance when stained.

Tissues for histopathological examination were fixed in buffered formol saline, sectioned and stained with haematoxylin and eosin. Haematology was performed on blood samples in EDTA. Packed cell volume (PCV) estimations were carried out using a microhaematocrit system. Thin blood smears were fixed with alcohol and stained with Giemsa. Clinical chemical estimations were carried out by Bloxham Laboratories (Teignmouth, Devon) on blood samples submitted by post in lithium heparin. Serological tests were performed by the Central Veterinary Laboratory, Weybridge, Surrey. Samples were examined for antibodies to Newcastle disease virus, paramyxoviruses 2–9 (excluding PMV5) and *Chlamydia psittaci*.

Results

Clinical findings

These are given in Table 1. Although the six pigeons appeared active and in good general health, five showed abnormalities. Four had pedal disorders, characterized by a twisting of the foot so that the digits were rotated medially and the bird took weight on the lateral aspects (Fig. 1). The pigeon with a history of inco-ordination walked in a jerky, swaying manner and on arrival had difficulty in perching and maintaining its balance.

All six birds showed consistently lower weights while in London than they had in Mauritius and some lost weight during this time. In two birds (numbers 0103 and 0118) there were 'fretmarks' (thin lines of weakness) on tail and primary feathers respectively. The response of the birds to ketamine hydrochloride and alphaxalone-alphadolone was similar to that of Domestic Pigeons *Columba livia* (Cooper 1984).

Post mortem findings

Gross examination revealed no major lesions in five of the birds, but 0061, which had shown clinical signs of inco-ordination, was found to have cerebellar hypoplasia or

Table 1. *Clinical findings and weights of six captive Pink Pigeons*

Bird's no.	Sex	Date hatched	Clinical history	Clinical findings on arrival	Weights (g)*				
					a	b	c	d	e
0077	M	26.6.81	Inclined feet	Marked pedal deformity. Matted feathers	290	295	280	270	—
0061	F	13.10.80	Inco-ordination	No pedal deformity	205	190	195	195	200
0097	F	27.10.81	Inclined feet	Marked pedal deformity. Tail damage	225	225	245	240	245
0020	F	10.12.78	Produced two young with inclined feet, very slight pedal deformity	Possible pedal deformity. Tail damaged	260	240	245	215	—
0103	M	24.12.81	Inclined feet	Marked pedal deformity Fretmarks on tail/ feathers. Tail damaged. Cloacal soiling (green)	205	200	235	225	220
0118	M	15.9.82	Inclined feet	Marked pedal deformity. Fretmarks on secondaries. Cloacal soiling (green)	225	215	235	220	—

* a = day 1, b = day 4, c = day 9, d = day 26, e = day 27.

aplasia: only a small tissue remnant was present. In addition there was an abscess above its cloaca: bacteriological examination of this was not performed. Other findings included a bent keel in three birds (numbers 0103, 0061 and 0020) and a small right ovary in bird 0020. Liver weights ranged from 4 to 8 g.

Radiographs showed no skeletal lesions other than rotation of the distal end of the legs in four birds. Dissection of the legs of the four affected pigeons confirmed that the tibio-tarsal joints were normal and there was no evidence of deviation or luxation of the gastrocnemius tendons ('slipped hock'). However, the distal end of the tarsometatarsus bones showed slight rotation and associated malposition of tendons. That this was essentially a skeletal change was confirmed by comparison of prepared tarsometatarsus bones from an affected bird with those from normal Pink and Domestic Pigeons.

No parasites were detected in faeces or intestinal contents. Bacterial and fungal isolates are listed in Table 2. Histological sections failed to reveal any cerebellar tissue in the brain of bird 0061. Other findings were chronic interstitial and/or glomerulo nephritis (5/6) birds), chronic inflammatory infiltration of the liver (4/6), myocardial adipose tissue (3/6) and a small pancreatic granuloma (1/6). Haematological findings are given in Table 3 and clinical chemistry results in Tables 4 and 5. All birds were negative for antibodies to Newcastle disease virus, paramyxoviruses 2–9 and *C. psittaci*.

Discussion

The management method employed permitted ready observation and handling of the pigeons. However, as the weight losses and lower ranges suggested, keeping all six birds together was probably not ideal: this species fares better if not maintained in groups (Jones *et al.* 1983).

The absence of intestinal and blood-borne parasites is welcome in view of the need to maintain captive Pink Pigeons in good health and to ensure that in due course

Figure 1. A Pink Pigeon showing the severe pedal abnormality.

potentially pathogenic organisms are not introduced into the wild population. Likewise, it is encouraging to note the absence of antibodies to Newcastle disease virus, paramyxovirus and *C. psittaci*. However, it is possible that this could render the captive birds particularly susceptible to these organisms, as occurred in the United States when young foster-reared Pink Pigeons succumbed to *Herpesvirus* infection (Snyder *et al.* 1985).

There has been one report of a blood parasite from this species—*Leucocytozoon marchouxi* from a captive bird (Peirce 1984)—and this protozoon was also detected in captive Pink Pigeons examined on Mauritius in December 1984 (Cooper & Peirce unpublished) but its significance is uncertain.

Table 2. *Bacterial and fungal isolates from Pink Pigeons*[*]

Bird no.	Site	Sample 1	Sample 2	Sample 3	Sample 4 Autopsy
1 (0118)	Throat	*Neisseria* sp. *Escherichia coli* *Staphylococcus aureus* *Enterobacter cloacae* *Flavo. meningosepticum* *Pasteurella* sp.	*Pasteurella* sp. *Flavobacterium meningosepticum*	*S. aureus* *Lactobacillus* sp. *Klebsiella pneumoniae* *Pseudomonas fluorescens* gp. *Aspergillus fumigatus*	Trachea—no isolates
	Cloaca/ intestine	*Lactobacillus* sp. *E. coli* *Strep. salivarius*	*E. coli* *Strep. salivarius*	*E. coli*	No isolates
2 (0061)	Throat	*Neisseria* sp. *E. coli* *Ent. cloacae* *Ps. putida* *Past. multocida* *Acinet. calco* var *amitratus*	*Neisseria* sp. *Ent. cloacae* *Past. multocida* *Asp. niger*	*S. aureus* *Lactobacillus* sp. *Kleb. pneumoniae* *Ent. agglomerans*	No isolates
	Cloaca/ intestine	*E. coli*, *Prot. mirabilis* *Strep. faecalis* 3	*E. coli*, *Prot. mirabilis* *Strep. faecalis* 3	*E. coli*, *Strep. faecalis* 3	*Prov. rettgeri*
3 (0103)	Throat	*Ent. agglomerans* *Ent. cloacae* *Past. multocida* *Acinet. calcoaceticus* var *lwoffi* *Serratia rubidaea*	*Ent. cloacae* *Past. multocida*	*Kleb. oxytoca* *Asp. niger* *E. coli* *Strep. faecalis* 3	*Lactobacillus* sp. *Strep. lactis* *Strep. faecium* 3 (2 strains)
	Cloaca/ intestine	*E. coli* *Strep. faecium* 1 *Strep. faecalis* 2	*E. coli* *Kleb. pneumoniae* *Citro. diversus-levinea*	*Strep. faecalis* 3 CDC group 8 *E. coli*	*Strep. faecalis* 3 *Prov. rettgeri* *E. coli*
4 (0020)	Throat	*S. aureus* *Ent. cloacae* *Past. multocida*	*S. aureus* *Ent. cloacae*	*E. coli* *Asp. niger* *Kleb. oxytoca*	No isolates
	Cloaca/ intestine	*E. coli* *Strep. faecalis* 3 *Strep. faecium durans*	*E. coli* *Strep. faecium durans* *Strep. faecalis* 3	*E. coli*	*Prov. rettgeri* *E. coli* *Strep. faecalis* 3 *Aerococcus* sp.
5 (0097)	Throat	*Ent. sakazaki* *Strep. milleri* *Past. aerogenes* *Ent. cloacae*	*Ent. cloacae* *Strep. milleri*	*S. aureus* *Ent. cloacae* *Strep. faecium*	No isolates
	Cloaca/ intestine	*E. coli* *Ps. putida* *Ent. cloacae*	*E. coli*	*E. coli*	*Kleb. pneumoniae*
6 (0077)	Throat	*Serr. liquefaciens* *Ent. cloacae* *Ps. putida*	*Ent. cloacae*	CDC group VE-1 *Ent. agglomerans* *Ps. fluorescens* *Serratia* sp.	*Asp. niger*
	Cloaca/ intestine	*E. coli* *Yersinia* sp. *(pestis)*	*E. coli* *Yersinia* sp. *(pestis)*	*E. coli* *Strep. faecalis* 3	No isolates

[*] Cloacal swabs were taken when the birds were alive (Samples 1, 2 and 3), intestinal samples at autopsy (Sample 4).

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occurred in the
to *Herpesvirus*

-Leucocytozoon
also detected in
ooper & Peirce

Table 3. *Haematological findings from six captive Pink Pigeons*

Bird no.	Packed cell volume (%)*				Parasites	Other abnormalities
	a	b	c	d		
0077	52	47	47	48	None	None
0061	51	49	52	—	,,	,,
0097	50	46	46	—	,,	,,
0020	50	(33)	40	—	,,	,,
0103	50	45	(39)	52	,,	,,
0118	53	47	(35)	44	,,	,,

* Number in brackets indicate blood partly clotted.

Table 4. *Clinical chemistry results from six captive Pink Pigeons*

Bird no.	Ca (mmol/l)			Mg (mmol/l)			PO_4 (mmol/l)			TP (g/l)		
	a)	b)	c)	a)	b)	c)	a)	b)	c)	a)	b)	c)
0077	0	1·50	2·09	0·36	1·86	0·97	7·5	0	0·39	55·2	117	44·1
0061	1·86	1·80	2·06	0·60	1·74	0·96	1·32	0·84	0·86	93·0	105	42·6
0097	0·66	2·04	2·24	1·54	1·68	1·14	0·55	1·26	0·72	101	91	50·0
0020	1·02	1·86	2·24	1·44	0·90	1·04	1·98	0·12	0·88	73·8	120	50·4
0103	NP	1·58	B	NP	1·62	B	NP	5·16	B	NP	113·4	B
0118	NP	1·74	1·62	NP	0·48	1·23	NP	2·28	2·37	NP	95·4	34·2

Bird no.	Alb (g/l)			Urea (mmol/l)			Glucose (mmol/l)			Globulin (g/l)		
	a)	b)	c)	a)	b)	c)	a)	b)	c)	a)	b)	c)
0077	16·2	45·0	16·6	6·0	3·6	1·7	14·6	7·4	16·1	NP	NP	27·5
0061	22·2	30·6	12·6	1·8	4·2	2·4	13·8	11·0	16·4	NP	NP	30·0
0097	18·7	21·6	16·2	15·4	2·4	2·2	15·8	13·1	14·2	NP	NP	33·8
0020	16·2	27·0	14·4	0	1·8	1·4	7·9	11·6	16·0	NP	NP	35·8
0103	NP	37·2	B	NP	7·2	B	NP	11·0	B	NP	NP	B
0118	NP	21·0	14·3	NP	1·8	5·3	NP	7·9	14·0	NP	NP	19·8

NP = tests not performed. B = sample broken in transport

The bacterial isolates from the birds are of interest. Many of the organisms present are commonly cultured from the throat or gut (or both) of other avian species, including the Domestic Pigeon. Other isolates were potential avian pathogens e.g. *Pasteurella* spp., and the fungi *Aspergillus fumigatus* and *A. niger*. Gram-negative coccobacilli isolated from one bird (0077) were yersiniae and conformed biochemically to *Y. pestis*. The source is unclear; other bacteria of probable rodent origin have been isolated previously from captive Mauritian birds (Cooper *et al.* 1981). The failure to isolate bacteria from some of the birds' intestines *post mortem* cannot be explained: possibly it indicates a sampling or technical error.

The clinical chemical results are difficult to interpret since no previous analyses appear to have been carried out on the blood of the Pink Pigeon. However, comparison of the results with those obtained from two clinically healthy Domestic

sites	Other abnormalities
ne	None
	"
	"
	"
	"

eons

TP (g/l)		
a)	b)	c)
55·2	117	44·1
93·0	105	42·6
101	91	50·0
73·8	120	50·4
NP	113·4	B
NP	95·4	34·2

Globulin (g/l)		
a)	b)	c)
NP	NP	27·5
NP	NP	30·0
NP	NP	33·8
NP	NP	35·8
NP	NP	B
NP	NP	19·8

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healthy Domestic

Table 5. *Serum enzyme results from six captive Pink Pigeons*

Bird no.	SGOT (IU at 30°C)			SGPT (IU at 30°C)			GGT (IU at 30°C)			LDH (IU at 30°C)		
	a)	b)	c)	a)	b)	c)	a)	b)	c)	a)	b)	c)
0077	76·8	157	138	0	0	10·6	15·6	15·6	138·7	666	3434	1412
0061	25·8	123·6	172·8	0	0	15·2	19·2	31·2	32·4	1044	2190	1694
0097	112	47·4	83·2	0	0	13·2	14·3	22·8	74·4	1991	2508	174·2
0020	51·6	171	177·8	0	0	12·2	9·6	52·8	17·4	1680	3150	1224
0103	NP	162	B	NP	0	B	NP	35·4	B	NP	3768	B
0118	NP	135	222	NP	6·6	26	NP	1·2	43·3	NP	1752	1845

NP = tests not performed. B = sample broken in transport.

Pigeons showed many similarities, especially in so far as the figures for calcium, magnesium, urea and SGPT were concerned. Other values tended to be higher in the Pink Pigeons, in particular those for LDH (Domestic Pigeons 735 and 825 IU, Pink Pigeons 66–3768 IU): it may be significant that the birds with the highest LDH values were those that lost most weight in London.

The wide range of some of the Pink Pigeon results may indicate significant individual differences, perhaps suggestive of disease, but may, alternatively, mean that the system of sampling and submission to an outside laboratory should be re-assessed.

Despite the clinical signs exhibited, diagnosis of cerebellar hypoplasia/aplasia in one bird was unexpected. Nothing is known of the cause or heritability of this condition in Pink Pigeons but it is believed to be genetic in origin in poultry (Peckham 1972).

The cause and pathogenesis of the pedal lesions remain unclear. Jones *et al.* (1983) suggested that it may be attributable to a shortening of the flexor tendons but the findings in this study indicate that there is a rotation of the distal tarsometatarsus, rather similar to that described in the carpometacarpals of geese with 'slipped wing' (Kreeger & Walser 1984). The question of the heritability of the condition is also unclear; its high prevalence [10 out of 116 Pink Pigeons (9%) reared beyond 30 days] in such a small captive group suggests that genetic factors may be responsible and it may be a consequence of inbreeding. Other factors cannot be eliminated. High protein diets have been implicated in 'bandy legs' and slipped wings in slow growing captive waterfowl (Kear 1973) and too rapid weight gain in Darwin's Rheas *Pterocnemia pennata* may cause bowed knees (Benirschke 1977). Some of the Rheas also had a condition equivalent to 'club foot' and possibly akin to the inclined feet observed in the Pink Pigeons. Unlike the condition in the latter, the deformity could be corrected by the application of metal splints while the Rheas were still growing. Benirschke postulated that it was caused by too rapid prenatal growth resulting in a positional anomaly from crowding *in ovo*. In Pink Pigeons, however, this condition does not express itself until after the squabs are two weeks old. Careful study is warranted, together with the establishment of a formal studbook. Further work on the pedal abnormality has been carried out at JWPT and confirms the findings described above (Flach & Cooper unpublished).

Other pathological findings were probably of no consequence but the bent keels in three birds may have had a genetic basis. Likewise the presence of microscopic renal lesions in five of the six birds may be significant.

The Pink Pigeon's long-term survival depends upon intensive management

(Jones 1987). It is important that birds bred in captivity are maintained in good health and that every effort is made either to eliminate, or to minimize the effects of, developmental and other disorders. The studies reported in this paper have thrown some light on the latter and have at the same time provided much needed baseline data on the species. It is vital that the Pink Pigeon population continues to be closely monitored.

We acknowledge the support of members of staff of the Royal College of Surgeons of England who helped tend the pigeons and provided valuable technical assistance. Our thanks are due to Dr M.A. Peirce for examining blood smears and to Dr.G.A. Cullen for arranging serological investigations. The assistance and advice of Dr Peter Bloxham are much appreciated. Finally we are indebted to Mr Wahab Owadally, Conservator of Forests, and the Mauritius Government for permitting us to have these pigeons for investigation, and Mr John Hartley of JWPT both for arranging their transportation and for his help and encouragement in our studies.

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SCREENING PROGRAMMES

Screening is an integral part of health monitoring and is intended:

a) to provide information on "healthy" animals as well as those in which disease is present or suspected.

b) to ensure that potentially useful biological data on the species are collected and recorded.

If the screening programmes are to be carried out properly and be of maximum value, sampling must be carried out whenever possible - for example, clinically when animals have to be handled or moved, *post mortem* whenever an animal is found dead or has to be culled. An "opportunistic" approach is needed. In addition, where feasible, clinical screening should be planned and carried out at prescribed intervals.

Further information on screening is to be found in "Diseases and Threatened Birds" (Cooper, 1989): although orientated particularly towards birds, this is applicable to other species.

The following protocols are recommended:-

Clinical Screening (live animals)

Basic

Observation and examination

1) Presence or absence of:

   a. clinical signs of disease
   b. injuries or external lesions
   c. ectoparasites

2) a. bodyweight
   b. measurements
   c. condition score

   } coupled with standard data on sex, age and reproductive status

3) Gross appearance of:

   a. faeces

Laboratory tests

1) Presence or absence of protozoan and metazoan parasites in faeces
2) PCV (haematocrit) and total blood protein
3) Differential blood counts plus presence or absence of parasites or cellular abnormalities in blood smears

Additional investigations, if personnel and facilities permit

1) Bacteriological examination of swabs from:
   a. trachea
   b. rectum/cloaca
2) Blood tests - complete haematology and biochemistry
3) Examination of serum for antibodies (serology)

Whenever possible - and always if an animal is ill - a full clinical examination should be carried out and supporting laboratory tests performed. In this case a standard clinical sheet should be completed.

Figure 1 indicates the different samples which may need to be taken as part of, or at the same time as, clinical screening.

Post-mortem screening (dead animals)

Basic

1) Gross examination:

   a. bodyweight
   b. measurements
   c. condition score

   } coupled with standard data on sex, age and reproductive status

   d. appearance of internal organs
   e. presence or absence of fat
   f. presence or absence of ectoparasites
   g. presence or absence of endoparasites in alimentary or respiratory tract

2) Toxicology - submission or retention (frozen) of carcase or tissues for analysis (eg. for chlorinated hydrocarbon pesticides, heavy metals)

Additional investigations, if personnel and facilities permit

1) Bacteriology:
   a. heart blood
   b. intestinal contents
   c. any significant lesions

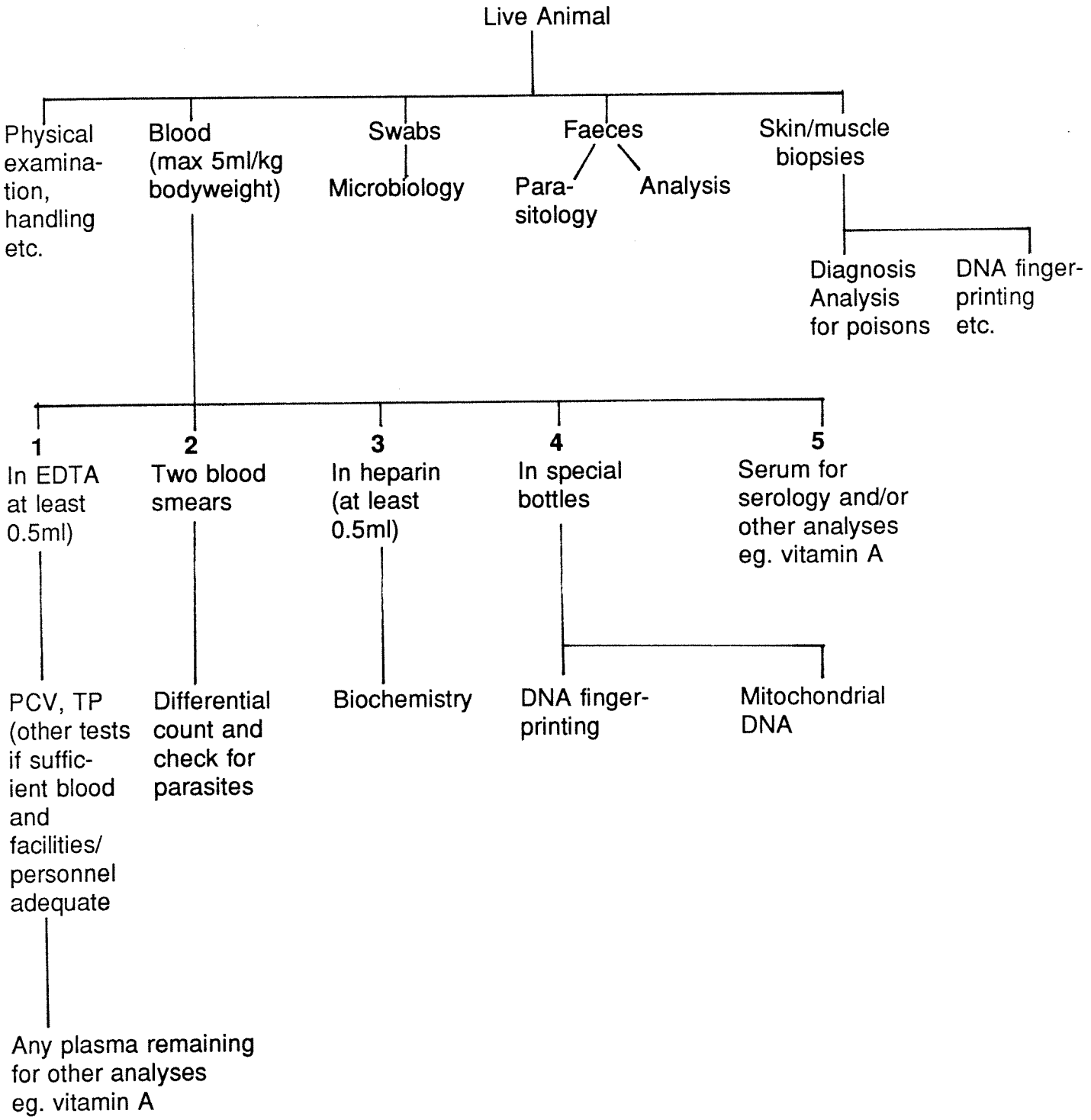
2) Histopathology:
   a. lung
   b. liver
   c. kidney
   d. any significant lesions

3) Other tests - submission or retention (frozen/fixed) of tissues for virology, mycoplasmology, electronmicroscopy etc.

Whenever possible a full *post-mortem* examination should be carried out and supporting laboratory tests performed. In this case a standard *post-mortem* sheet should be completed.

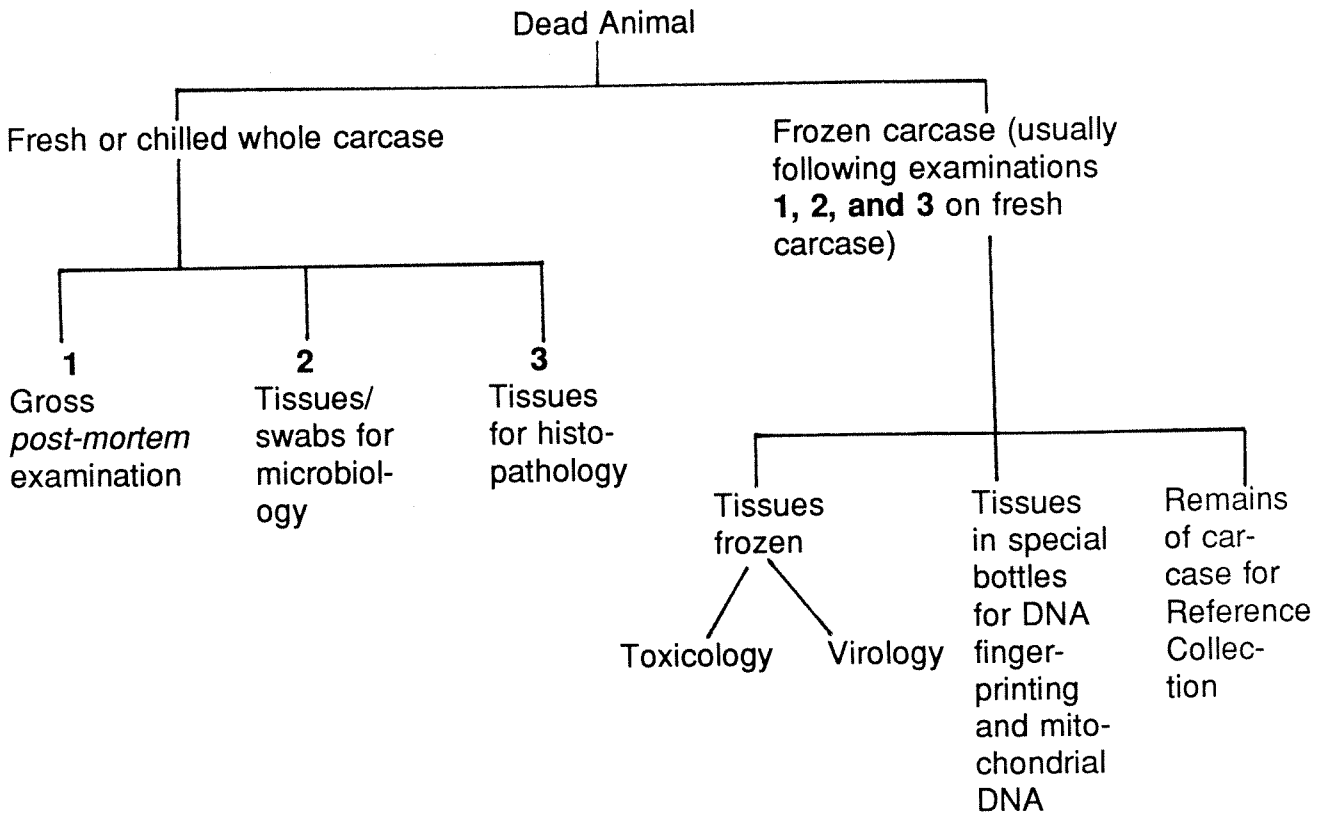
Figure 2 indicates the different samples which may need to be taken as part of, or at the same time as, pathological examination.

Figure 1



Material should be retained for reference whenever feasible - for example, blood smears and parasites. Serum can be stored for subsequent investigation.

Figure 2



Material should be retained for reference whenever feasible. If a Reference Collection exists the carcase should be fixed in formalin or alcohol other than small portions of tissue eg. liver which should be frozen for DNA work.

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J.E. COOPER

REVISED

DISEASE AND CONSERVATION OF THREATENED SPECIES

Report of A Working Group Meeting

28-29 May 1991

National Zoo, Washington, D.C.

Arranged by CBSG/SSC/IUCN in collaboration with AAZPA, AAZV and VSG.

Supported, in part, by a grant from AAZPA

8 October 1991

Introduction

There has arisen, in the captive breeding and the conservation communities, a concern about the risk of diseases acquired in captivity being introduced into wild populations with the release or reintroduction of captive held, and captive-bred wild animals. There is also concern that diseases endemic in wild populations may adversely affect released animals, jeopardizing the entire effort. Disease risks need to be addressed in the planning of any captive breeding - release/translocation program so that appropriate pre- and post-release health monitoring procedures can be developed, thereby reducing the potential on the released and native populations.

Disease, whether induced by viruses, procaryotes, or eucaryotes has long been recognized as an important selective factor in the evolution of all organisms. Mechanisms for recognition and defense against invasion by foreign organisms and mechanisms for the repair of damage are prominent in vertebrates and present in all eucaryotes. The challenges of disease may sometimes be the most powerful evolutionary selection forces acting on all life forms.

A general lack of data or information on (1) the incidence, distribution and risks of disease in captive populations, (2) the distribution and incidence of disease in wild populations, (3) effective quarantine requirements, and (4) detection and monitoring of disease, has resulted in a lack of a working database for informed risk assessment.

In an attempt to clarify the scope of the problem, a disease working group was formed, comprised of representatives from the following affiliations or institutions: American Association of Zoo Veterinarians, Association of Avian Veterinarians, American College of Zoological Medicine, American Association of Zoological Parks and Aquariums, Captive Breeding Specialist Group SSC/IUCN, Center for Reproduction of Endangered Species, Desert Tortoise Recovery Team, IUCN Veterinary Specialist Group, Pathologists, USFWS National Wildlife Health Research Center, University of Washington Veterinary College, Wildlife Disease Association, Zoological Society of London.

This working group meeting defined the following issues and recommended that:

A. Events be defined that may lead to potential situations for disease spread and instances described where disease transmission has occurred between populations. There is a need to fund a short-term project to assemble the literature and anecdotal information on such events

B. Information on disease processes in captive collections needs to be collected in a central location. There is an immediate need to fund the further development of MEDARKS for use by zoos as a standard record system and for a central database

C. Information on disease processes in wild populations needs to be collected on a current basis, assessed and monitored, and maintained in a central location. An agency and mechanisms to accomplish this task need to be identified.

D. Disease diagnosis has a central role in monitoring and assessment. Needs, limitations, current capabilities and future directions of disease diagnosis were outlined. Specific research and development needs were identified to utilize current technology to enhance our diagnostic capabilities

E. Effective quarantine procedures to prevent the spread of diseases between populations is essential. Protocols will need to be developed on a taxon, project, and geographic basis

F. Research resources available to further study disease processes and transmission in exotic species are limited. More resources are needed for targeted research to enhance our knowledge

G. The working group recommended that an international symposium be held to further discuss and explore the issues at hand and to begin drafting preliminary guidelines for the recognition, assessment and long-term monitoring of infectious disease processes and their impact on the conservation of captive and wild populations.

A. Disease Event Categories, Potential Problems, and Examples

1. Zoo to zoo animal movements (local and global) and zoo to private sector and private sector to zoo animal movements
   a. Regulatory inconsistencies of diagnostic screening (e.g. tuberculosis in non-domestic hoofstock)
   b. Lack of uniformity of preshipment procedures and quarantine (e.g. screening for chlamydia, salmonella, parasites; vaccinations and other preventative procedures, etc.)
   c. Lack of adequate transfer of medical records with animal movements (e.g., health certificate and medical history do not always accompany animal)
   d. Disease exposure during transportation (e.g., canids contracting viral diseases during transport; potential exposure during off-loading or zoonotic exposure)
   e. Lack of recognition of specific transmissible diseases in a collection prior to designated SSP moves (e.g., Herpes in many species,FIP, TB, etc.)
   f. Permanent identification of each animal (tattoos, bands or transponders)
   g. Lack of awareness and routine screening for potential hereditary defects and diseases

2. Translocations
   a. Contamination of naive population by infected animals and vice versus. (e.g., Leptospirosis in black rhino)
   b. Lack of recognition of specific transmissible diseases in the old and new environment prior to designated moves (e.g., parasites, canine distemper in black footed ferrets)

c. Appropriate long term monitoring of the health status of both populations
d. See 1a, 1b, 1d, 1f, 1g

3. Supplementation of Wild Populations by translocation of individual animals.
   a. 1f, 1g, 2a, 2b, 2c, 2d.

4. Supplementation of wild populations by utilizing artificial breeding techniques to enhance genetic diversity
   a. Determine health status of gamete donors and recipient
   b. Determine possible diseases transferred by genetic material (e.g., FMD, Brucella, viruses.)
   c. 1f, 1g, 2d

5. Supplementation of wild populations with captive animals
   a. Prior to release, determine health status of the captive animals and the receiving population, and other species (including domestic animals and humans) in the ecosystem (e.g., TB, Pasteurella, lung worms in Arabian Oryx)
   b. 1a, 1d, 1f, 1g, 2a, 2d.

6. Supplementation of captive population with wild populations by utilizing artificial breeding techniques and/or through individual animals
   a. 1f, 1g, 4a, 4b, 5a, 5b, 2d.

7. Introducing captive animals into suitable ecosystems
   a. Predict the disease impact of the animal on the existing resident species (including domestic and humans) and the reverse
   b. 1a, 1b, 1d, 1f, 1g, 2d.

8. Introduction of captive animals to repopulate an historic ecosystem
   a. Prior to release, determine health status of the captive animals and the receiving population, and other species (including domestic animals and humans) in the ecosystem (e.g., meningeal worm in cervids)
   b. 1a, 1b, 1d, 1e, 1f, 1g, 2a, 2c, 2d,

9. Rehabilitation of wild and confiscated individuals with return to the wild habitat, be it at or distant from the original collection point. (Pancake Tortoises, Monk Seals)
   a. 1a, 1b, 1d, 1f, 2a, 5a (e.g. confiscated Pancake Tortoises, Monk Seals)

10. Private sector and agency animal release programs and/or escapes, (including native and non-native species) in their home range or an appropriate or inappropriate ecosystem, (e.g., Desert Tortoises)
a. acknowledgment of our inability to always control and monitor the impact of these events.

11. Research Resources
a. Identify key personnel who have expertise with particular species and/or disease problems.
b. Obtain overviews of research resources from other organizations(e.g. AAZV, ACZM, WDA, AAV, etc.)

B. Lack of Biomedical Data Collection Across Captive Collections

Problem: Critical medical information affecting decisions that concern the movement of animals is currently limited.

1. There are no universally used standardized programs of biomedical data collection (clinical and pathology records) in captive collections. Existing Programs: a. medARKS; b. Individual zoo computerized record keeping system; c. Individual zoo handwritten record keeping systems; d. No medical records or scanty medical records

2. Within existing programs there is limited centralized processing of collected data between institutions. Existing Programs: a. ISIS (clinical pathology, pathology codes); b. Studbooks, SSPs and TAGs; c. AAZV (infectious disease committee.); d. Surveys performed by an individual with a particular disease or species interest

3. Priorities: a. Identification and incidence of infectious diseases that are affecting the living collection; b. Identification and incidence of infectious diseases that are causing mortality in captive collections; c. Standardization of data collection between institutions; d. Centralization of collected data; e. Methods of data availability

4. Recommendations
   a. SSPs and TAGs should have veterinary advisors (medical, pathology)
   b. Gathering of biomedical information should begin with species that have studbooks, SSPs or TAGs
   c. Develop a task force comprised of veterinary advisors, ISIS and medARKS representatives, other knowledgeable groups and individuals to develop a standardized format for data collection, centralization and distribution. This task force should be sanctioned and given high priority and funding by AAZPA in concert with other groups.

C. Collection of Information on the Health of Captive Species

For most endangered species, a centralized medical comparative data base does not exist. Developing an epidemiological data base is the foundation for comparison of disease risks in captive and wild populations, and translocations between and within each. Within the captive community, generation of such a data base should be given top priority and instituted via the following steps:

1. A veterinary advisor should be appointed to each regional captive management plan (e.g., SSPs, EEPs, etc.,). Such advisors should review all mortalities annually, evaluate the incidence of disease in the living population, and make recommendations regarding anesthesia, the prevention and monitoring of disease. Data collection should be standardized. An advisor should identify areas that require further research and assist in the identification of interested researchers and centralized facilities. Cooperation of regional management program veterinary advisors should take place through the auspices of the CBSG, including the distribution of annual regional reports for each species.
   a. CBSG should petition SSP through this report and other means to effect the addition of veterinary advisors to all SSP Committees.
   b. AAZV should also effect a similar petition and assist in the identification of interested veterinarians.

2. For each species, the Veterinary Advisor should supervise the establishment of centralized biomaterial (sera/tissue) banks to aid present and future research. These banks should be established in cooperation with ongoing projects.
   a. Letters of support from CBSG and AAZV as above.
   b. Identification of central funding resources.
   c. Commitment of directors of SSP institutions to make not only funding commitments (e.g., shipment costs of materials to the central banks), but also the manpower commitments for increased participation in such programs on the individual and supervisory levels (e.g., time for veterinarians to coordinate these activities and attend related meetings).

3. Centralized data banks, such as MedARKS should be encouraged, and further effort should be made to design appropriate software for these programs (such as was done with the orangutan medical management survey - similar studies with black lemurs and elephants are in progress).
   a. Encourage more rapid development of MedARKS, in particular, rapid development of the text medical record keeping system that would allow for the evaluation of medical problems in the living population.
   b. request that all medical data be submitted to the regional program Veterinary Advisor in MedARKS format, if not in the program itself.

4. Regional program veterinary coordinators should be included in any review evaluating disease risks in the reintroduction of captive species.

5. Additional contact and cooperation with the private community holding endangered species should be encouraged by:
   a. Identifying private holders that are listed in studbooks.
   b. Veterinary contact with holders of key species.
   c. Contact with private interest groups.
   d. Dissemination of information through lay publications.

D. Wild Population Concerns

All "translocation" activities have the potential to adversely impact wild populations. Generally, there is a paucity of information pertaining to the existence of diseases in a habitat, and if the data does exist it is difficult to assemble. Therefore, before any translocations occur, the following should be considered:

1. There are no universally used standardized programs of biomedical data collection (clinical and pathology records) for wild populations. Existing Programs: a. USFWS National Health Wildlife Laboratory; b. Individual national record keeping system; c. Individual regional, state and local record keeping systems; d. No international databases or systems except for diseases of domestic animals (FAO).

2. Translocation guidelines should apply to all species as resources are available.

3. Governments should identify or assign and agency or individual to serve as a central information source and central repository for disease related information. This office should be responsible for promoting public awareness and distribution of the guidelines.

4. During the planning of a translocation project, all interested parties should be assembled to discuss disease concerns, in relation to the entire project.

5. Disease related questions (handout) should be answered with regard to the prevalence of agents of concern in a habitat and potential impact on endemic species. a. This should be done after review of pertinent literature and diagnostic databases; b. Consideration should be given to undertaking significant specific surveys or monitoring efforts to address unanswered questions.

6. The benefits to the species should be considered with respect to the potential uncontrollable disease risks: a. An individual or agency should be designated to make the final decision.

7. If a decision is made for a translocation, consideration should be given to establish a monitoring program for both the introduced animals, the endemic population and other ecosystem components.

E. Quarantine Considerations for Reintroduction Programs as a Component of an Overall Health Screening Procedure

There is a recognized need and obligation to develop a Model Procedures Manual/Guidebook to address infectious disease-related issues in the release of captive wildlife. This document should include advice on a number of basic procedures including general standards for quarantine and diagnostic test which will probably be applicable at the taxon level, such a document has been started by the AAZPA (attached). It is understood that quarantine is one of several components of an overall health screening procedure to prevent the transfer of infectious diseases to various animals in the ecosystem where the reintroduced animals are released. It should be also recognized that the type and length of a quarantine is dependant upon: 1- species 2- disease concerns 3- facilities available. There are documented situations where a quarantine had a negative effect on the animals (e.g. introduction of Gould's Wild Turkey from Mexico to Arizona where the USDA required quarantine resulted in self-destruction of the bird).

For an effective quarantine the medical advisors must be aware of the infectious diseases of concern for this species and /or diseases that the animals may have been exposed to while in captivity. This information must be derived from a systematic gathering and review of medical and pathology data generated on the species while in captivity. The regulatory and unofficial concerns of the country receiving the animals must also be known and addressed.

The quarantine period will serve as a time to collect and process the necessary samples from these animal to assure their health status and hopefully detect animals who may be incubating or carriers of infectious diseases of concern. The reliability of the testing procedures is a concern of medical advisors and has been addressed elsewhere.

The quarantine process will occur on several levels and may have varied functions at each level. The first level of quarantine occurs at the captive animal's home institution. It may also be necessary to collect the animal at a central location prior to shipment to their final destination and it will be necessary to continue and possibly augment the quarantine procedure. The final area of quarantine will occur in the area of reintroduction where appropriate testing will also occur.

The standards of the quarantine should be guided by the following concepts:

1. Decisions should be made on pre-entry vs post-entry quarantines. Usually both are needed.

2. Quarantines by definition should be all-in/all-out.

3. Quarantines by definition should isolate the animals from known routes of exposure for the primary diseases and parasites of concern, and/or treatments of animals in quarantine should be conducted to remove diseases or parasites.

4. Quarantines must be both general and specific . During the quarantine period, any abnormal health condition must be investigated and documented. In addition, specific testing required to document freedom of disease or parasites in question should be conducted (serology, culture, blood smears, fecals, ectoparasite infections, etc.)

5. Whenever possible, length of pre-entry and post-entry quarantine should be longer than incubation periods of any of the acute infectious diseases or parasites in question.

6. Freedom from a specific disease or parasites in the source population, when adequately documented, should be considered as an acceptable alternative to testing of animals in quarantine when such testing may be overly harmful to the animal or if no testing methods are available.

7. Quarantine standards for translocation of wild species should be formulated with consideration of current standards for the same potential disease problems in domestic animals so that wildlife restoration programs are not burdened with unreasonable restriction.

8. Prior to initiating a quarantine, a decision must be reached regarding the disposition of animals that test positive. In particular, whether entire groups of animals will be disqualified if one animal is positive.

F. Diagnostic Capabilities

1. Summary of the Problem
Limited resources available to evaluate samples and interpretation of the data.

   a. Limited facilities;

b. Lack of a priority list of high risk, low risk and undefined diseases. Define list of realistic goals in terms of disease diagnosis and captive management.
c. Limited diagnostic reagents available for making disease diagnosis.
d. Lack of quality assurance programs at the laboratory level.

2. Solutions

a. For limited facilities
   1) List of currently available labs to do wildlife diagnosis
   2) Support the development of wildlife disease centers with specialty areas.
      a) Reptiles - Florida
      b) Avian - Wisconsin
      c) Cooperation between universities and zoological parks and aquariums - San Diego and Washington State University
   3) Support quality control programs

b. Prepare a priority list through the various SSP groups
c. Improve the quality of diagnostic reagents via biotechnology
d. Standardized list of sample selection via handouts and workshops.
e. Increase the validity of laboratory interpretation by increasing sensitivity and specificity. This increased validity will increase compliance of veterinarians and biologists working with SSP groups.

3. Implementation and Interactions with Other Working Groups

a. Prepare directory of currently available diagnostic laboratories.

b. Recommend use of a letter to be sent to Colleges of Veterinary Medicine inquiring about interest in developing centers for wildlife disease management. Letter also to biotechnology centers stating our needs. Request listing of contact individuals within each institution interested in wildlife disease. Also need to send letter to AVMA.

c. Request the top 5 diseases from each SSP group. Request a report on causes of mortality and morbidity from each SSP group.

d. Bring together individuals involved in wildlife disease/conservation with researchers in biotechnology. This would be best achieved through a meeting.

e. Need to identify a person or persons within each SSP group to develop a handout for collection and handling of biologic specimens for evaluation. This should de done in consultation with a contact person in the lab receiving the samples.

Essentially there would be a brochure for each of the SSP programs developed.

f. Put together a list of papers in the literature that are relevant to the diseases of concern to the SSP groups. Need to keep this file up to date. Needs to be a centralized repository - possibly Minnesota. Needs to be an active computerized file. This file would center on diagnostic tests and infectious diseases.

g. Quality assurance - routine test checks between various laboratories. Need to establish serum and tissue banks for various specimens.

h. Need to send out letter to universities inquiring about existence of various tissue/serum banks.

G. International Symposium

The working group recommended that an International Symposium be held to assemble current and state-of-the-art information on the past, present and future impact of infectious diseases as they relate to the captive management, introduction, reintroduction and supplementation of populations of captive and free-roaming species. There has not been a symposium on these topics for 10 years. One goal of the symposium is to generate guidelines to be used by captive and free ranging wildlife managers in an attempt to minimize the spread of human and captivity induced disease events.

Title: **Implications of Infectious Diseases for Captive Propagation and Reintroduction Programs of Threatened Species.**

Outline of Sessions

0. Introduction to Problem
1. Review of translocations: rationale and types; reintroductions; translocations
2. Historical survey of disease problems associated with releases; Sections on mammals, birds, reptiles, amphibians, freshwater fish, marine vertebrates (fish, reptiles, mammals).
3. Investigation, monitoring and surveillance of disease in captive animals
4. Investigation, monitoring and surveillance of disease in free-ranging animals
5. Interspecies transmission of infectious agents
6. Emerging infectious diseases
7. Future thrusts in diagnostic technology
8. Information and data collection systems
9. Impact of infectious disease on population dynamics

10. Predisposing factors to infectious diseases: genetic, immunologic, nutritional
11. Economic considerations of monitoring and screening programs
12. Vaccination and prevention
13. Government and international interactions
14. Planning and risk assessment for release programs

We have suggestions for session leaders (chair persons). Each session would include a few papers and a discussion period. There would be poster displays and workshops (e.g., informatics, diagnostics).

The suggested symposium sessions originated from the issues identified during the working group. Sessions will expand on these issues by drawing on international experts in a particular field. Proceedings from the symposium will be published in such a manner so that they are universally available to those most in need of the information. This will be accomplished by publishing the proceedings in an internationally recognized journal.

Disease Working Group Meeting Participant List

Mitch Bush
Dept of Animal Health, National Zoo
Washington, D.C. 20008
Ph=202-673-4793; Fax=202-673-4733

Joshua Dein
USFWS National Wildlife Health Research Center
6006 Schroeder Road
Madison, WI 53571
Ph=608-271-4640; FTS=364-5418; Fax=same

Scott Derrickson
NZP Conservation and Research CTR
Front Royal, VA 22630
Ph=703-635-6510; Fax=703-635-6551

Jim Evermann
Dept Vet Clinical Med/Surg
College of Vet Med
Washington State Univ
Pullman, WA 99164
Ph=509-335-9696; Fax=509-335-7424

Elliott Jacobson
J-126,HSC, College of Veterinary Medicine
University of Florida
Gainesville, FL. 32610
Ph=904-392-22; 392-4751; Fax=071-392-3766

James K. Kirkwood
Department of Veterinary Science
Institute of Zoology
Zoological Society of London
Regent's Park, London NW1 4RY
Ph=071-722-3333 ex 870; Fax=071-483-4436

Eric Miller
St. Louis Zoological Park
1 Government Drive
Forest Park
St. Louis, MO 63110
Ph=314-781-0900 ext. 277; Fax=314-647-7969

Dick Montali,
Dept of Pathology, National Zoo
Washington, D.C. 20008
Ph=202-673-4869; Fax=673-4660

Victor Nettles
SCWDS, College Vet. Med
Univ. of Georgia
Athens, GA 30602
Ph=404-542-1741; Fax=404-542-5743

Ulie Seal
CBSG
12101 Johnny Cake Road
Apple Valley, MN 55124
Ph=612-431-9325; Fax=612-432-2757

Michael Worley
CRES, San Diego Zoo
PO Box 551
San Diego, CA 92112
Ph=619-231-1515 ex.l4448; Fax=619-557-3959

Susan K. Wells
Audubon Park Zoo
6500 Magazine St
New Orleans LA 70118
Ph=504-861-5109; Fax=504-866-0819

Peregrine L. Wolff
Minnesota Zoo
13000 Zoo Blvd
Apple Valley, MN 55124
Ph=612-431-9361; Fax=612-432-2757

COLUMBA (NESOENAS) MAYERI

PINK PIGEON

CONSERVATION VIABILITY ASSESSMENT

REPORT

SECTION 9

REFERENCE MATERIALS

PART III

VISITOR'S GAME LICENCE

M. ..... (1) .....
resident at ..... (2) holder of Passport No. .....
of ..... (3) is authorised to hunt game for one month from ..... (4) .....
..... Police Station.

Date .....

..... *Signature of Officer in Charge.*

(1) Name of licensee
(2) Place of residence in Mauritius
(3) Country from which passport was issued
(4) Date of issue of the licence.

SIXTH SCHEDULE

(section 9)

LICENCE FEES

Game Licence—	Rs.	c.
Rodrigues	15	00
Any other part of Mauritius	363	00
Visitor's	50	00

SEVENTH SCHEDULE

(section 15(2))

Common Name	*Scientific Name*
Gecko	Phelsuma guentheri
Gecko	Phelsuma guimbeaui
Mauritius Bulbul (Merle Charpentier) ...	Hypsipetes olivacea
Mauritius Cuckoo Shrike (Merle Cuisiner)	Coquus typicus
Mauritius Fly Catcher (Coq de Bois) ...	Tchitrea bourbonnensis
Mauritius Fody (Oiseau Banane) ...	Foudia rubra
Mauritius Kestrel (Crecerelle) ...	Falco punctatus
Mauritius Parakeet (Grosse Cateau) ...	Psittacula echo
Mauritius Pink Pigeon (Pigeon des Mares)	Nesoenas maveri
Mauritius White Eye (Oiseau Lunette) ...	Zosterops curvirostris
Red Tailed Tropic Bird (Paille en Queue à brins rouges)	Phaston rubricauda
Rodrigues Bat (Chauve Souris) ...	Pteropus rodricensis
Rodrigues Fody (Cardinal Jaune) ...	Foudia flavicans
Rodrigues Warbler (Fauvette) ...	Bebrornis rodericana
Round Island Snake	Bolyeria multicarinata
Round Island Snake	Casarea dussumieri
Serpent Island Skink	Cyrtodactylus serpensinsula
Telfair Skink	Leiolopisma telfeirii
Trinidade Petrel	Pterodroma arminjondana

By Authority: L. CARL ACHILLE, Government Printer, January 1984. 9616/1/84—355

Price: Rs 2.00

THE WILDLIFE ACT 1983

Act No. 33 of 1983

I assent,

D. BURRENCHOBAY
Governor-General

31 October, 1983.

ARRANGEMENT OF SECTIONS

An Act

To amend and consolidate the law relating to game, camarons and shrimps and to make better provision for the protection of wildlife.

ENACTED by the Parliament of Mauritius, as follows—

1. Short title.

This Act may be cited as the Wildlife Act 1983.

2. Interpretation.

In this Act—

"authorised officer" means a public officer entrusted by the Minister with responsibility for carrying out all the functions specified in this Act;

"camaron" means the native freshwater crustacea known as macrobrachium lar, macrobrachium australe or macrobrachium hirtimanus;

"close season", in relation to any game, means a period during which hunting of that game is prohibited;

"game" means the wildlife specified in the First Schedule;

"game licence"—

(a) means a licence authorising its holder to hunt game;

(b) includes a visitor's game licence;

"hunt" includes kill, shoot, trap, capture, disturb or molest;

"marine wildlife" means wildlife living below the surface of the sea;

"Minister" means the Minister to whom responsibility for the subject of wildlife is assigned;

"protected wildlife" means wildlife, other than the game or wildlife specified in the Second Schedule;

"shrimp" means the native freshwater crustacea known as caridina, atrya or ortmannia;

"visitor's game licence" means a licence issued under section 9(4);

"wildlife"—

(a) means an animal living in a wild state;

(b) does not include marine wildlife.

3. Protected wildlife.

(1) Subject to subsection (2), no person shall, except with the written authorisation of the authorised officer—

(a) hunt, rear, have in his possession, purchase, sell or export any protected wildlife; or

(b) export or, subject to section 20, have in his possession any dead protected wildlife or a stuffed specimen of protected wildlife.

(2) Any person may—

(a) capture for the purpose of rearing; or

(b) rear,

any bird specified in the Third Schedule.

4. Birds.

No person shall—

(a) take or destroy the egg or nest of any wild bird other than a bird specified in the Second Schedule;

(b) sell or buy any bird specified in the First Schedule during a close season;

(c) kill or otherwise destroy any bird specified in the Third Schedule.

5. Hunting devices.

(1) Subject to this Act, no person shall—

(a) hunt any wildlife or carry a gun on land owned or occupied by another person except with that other person's consent;

(b) hunt any wildlife by night;

(c) hunt any wildlife by means of—

(i) a drug, poison or a poisoned weapon or bait;

(ii) an explosive;

(iii) fire;

(iv) a firearm capable of firing more than one round at a time;

(v) a missile containing a detonator; or

(vi) a pit.

(2) No person shall—

(a) hunt by means of;

(b) have in his possession;

(c) purchase; or

(d) sell

a snare or gin trap.

6. Hunting of game.

(1) Subject to subsections (2) and (3) and to section 5, no person shall hunt—

(a) any game unless he is the holder of a game licence;

(b) any game specified in the first column of the Fourth Schedule at any time other than during the corresponding period specified in the second column of that Schedule;

(c) game—

(i) from a vehicle; or

(ii) with the aid of artificial light;

(d) deer—

(i) with a firearm of 0.22 or smaller calibre; or

(ii) with a shotgun loaded with leadshot.

(2) The authorised officer may, subject to such conditions as he thinks fit, authorise any person to hunt game for scientific purposes at any time of the year and by any method approved by the authorised officer.

(3)*(a)* Subject to paragraph *(b)*, a person or his agent may hunt any game found straying on any cultivated portion of that person's land or damaging that person's crop.

(b) Where a person, acting under paragraph *(a)* kills any game, he shall forthwith send the carcass to the nearest police station and the police officer in charge of the station shall forward the carcass to a social security officer for disposal.

(4)*(a)* The authorised officer may require the carcass of any game to be marked for identification purposes.

(b) no person shall deface any mark placed on the carcass of game under paragraph *(a)*.

7. Introduction of animals.

Where a bird, insect or other animal specified in the First, Second and Third Schedules is not found on—

(a) the Island of Mauritius;

(b) an island adjacent to the coast of the Island of Mauritius, or

(c) any other island,

no person shall, except with the written authorisation of the authorised officer, introduce that bird, insect or other animal in that island.

8. Camarons and shrimps.

(1) No person shall—

(a) catch or sell any berried female camaron between 1 October of any year and 1 March of the following year;

(b) catch or sell any camaron of less than 8.5 centimetres in length measured from the back of the eye to the tip of the tail;

(c) fish for camarons or shrimps with—

(i) any explosive or poisonous substance;

(ii) the aid of artificial light;

(d) subject to subsection (2), catch any camaron or shrimp in any natural water course except with the written authorisation of the authorised officer.

(2) Subject to subsection (1)*(a)*, *(b)* or*(c)*(i), any person who owns land bordered or crossed by a natural water course, or his agent or any person authorised by him in writing, may catch or fish for, camarons or shrimps—

(a) where the water course borders the land, in the portion of the water course bordering the land up to the middle line;

(b) where the water course crosses the land, in the portion of the water course running across the land.

(3) It shall be a defence for a person charged with the offence of catching a camaron under subsection (1)*(a)* or *(b)* to prove that the camaron was forthwith returned to the water with the least possible injury.

(4) Subject to subsection (1)*(a)* and *(b)*, no person shall sell any camaron or shrimp unless he is the holder of a permit issued by the authorised officer.

9. Licences.

(1) Subject to subsection (4), an application for a game licence shall—

(a) be made to the Commissioner of Police; and

(b) be in the form specified in Part I of the Fifth Schedule.

(2) Subject to section 10, the Commissioner of Police may, on receipt of an application—

(a) in the Island of Mauritius, grant a certificate to the applicant approving the issue of the licence;

(b) in Rodrigues, grant a licence on payment of the fee specified in the Sixth Schedule.

(3) The Accountant-General shall, on production of a certificate issued under subsection (2)*(a)* and on payment of the appropriate fee specified in the Sixth Schedule, grant the licence applied for.

(4)*(a)* A bona fide visitor to Mauritius who is not the holder of a Mauritius passport and who wishes to obtain a visitor's game licence shall make a written application in the form specified in Part II of the Fifth Schedule to a Superintendent of Police.

(b) The Superintendent may, on receipt of an application under paragraph *(c)* and on payment of the appropriate fee specified in the Sixth Schedule, grant on such conditions as he thinks fit a visitor's game licence in the form specified in Part III of the Fifth Schedule.

10. Restrictions.

(1) No licence shall be issued to—

(a) a minor; or

(b) a person who has, within the 5 years preceding the date of the application, been convicted of an offence under this Act or any enactment repealed by section 19.

(2) No game licence shall be issued to a gamekeeper except with his employer's written consent.

11. Transfer of Licences.

(1) Subject to subsection (2), no licence shall be transferable.

(2)*(a)* The Commissioner of Police may, on the application of the employer of a gamekeeper, transfer the game licence of the gamekeeper to another gamekeeper in the service of that employer.

(b) Where a game licence is transferred under paragraph *(a)*, the name of the new gamekeeper shall be endorsed on the licence by the Commissioner of Police.

12. Arrest.

(1) Any person who commits an offence under this Act may be arrested without warrant by the owner or occupier of the land on which the offence is committed or by any agent of the owner or occupier or by any police officer or forest officer.

(2) Any gun, net, gin, snare, tackle or other device or animal produce found in the possession of a person arrested under subsection (1) shall be seized.

(3) The authorised officer may dispose in such manner as he thinks fit any animal produce of a perishable nature seized under subsection (1).

13. Search and entry.

(1) Where a person is seen or found carrying a gun, net, gin, snare. tackle or other device or hunting on any land, a police officer or forest officer may, for the purpose of this Act, enter the land without warrant.

(2) Where a Magistrate is satisfied by information given on oath that there is reasonable ground to believe that an offence under this Act has been or is about to be committed, he may issue a warrant authorising a police officer or forest officer to enter any land or premises and to search for any wildlife unlawfully obtained.

(3) Notwithstanding subsection (2), a police officer not below the rank of sergeant or a forest officer may, where he has reasonable ground to suspect that an offence has been or is likely to be committed under this Act—

(a) enter and search the premises of any person to whom a licence has been issued;

(b) stop and search any vehicle or vessel;

(c) seize any gun, net, gin, snare, tackle or other device used in contravention of this Act.

14. Regulations.

(1) The Minister may make such regulations as he thinks fit for the purposes of this Act.

(2) Any regulations made under subsection (1) may provide for—

(a) the amendment of the Schedules;

(b) the prohibition of the hunting of any game and the carrying of a gun in any specified area.

15. Offences.

(1) Any person who—

(a) shoots on or across any public place, or any path or footway on private premises;

(b) is found with any gun, net, tackle or simliar device, or a dog on any land without the consent of the owner or occupier of the land, and any person found in the company of that person;

(c) on any land of which he is not the owner or occupier—

(i) does any act with the intention of frightening wildlife away from the land; or

(ii) has in his possession carbonic acid, sulphur or any substance or matter likely to frighten game away from the land;

(d) without lawful excuse or reasonable justification has in his possession the carcass or meat of any game during the close season;

(e) digs any pit, hole or excavation for the purpose of capturing game;

(f) has in his possession any wild birds' nest or egg other than that of a bird specified in the Second Schedule;

(g) contravenes any condition of a licence or any authorisation or permit issued under this Act; or

(h) otherwise contravenes this Act or any subsidiary enactment made under this Act,

shall commit an offence.

(2) Any person who commits an offence—

(a) under section 6(1)*(a)* shall, on conviction, be liable to a fine not exceeding Rs 5,000 and imprisonment for a term not exceeding 6 months;

(b) in relation to an animal specified in the Seventh Schedule shall, on conviction, be liable to a fine not exceeding 4000 rupees and to imprisonment for a term not exceeding 2 years;

(c) for which no penalty is specifically provided shall, on conviction, be liable to a fine not exceeding 2000 rupees and to imprisonment for a term not exceeding 12 months.

16. Forfeiture.

The court by which a person is convicted of an offence may order—

(a) the forfeiture to the Crown of any gun, net, gin, snare, tackle or other device and of any animal or animal produce seized under this Act in connection with that offence;

(b) the cancellation of any licence held by that person or of any authorisation or permit granted under this Act to that person.

17. Jurisdiction.

Notwithstanding—

(a) section 114 of the Courts Act; and

(b) section 72 of the District and Intermediate Courts (Criminal Jurisdiction) Act,

a Magistrate shall have jurisdiction to try an offence under this Act and may impose any penalty provided under this Act.

18. Repeal.

The following enactments are repealed—

(a) The Camarons and Shrimps (Protection) Act;

(b) The Game Act;

(c) sections 11(3), 11(4), 15(2), 19 and 49 of the Licences Act;

(d) sections 92 to 94 of, and the Schedule to, the Criminal Code (Supplementary) Act;

(e) Proclamation No. 37 of 1900;

(f) Proclamation No. 20 of 1914;

(g) Proclamation No. 9 of 1967;

(h) Proclamation No. 13 of 1973;

(i) Government Notice No. 140 of 1883;

(j) The Rodrigues Birds Protection Regulations 1923.

19. Consequential amendments.

(1) The Licences Act is amended—

(a) in section 11(5) by deleting the words " licences to shoot game, and ";

(b) in the Second Schedule by deleting item A, items B and C being relettered A and B.

(2) The Rodrigues Licences Regulations 1921 are amended by deleting—

(a) in regulation 8(4), the words " Licences to shoot game, and ";

(b) regulation 26;

(c) paragraph (5) of regulation 36, paragraphs (6) and (7) being renumbered accordingly;

(d) item 6 of Schedule B.

20. Transitional provision.

(1)*(a)* Any person having on his land or premises any pit, hole or excavation by means of which game may be captured shall, within 30 days of the commencement of this Act, fill up the pit, hole or excavation.

(b) Any person who fails to comply with paragraph *(a)* shall commit an offence and shall, on conviction, be liable to a fine not exceeding 2000 rupees and to imprisonment for a term not exceeding 12 months.

(2) Any licence issued under an enactment repealed by section 19 or item A of the Second Schedule to the Licences Act shall be deemed to have been issued under this Act and shall continue in force for the unexpired portion of the period for which it was issued.

(3) Any person who has in his possession any wildlife or a stuffed specimen of wildlife other than that specified in the First, Second and Fourth Schedules, shall, within 3 months of the date of commencement of this Act, make a written application to the authorised officer for a permit.

(4) On receipt of an application under subsection (3), the authorised officer may reject the application or grant it on such conditions as he thinks fit.

(5) Where the authorised officer rejects an application under subsection (4), the applicant shall, on being paid such compensation as the authorised officer thinks fit, surrender the wildlife or the stuffed specimen of the wildlife to the authorised officer.

(6) Any person who feels aggrieved by a decision of the authorised officer under subsection (5) may appeal to the Supreme Court within such time and in such manner as may be provided by rules made by the Supreme Court for the purpose.

21. Commencement.

This Act shall come into operation on a day to be fixed by Proclamation.

Passed in the Legislative Assembly on the twenty-eighth day of October, one thousand nine hundred and eighty-three.

L. RIVALTZ QUENETTE

Acting Clerk of the Legislative Assembly

FIRST SCHEDULE

(sections 2 and 4)

GAME

Common Name	*Scientific Name*
Deer other than fawns (cerfs)	Cervus (rusa) unicolor
Hare (lièvre)	Lepus nigricollis
Partridge (perdrix)	Francolinus spp.
Quail (caille)	Perdicula spp.
Wild guinea fowl (pintade sauvage)	Numeda spp.
Wild pig (cochon marron)	Sus. spp.

SECOND SCHEDULE

(sections 2 and 4)

UNPROTECTED WILDLIFE

Common Name	*Scientific Name*
Bulbul (condé)	Otocompsa jocosa
Caméléon	Agama calotes varsicolor
Couleuvre	Lycodon anlicus

SECOND SCHEDULE—*continued*

Crow (corbeau)	Corvus spp.
Fresh water fish	
House geckos	
Invertebrates, except butterflies ...	Papilio manlius and Euplosa euphon and snail Euglandina rosea
Mongoose	Herpestes griseus
Monkey (jacot)	Macaca irus irus
Mouse (souris)	Mus spp.
Petite Cateau Verte	Psittacula torquata
Rabbit (lapin)	Oryctolagus cuniculus
Rat	Rattus spp.
Schlug schlug (Weaver) (serin de Natal)	Ploceus spilonotus
Shrew	Suncus murinus
Sparrow (moineau)	Passer domesticus
Tenrac (tendrac)	Centetes spp.

THIRD SCHEDULE

(sections 2, 3 and 4)

PROTECTED WILDLIFE WHICH MAY BE CAPTURED AND REARED

Common Name	*Scientific Name*
Barred Ground Dove (Petite Tourterelle)	Geopalia striata
Madagascar Fody (cardinal) ...	Foudia madagascariensis
Madagascar Turtle Dove (Pigeon Ramier)	Steptopelia picturata
Spice Finch (Pingo)	Munia punctulata
Spotted Dove (Grosse Tourterelle à Collier)	Spilopelia chinensis suratensis
Waxbill (Bengali)	Estrilda astrild
Yellow fronted Canary (serin du pays) ...	Serinus mozambicus

FOURTH SCHEDULE

(section 6)

HUNTING SEASON

Deer	From the first Saturday of June to the last Sunday of September
Caille and Perdrix ...	From 2 April to 14 August
Wild guinea fowl ...	From 16 April to 14 September

FIFTH SCHEDULE

(section 9)

PART I

APPLICATION FOR A GAME LICENCE

I ..... (1) ..... (2)

of ..... (3) hereby apply for a game licence for the year ending 31 December 19.....

DESCRIPTION OF APPLICANT

Age .....

Height (tall, short or medium) .....

Complexion .....

Colour of hair .....

Colour of eyes .....

Any distinctive marks .....

I certify that the above declaration is true and correct.

Date ....

Signature of Applicant

I ..... the employer of .....

hereby consent to the grant of a game licence to .....

Date ....(

Signature of Employer

(1) Name of applicant

(2) Profession of applicant

(3) Full address of applicant

(4) Signature of employer (where applicant is a gamekeeper)

PART II

APPLICATION FOR A VISITOR'S GAME LICENCE

I, ... (1) resident at .....

(2) hereby apply for a visitor's game licence.

Nationality .....

Passport No. .....

Place and date of issue .....

Date of arrival in Mauritius .....

Intended date of departure .....

I certify that the above particulars are correct and that I do not intend to sta in Mauritius for more than one month.

..... Police Station.

Date ....

Signature of Applicant

(1) Name of applicant

(2) Place of residence in Mauritius

Price: *Rs 4.00*

THE FORESTS AND RESERVES ACT 1983

Act No. 41 of 1983

I assent,

11 November 1983

D. BURRENCHOBAY
Governor-General

ARRANGEMENT OF SECTIONS

Section

An Act

To amend and consolidate the law relating to forests, reserves and related matters

ENACTED by the Parliament of Mauritius, as follows—

1. Short title.

This Act may be cited as the Forests and Reserves Act 1983.

2. Interpretation.

(1) In this Act—

"authorised officer" means a public officer entrusted by the Ministe with responsibility for carrying out all the functions specifie in this Act;

"base line", in relation to a mountain range, means the lin specified as such in the First Schedule;

"Chief Surveyor" means the Chief Surveyor of the Ministry o Housing, Lands and the Environment;

"Crown lands" includes land vested in the Curator;

"destroy" includes bark, break, burn, bury, cut, fell, saw, uproot;

"district" has the same meaning as in the Local Government Act;

"escarpment" means the bank of a river, rivulet or feeder, the mean slope of which makes an angle of not less than 60 degrees with the horizontal line;

"feeder" means the affluent of a river or rivulet;

"forest land" includes a national forest and all land which is not under cultivation and which is covered by trees;

"forest officer" means any public officer authorised in writing by the authorised officer;

"forest produce" includes bark, charcoal, coral, creeper, earth, fandia, fibres, firewood, fruit, grass, gum, honey, leaves, litter, moss, bird's nest, peat, plants, resin, roots, sand, sap, seeds, spices, stones, trees, wax, withies and any other thing which the Minister may by regulations declare to be forest produce;

"game" has the same meaning as in the Wildlife Act;

"implement" includes any air rifle, bow and arrow, catapult, trap, noose, poison, axe, hatchet, saw or other instrument capable of being used for destroying trees or working timber;

"Minister" means the Minister to whom responsibility for the subject of forests is assigned;

"mountain range"—

(a) means a mountain or mountain range specified in the First Schedule; and

(b) includes the main chain and all spurs pertaining to the system;

"mountain reserve" means land lying between the ridge line and the mountain reserve line on either side of a mountain range;

"mountain reserve line", in relation to a mountain reserve, means, subject to subsection (2), a line situated on the side or slope of the mountain reserve at an altitude which exceeds that of the base line by one-third of the difference of altitude between the ridge line and the base line;

"national forest" means a forest declared as such under section 4;

"nature reserve" means an area specified in the Second Schedule;

"occupier", in relation to immovable property—

(a) means the lessee;

(b) includes a person having possession of the property;

"owner"—

(a) includes a person having a legal interest in immovable property;

(b) does not include an occupier;

"Permanent Secretary" means the Permanent Secretary of the Ministry of Agriculture, Fisheries and Natural Resources;

"protected plant" means a plant or a class of plants specified in the Third Schedule;

"remove" means carry, convey, or take away in any manner;

"reserve" means a mountain, nature, river or road reserve;

"river" means a river specified in the Fourth Schedule;

"river reserve" means—

(a) where there is an escarpment, the land extending from the edge of a watercourse to the top of the escarpment;

(b) where there is no escarpment, the land extending from the edge of a watercourse to a distance measured on the horizontal plane—

(i) in the case of a river, of 16 metres;

(ii) in the case of a rivulet, of 8 metres;

(iii) in the case of a feeder, of 3 metres;

"rivulet" means a rivulet specified in the Fourth Schedule;

"road" has the same meaning as in the Roads Act;

"road reserve" means the land on each side of a road which forms part of the domaine public;

"stream" includes—

(a) any marsh or morass situated on Crown land from which a stream flows;

(b) any marsh or morass not situated on Crown land declared to be a stream by the Minister, by regulations;

"structure" includes fencing;

"tree" includes live or dead timber, shrubs, underwood, brushwood, bamboo, palm, branches, and twigs;

"wood"—

(a) means any tree which has been cut or has fallen down; and

(b) includes any timber or produce derived from a tree.

(2) For the purpose of determining a mountain reserve line—

(a) a point in the ridge line shall have for its corresponding point in the reserve line a point lying in the same vertical plane as the point to be taken in the base for the measurement of altitude;

(b) the line passing through points in the ridge, reserve and base lines shall be the one which has least length in the horizontal projection;

(c) the reserve line shall—

(i) not be a curved line;

(ii) be composed of a series of straight lines following generally the theoretic line and neglecting its smaller sinuosities, drawn so as to ensure that in the whole no additional area is given to the reserve for any one property and that the reserve line is in no case less than 60.96 metres above the base line.

3. Nature Reserves Board.

(1) There is established a Nature Reserves Board which shall advise he Minister—

(a) on any area which, in the opinion of the Board, shall be a nature reserve; and

(b) generally on all matters relating to nature reserves.

(2) The Board shall consist of—

(a) the Permanent Secretary or his representative, who shall be the Chairman; and

(b) not less than 5 nor more than 8 other members appointed by the Minister on such terms and conditions as he thinks fit.

(3) Subject to such directions as the Minister may give, the Board shall egulate its meetings and procedure in such manner as it thinks fit.

4. National Forest.

(1) The Minister may, by regulations—

(a) declare any Crown land which is a forest to be a national forest;

(b) specify the boundaries of every national forest.

(2) Any area declared to be a national forest shall be inalienable and hall not be devoted to any use other than as forest land.

5. Survey of mountain reserves.

(1) The Chief Surveyor may, after giving not less than 10 days' written otice to the owner or occupier of a mountain reserve, by means of a survey etermine the mountain reserve line of a mountain range or the boundary f a mountain reserve.

(2) Notwithstanding section 15 of the Land Surveyors Act, a plan of very survey under subsection (1) shall be made and deposited in the Registry nd endorsed by the Registrar with the date of deposit.

(3) Every plan deposited under subsection (2) shall be open for inspec- on as soon as a notice to that effect is published by the Registrar in the *Gazette* and in three daily newspapers and for 30 days from the last public- tion of the notice.

6. Appeal against survey.

(1) Any person who is dissatisfied with a determination under section 5 hich affects any property of which he is the owner or occupier may, within 0 days of the last publication of a notice under section 5, appeal against the etermination to the Supreme Court within such time and in such manner as ıay be provided by rules made by the Supreme Court for the purpose.

(2) The Supreme Court may, on an appeal under subsection (1), make such order as it thinks fit.

7. Deposit of survey and plan.

(1) The Registrar shall—

(a) within 30 days of the last publication of a notice under section 5; or

(b) where an appeal is made under section 6, on the determination of the appeal,

deposit in the office of the Chief Surveyor, the survey and plan subject to such alterations as may have been ordered, on appeal, by the Supreme Court.

(2) In any proceedings relating to a mountain reserve, a copy of a plan deposited under section 5 and signed by a surveyor, may be received in evidence in lieu of the original plan.

8. Removal of trees and brushwood.

(1) The authorised officer may authorise the owner or occupier of—

(a) a mountain reserve to cut or remove—

(i) dead or dying trees; or

(ii) live trees of small size in coppice, for the purpose of improving the growing stock in the mountain reserve;

(b) a river reserve to cut or remove trees for—

(i) building a bridge;

(ii) making a road or establishing a path;

(iii) obtaining convenient access to a stream;

(iv) replanting the land.

(2) The authorised officer may impose such conditions on the grant of an authorisation under subsection (1) as he thinks fit, including section 8—

(a) to enable forest officers to exercise proper control over the operations;

(b) as to the security to be furnished by the owner or occupier for the payment of expenses incidental to any control exercised under paragraph *(a)*;

(c) concerning the replanting of the land.

(3) The owner of a mountain or river reserve may destroy cuscuta creeper growing on the reserve and may, in the presence and subject to the directions of the authorised officer, lop off the branches of trees where such a course of action is necessary to destroy the cuscuta creeper.

9. Planting of reserves.

Where a mountain or river reserve is—

(a) uncultivated;

(b) cultivated in such manner as to cause soil erosion;

(c) unoccupied and the owner cannot be ascertained,

ıe authorised officer may cause the land to be planted or replanted in such ıanner as he thinks fit.

10. Trees bordering roads.

(1) Except with the written authorisation of the authorised officer, no ɛrson shall destroy a tree on a road reserve.

(2) The authorised officer may, with the written consent of the owner of ınd bordering a road reserve, plant one row of trees along each side of the ɔad reserve in such manner as he thinks fit.

(3) Except with the consent of the owner of the building or land, as the ıse may be, no tree shall be planted within—

(a) 10 metres of a building;

(b) one metre of a boundary between the property of different owners.

(4) *(a)* Subject to paragraph *(b)*, no person shall damage or, except ith the written approval of the authorised officer, cut or remove a tree owing or planted within 2 metres of either side of a road.

(b) Paragraph *(a)* shall not affect the power of a person to cut trees ıder—

(i) the Electricity Act;

(ii) the Public Health Act;

(iii) the Roads Act; and

(iv) the Telephone Act.

11. Destruction of trees in unsurveyed forest.

(1) No person shall destroy a tree on forest land which is—

(a) adjacent to land belonging to or claimed by the Crown;

(b) in the possession of or claimed by the Curator; or

(c) adjacent to a mountain reserve,

ıless the forest land has been surveyed under the Land Surveyors Act and s boundaries, as determined by the survey, are clearly marked out and ɛfined on the spot.

(2) No offence under subsection (1) shall be committed by the owner of ıe land where he cuts or marks trees for the purpose of defining the boun-ıries of the land if—

(a) he has given prior written notice of his intention to the Chief Surveyor; and

(b) no more damage is done to the trees than is necessary for the purpose.

12. Powers of search, seizure and arrest.

(1) Any forest officer or police officer, the Chief Surveyor, the authorised officer, or the owner or occupier of the land on which an offence is committed, may, without warrant, arrest any person found committing an offence under this Act.

(2) Any forest officer or police officer, the Chief Surveyor or the authorised officer may at all reasonable hours enter—

(a) Crown land, forest land or any reserve;

(b) any land adjacent to Crown land, a mountain, nature or river reserve;

(c) any land which it may be necessary to cross in order to reach Crown land, a mountain, nature or river reserve.

(3) Any forest officer or police officer or the owner or occupier of the land, who finds any animal, other than game, on Crown land, a mountain, nature or river reserve may seize and impound the animal.

(4) Any animal seized and impounded under subsection (3) shall be dealt with in the manner specified in section 4 of the Prevention of Cruelty to Animals Act.

(5) The authorised officer or any forest officer may, at all reasonable hours, enter any premises where wood is kept and inspect the premises and the wood found on the premises.

(6) Where in the course of an inspection under subsection (5), the authorised officer or any forest officer has reason to believe that the wood kept on the premises has been obtained in contravention of this Act, he may seize and remove the wood.

(7) Any wood seized under subsection (6) and in respect of which a conviction for an offence under this Act ensues shall be forfeited unless the court, on being satisfied that the wood was obtained or removed from any land, other than Crown land, without the knowledge of the owner or occupier, orders that the wood be returned to the owner or occupier of the land.

(8) Any forest officer or police officer may, for the purposes of this Act, stop any vehicle carrying forest produce and—

(a) where the driver or any person in charge of the vehicle fails to comply with an order given to him by the forest officer or police officer, he shall commit an offence; or

(b) where the forest officer or police officer has reason to believe that an offence is being or has been committed in contravention of this Act with respect to the forest produce carried by the vehicle, he may seize and remove the forest produce.

(9) Any cattle, vehicle, implement, or forest produce found in the possession of any person who contravenes this Act may be seized and taken to a police station and the officer in charge of the station shall retain them at such place as he thinks fit for production in respect of any prosecution for an offence under this Act.

13. Certificate of authorised officer.

In any prosecution for an offence under this Act, a certificate signed by or under the authority of the authorised officer relating to—

(a) the fact that the alleged offence was committed on Crown land, a reserve or a national forest; or

(b) the value of any forest produce or damage caused, shall be evidence of the facts stated in the certificate.

14. Offences.

(1) No person shall—

(a) plant a mountain or river reserve, or cause the reserve to be planted, otherwise than with fruit trees, forest trees or crops approved by the authorised officer;

(b) cultivate a mountain or river reserve otherwise than in accordance with any directions that may be given by the authorised officer;

(c) without the written authority of the authorised officer build any structure on a mountain or river reserve.

(2) No person shall—

(a) without the written authority of the authorised officer or in the case of forest land, the owner—

(i) introduce any article or thing injurious to plant life onto Crown land, forest land or a mountain, river or nature reserve;

(ii) be in possession of a firearm or an implement on Crown land, forest land or a mountain, river or nature reserve;

(iii) depasture any animal or allow any animal to graze on Crown land, forest land or a mountain, river or nature reserve;

(iv) damage, destroy, dig or remove any forest produce on or from Crown land, forest land or any reserve or be in possession of any forest produce so damaged, destroyed, dug or removed;

(v) act negligently or maliciously in a manner which causes or is likely to cause soil erosion;

(b) deposit or throw any rubbish, article or thing of a dangerous or offensive nature on any Crown land or reserve;

(c) introduce any plant or animal into a nature reserve;

(d) light a fire in a nature reserve without the written authority of the authorised officer;

(e) in any way interfere with a nature reserve or damage any feature on a nature reserve;

(f) be in a national forest, between 6 p.m. and 6 a.m.

(g) plant, cultivate or intentionally spread or propagate cuscuta creeper; or

(h) damage or interfere in any way with a protected plant.

(3) Any person who, without the authority of the authorised officer:—

(a) marks any forest produce or affixes on any forest produce a mark used by a forest officer to indicate that the forest produce is the property of Government or that it may be lawfully cut or removed;

(b) alters, obliterates, removes or defaces any stamp, mark, sign or permit used by a forest officer;

(c) alters, obliterates, removes or defaces any stamp, mark or sign appearing on a forest produce;

(d) covers any tree stump on Crown land, forest land, a reserve or a road reserve with brushwood or earth or by any means conceals, destroys or removes a tree stump; or

(e) wears any uniform, badge or other mark issued to be worn by a forest officer,

shall commit an offence.

(4) Any person who contravenes this Act or any subsidiary enactment made under this Act or any direction given by the authorised officer shall commit an offence.

15. Penalties.

(1) Any person who commits an offence for which no penalty is otherwise expressly provided shall, on conviction, be liable to a fine not exceeding 5,000 rupees and to imprisonment for a term not exceeding 24 months.

(2) The Court before which a person is convicted of an offence shall, in addition to any penalty imposed—

(a) order the forfeiture to the Government of—

(i) any article or thing used in connection with the commission of the offence; and

(ii) any forest produce which is the object of the offence;

(b) order the offender to pay 3 times the value of the forest produce in respect of which the offence was committed, or such sum as it thinks fit for the repair of, or as compensation, for damage or loss caused by the commission of the offence;

(c) in the case of a conviction under section 14(1) and (2)*(a)* and *(b)* order the offender to remove, within such time as may be specified by the court—

(i) the plant cultivated or structure built on the mountain or river reserve;

(ii) the article, thing or rubbish introduced, deposited or thrown on the Crown land or reserve.

(3) Any animal, article or thing or forest produce forfeited under this Act shall be disposed of in such manner as the authorised officer thinks fit

(4) Any person who fails to comply with an order made under subsection (2)*(c)* shall commit an offence and shall, on conviction, be liable to a fine not exceeding 5,000 rupees and to imprisonment for a term not exceeding 2 years.

(5) The court before which a person is convicted of an offence under subsection (4) may, in addition to any penalty imposed, authorise the authorised officer to remove the plant, structure, article, thing or rubbish at the expense of the offender.

16. Jurisdiction.

Notwithstanding—

(a) section 114 of the Courts Act; and

(b) section 72 of the District and Intermediate Courts (Criminal Jurisdiction) Act,

a Magistrate shall have jurisdiction to try an offence under this Act and may impose any penalty by this Act.

17. Regulations.

(1) The Minister may make such regulations as he thinks fit for the purposes of this Act.

(2) Any regulation made under subsection (1) may provide for—

(a) the taking of fees;

(b) the amendment of Schedules.

18. Repeal.

The following enactments are repealed—

(a) the Forests and Mountain and River Reserves Act;

(b) the Woods and Forests Act;

(c) the Rodrigues Bois Noir Timber Regulations 1939 ;

(d) the Rodrigues Forests Regulations 1882.

19. Transitional provision.

Where, at the commencement of this Act, any land already under the cultivation of sugar-canes becomes part of a moutnain or river reserves, the Minister may direct that the owner or occupier of the land may, notwithstanding this Act, continue to cultivate the sugar-cane for a period not exceeding 3 years.

20. Commencement.

This Act shall come into operation on a day to be fixed by Proclamation.

Passed in the Legislative Assembly on the seventh day of November, one thousand nine hundred and eighty-three.

L. RIVALTZ QUENETTE

Acting Clerk of the Legislative Assembly

FIRST SCHEDULE

(Section 2)

MOUNTAIN RANGES

1. Port Louis and Calebasses Ranges

These ranges lie in the districts of Port Louis, Moka, Pamplemousses and Flacq and form boundary lines for these districts.

The peaks in these ranges are Mount Ory, Pouce, Pieter Both, Deux Mamelles, de la Découverte and Motte à Thérèse.

The spurs in these ranges are Pailles, Signal, Citadel, Prêtres, Longue, Bonamour and Nicolière.

These ranges shall be deemed to include the mountains Rempart and Pavillon.

The base line of these ranges shall—

(a) in the district of Port Louis, be a horizontal contour line 45.72 metres above mean sea level;

(b) in the other districts, follow the following roads; the Trunk Road from the point to which it crosses St. Louis stream to its junction with the Port Louis to Moka and Grand River South East Road at Mount Ory, then along this road to its junction with the Bois Chéri Road, then along this road to its junction with the Rivière Baptiste Road; along this road to its junction with the Crève Coeur Road near Napoléon Bridge; then along Crève Coeur Road to its junction with the Victoria Road; then along this road to its junction with the Old Calebasses Road; then along the Old Calebasses Road to its junction with the Higginson Road; then along Higginson and Brisée Verdière roads to their junction with the Port Louis—Central Flacq Road; then along that road towards Villebague and following Old Villebague Road to the Pamplemousses Road; then along the Pamplemousses Road to Bazire Bridge on the boundary of the district of Port Louis.

2. Mont Piton

3. Montagne Fayence

4. Montagne Blanche

5. Petit Malabar

6. Grand Malabar

7. Corps de Garde

8. Candos Hill

The base line for the mountain ranges numbered 2 to 8 shall be in each case the nearest surrounding public roads.

9. Rempart

The base line for this range shall follow Rivière Papayes till its junction with Rivière du Rempart; thence following Rivière du Rempart till it meets the Black River Road; then along the Black River Road till this road meets the Tamarin River; thence up the Tamarin River to its source.

FIRST SCHEDULE—*continued*

10. Tamarind and Terre Rouge Ranges

On the sea the base line shall be the Coast Road, commencing at the Tamarind River and ending at Grande Rivière Noire; thence up Grande Rivière Noire to its source on the South side; and up to Tamarin River and its source on the North side. On the East side the base line shall be the public road between Henrietta mill and Tamarind Falls mill.

11. Rivière Noire and Morne Brabant Ranges

The peaks in these ranges are Morne Sec, Rivière Noire, Laporte, Canot and De Fouge.

On the sea side the base line shall follow a horizontal contour line 45.72 metres above mean sea level, from its intersection with the Grande Rivière Noire in the North, in a southerly direction till its intersection with the Baie du Cap River; it shall follow up the main stream of Baie du Cap River above the point where the river is called Baie du Cap; it shall follow the course of the main tributary passing through Chamarel Estate; the remaining base line shall be Grande Rivière Noire and its tributary the Grande Gorges stream.

12. Savanne Range

On the sea side the base line shall follow a horizontal contour line 182.88 metres above mean sea level. After this line running East cuts the course of Savanne River, the base line turning inland shall follow the course of the main stream of this river up to its source. When the horizontal contour line of 152.40 metres running West along the Coast cuts the course of Baie du Cap River it shall turn up that river and follow its course in the same manner as that specified for the Rivière Noire Range.

13. Perruche

The base line shall be a horizontal contour line of the same altitude as the water level of the Mare aux Vacoas.

14. Bambous and Créole Ranges

The peaks of these ranges are Hollandais, Négresse, Bambous and Grand River South East.

The spurs of these ranges are Old Grand Port, Lion and du Diable.

On the sea side between the rivers Créoles and Grand River South East the base line shall be a horizontal contour line 182.88 metres above mean sea level. Thereafter it shall follow the course of the streams of these two rivers.

The reserve line for these ranges shall in no case, however, have a less altitude than 365.76 metres above mean sea level.

15. Lagrave and Chevillard or d'Auvillard Ranges

The peaks of these ranges are Lagrave, La Selle and Table à Perrot.

The base line for these ranges shall be on the Southern side, the Rivière des Créoles and its tributary Eau Bleue to its source and on the Northern side Grand River South East along its course up to its source.

16. Montagne Chaumont

The base line shall be the Plaines Wilhems Road at the thirteenth milestone.

FIRST SCHEDULE—*continued*

17. Montagne Pauline

This mountain is situated in the District of Grand Port near former Cluny Railway Station.

The base line shall be the River Beemanique on the West and South sides, and the River Eau Bleue on the East and North sides.

18. Montagne Dalais

This mountain is situated in the District of Grand Port in the Cent Gaulettes Valley.

The base line shall be the River Eau Bleue and the Rivière des Créoles.

19. Montagne Maurice

This mountain is situated in the District of Flacq. The Grand River South East separates it from Bambou Mountain range.

The base line shall be on the South, Grand River South East and on the West, North and East the nearest public road.

20. Mountain Vernon

This mountain is situated in the District of Grand Port.

The base line shall be on the West and South the River Beemanique, on the East and North the nearest public road.

The altitude of the base line for all mountain ranges shall in no case be less than 45.72 metres above mean sea level.

SECOND SCHEDULE

(Section 2)

NATURE RESERVES

1. **Perrier (1.50 ha.)** — Crown Forest Block No. 52 bounded as follows—

Towards the East by a line on 137.46 metres between stones NR 1 and NR 2.

Towards the South by another line on 36.27 metres starting from stone NR 2 to stone NR 3.

Towards the West by Rivulet Cogliano to stone NR 4.

Towards the North by a road from Chemin Maingo to Crown land de Rauville on 160.63 metres from stone NR 4 to Stone NR 1.

SECOND SCHEDULE—*continued*

2. **Macchabée-Bel Ombre (3.611 ha.)** bounded as follows:—

Towards the North, from stone NR 3 on the summit of Tamarin Range by a line running along the boundary of Crown Lands Saint François and Boucherville on 1070.45 metres to stone ↑ by the remaining portion of Crown Land Mare Longue on 487.68 metres to stone ↑ 4, by Crown Land Quessy on 1356.35 metres up stone ↑ 5 by the remaining portion of Crown Land Sainfray a straight line running in a southerly direction on 765.96 metres up to stone NR 1, by the southern boundary of Crown Land Sainfray on 570.28 metres up to stone NR 2; thence by a straight line across Crown Lands Florin, Desgranges and Laing up to its junction with two forest roads, then by another forest road running in an easterly direction to "Les Mares" Branch Road on a developed length of 868.67 metres.

Towards the East by "Les Mares" Branch Road on a developed length of 251.46 metres up to feeder Pêche, thence by feeder Pêche up to stone NR 7, thence by the surplus of Crown Land Maudave (Terrain Raoul) on a straight line of 894.27 metres measured between stone NR 7 and NR 1 near River du Poste, thence along River du Poste up to its junction with Grand Bassin Road, along Grand Bassin Road up to its junction with "Les Mares" Branch Road on 928.71 metres, along "Les Mares" Branch Road up to its junction with boundary line separating the District of Plaines Wilhems and Savanne and thence along this boundary line up to Government boundary stone ↑ 35, at the summit of the Black River Gorges, thence along a straight line running between stone ↑ 35 and ↑ 31, thence by Crown Land Les Mares on a line broken into five parts measuring respectively 761.99 metres between stone ↑ 31 and stone ↑ 32, 1052.15 metres between stone ↑ 32 and stone ↑ 33, 135.63 metres between stone ↑ 33 and stone ↑ 25, 149.35 metres between stone ↑ 25 and stone ↑ 24, 789.12 metres from stone ↑ 24 to the crest of Mt. Cocotte.

Towards the South by the crest of Mt. Cocotte up to stone ↑ 26 thence along Mountain Reserves Bolgerd on a line broken into three parts measuring respectively 769.51 metres between stone ↑ 26 to stone ↑ 27, 227.07 metres between stone ↑ 27 to stone ↑ 28, 2047.61 metres between stone ↑ 28 to stone ↑ 29 (stone WF 73), thence by the property of Bel Ombre Sugar Estate on a line broken into two parts measuring respectively 822.03 metres from stone WF 73 to stone WF 74 and 1095.94 metres from stone WF 74 to stone WF 75, thence along Rivulet Jacobie up to stone WF 59, thence again by the property of Bel Ombre S.E. on a line broken into two parts measuring respectively 1874.18 metres between stone WF 59 and stone WF 60 and 2132.07 metres between stone WF 60 and stone WF 61.

Towards the West by privately owned land (Abondance Estate) on a line broken into two parts measuring 717.79 metres between stone WF 61 and stone WF 62, 558.69 metres between stone WF 62 and stone WF 63, thence partly by Abondance Estate and partly by Crown Land Fantaisie on a line broken into two parts measuring 633.97 metres between stone WF 63 and stone WF 64, and 1362.43 metres between stone WF 64 and stone WF 65, thence by the property of Bel Ombre S.E. on a line broken into five parts measuring respectively 574.84 metres from stones WF 65 to WF 66, 564.48 metres from stones WF 66 to WF 67, 1014.66 metres from stone WF 67 to

SECOND SCHEDULE—*continued*

WF 68, 316.99 metres from stones WF 68 to WF 69, 231.64 metres fro stones WF 69 to WF 70, thence along the boundary of Crown Land Coin d Mouchoir on 934.80 metres between stones WF 70 and WF 71, thence b Crown Land St. Denis on 720.23 metres up to stone WF 72, thence along th boundary separating Crown Lands Mesliers and St. Denis up to its junctio with Ligne Buguth, thence along Ligne Buguth in a westerly direction up t Black River Escarpment. Thence along the top of Black River Escarpme to its intersection with a straight line running through the top of Macchabé and Brise Fer spurs and thence by a straight line to stone NR 3.

3. **Corps de Garde (90.33 ha.)** — Crown Forest Block No. 211 bounded a follows:—

Towards the North and East by the crest of the mountain.

Towards the South by the crest of the mountain.

Towards the West by Canal La Ferme and by Crown Land La Ferme o a line broken into 14 parts measuring respectively from the Canal 60.96 metre to stone MRL 4, 320.95 metres to stone MRL 5, 189.89 metres to stone MRI 6, 139.60 metres to stone MRL 7. 173.43 metres to stone MRL 8, 171.9 metres to stone MRL 9, 408.12 metres to stone MRL 10, 172.51 metres t stone MRL 11, 196.90 metres to stone MRL 12, 209.70 metres to stone MRI 13, 240.18 metres to stone MRL 14, 164.89 metres to stone MRL 15, 232.2 metres to stone MRL 16 and 380.99 metres to stone MRL 17.

4. **Pouce (68.80 ha.)** — Crown Forest Block No. 1555 bounded as follows:—

Towards the North by a mountain spur.

Towards the East by the crest of the Pouce Mountain.

Towards the South by another mountain spur.

Towards the West by a line measuring about 1447.77 metres from one spu to the other.

5. **Cabinet (17.73 ha.)** — Crown Forest Block No. 60 bounded as follows:—

Towards the East by Le Cabinet belonging to the Central Electricity Board on a line broken into two parts measuring respectively 457.19 metres and 480.3(metres.

Towards the South by land of the Central Electricity Board on a line broke into four parts measuring respectively 96.01 metres, 129.84 metres, 120.4(metres and 71.93 metres.

Towards the North and West by Crown Land and lands belonging to the Centra Electricity Board on a line broken into three parts measuring respectivel 49.07 metres, 760.15 metres and 350.51 metres.

SECOND SCHEDULE—*continued*

6. Combo (206.84 ha.) — bounded as follows:—

Towards the North — by surplus of Crown Land Combo on a line starting from the crest line of Savanne Range and running along an existing path and along a road to the escarpment of River Savanne, thence in a straight line running in a North easterly direction to River Savanne.

Towards the East — by River Savanne from the above-mentioned point down to its junction with the Southern boundary of Crown Land Combo at stone 54.

Towards the South — by private property (Surinam Estate) in a straight line from stone 54 to stone 55 on the crest line of Savanne Range.

Towards the West — by private property on a line running along the crest line of Savanne Range from stone 55 to the starting point.

7. Les Mares (5.10 ha.) — (Part of Crown Land Les Mares and part of Crown Land Gouly Père) bounded as follows:—

Towards the North — by the surplus of Crown Lands "Les Mares" and "Gouly Père"; a forest road between, on a developed length of one thousand and seventy two feet or 326.7 metres.

Towards the East — by the surplus of Crown Land "Gouly Père" on a straight line measuring four hundred and ten feet or 124.9 metres.

Towards the South — again by the surplus of Crown Lands "Les Mares" and "Gouly Père" on a straight line measuring seven hundred and sixty seven feet or 233.7 metres and

Towards the West — by the surplus of Crown Land "Les Mares" on a line broken into three parts measuring respectively three hundred and sixty eight feet or 112.1 metres, eighty eight feet or 26.8 metres and three hundred and fifty five feet or 108.2 metres.

8. Gouly Père (10.95 ha.) — (Part of Crown Land Gouly Père and part of Crown Land Declerc) bounded as follows:—

Towards the North — by the surplus of Crown Land "Gouly Père", a forest road between, on a developed length of one thousand three hundred and eighty one feet or 420.9 metres.

Towards the East — again by the surplus of Crown Lands "Gouly Père" and "Declerc", a forest road between, on a developed length of six hundred and eighty nine feet or 210.0 metres.

Towards the South — by the sinuosities of a water course (an affluent of Rivulet des Chevrettes) and

Towards the West — by part of the boundary line separating Crown Land "Declerc" from Crown Land "Gouly Père" on a length of ninety five feet or 28.9 metres and also on a straight line measuring six hundred and seventy six feet or 206.0 metres.

SECOND SCHEDULE—*continued*

9. Bois Sec (5.91 ha.) bounded as follows:—

Towards the North — from a point situated at the intersection of the ridge of Bois Sec Mountain and the straight line joining stones WF 50 and WF 51 along the ridge of Bois Sec Mountain on a developed length of 600.45 metres to a stone marked M.R.L.

Towards the East — by a straight line measuring 168 feet or 51.21 metres.

Towards the South — by seven straight lines measuring respectively 60.04 metres, 84.43 metres, 174.04 metres, 53.03 metres, 81.69 metres, 122.53 metres and 48.16 metres.

Towards the West — by a straight line measuring 60.96 metres.

10. Ile Ronde.

11. Ilot Gabriel.

12. Ile Plate.

13. Coin de Mire.

14. Ilot Marianne.

15. Ile aux Aigrettes.

16. Ile aux Cocos.

17. Ile aux Sables.

18. Ile aux Serpents.

THIRD SCHEDULE

(Section 2)

PROTECTED PLANTS

1. All indigenous orchids (Orchidées)
2. *Ochna mauritiana* (Bouquet banané)
3. *Hornea mauritiana* (Arbre à l'Huile)
4. All *Diospyros* species (Ebène)
5. *Sideroxylon grandiflorum*
6. *Cordyline mauritiana*
7. All *Tambourissa* species (Bois tambour)
8. All *Trochetia* species (Boucles d'Oreilles)
9. *Erythroxylon laurifolium* (Bois de ronde)
10. All indigenous ferns (Fougères)

FOURTH SCHEDULE

(Section 2)

RIVERS AND RIVULETS

Plaines Wilhems

Rivers	*Rivulets*
Grand River N.W. Terre Rouge:	
Couacaud	Isnard; Quirin
Des Plaines Wilhems; (below the bridge at Highlands S.E.);	
Du Mesnil (below Abbé de la Caille Street)	Ducray (from boundary of Highlands and Trianon).
	Du Mesnil (below junction of Feeders du Mesnil I and II; Pasquet).
Seche (below junction of Rivulet Poule d'Eau)	Sèche (below Crown Land Joachim)
	Gros Cerf
	Poule d'Eau, Lamy
Du Rempart (below junction of River Cogliano)	
Papayes (below junction of Feeder Good End)	Perichon
Cogliano	Sèche (du Rempart)
	Grand Tatamaka; Petit Tatamaka
	St. Martin
Tamarin	Séligné; Cap Martin
Bambous	Rouge; Pavé
Des Aigrettes	Legoff; Augustin; Gros Piquet; Bigaignon; Cresson
Eau Bleue (8 metres reserves in underground course on Eau Bleue and Cluny Estates)	Osterlog; Mc Gregor (below junction of Feeder Boule)
	Sènèque
Rivière du Poste (Savanne) ...	R. Casse Couteaux
Rivière Citron	
Bois Martin (down the bridge at Highlands S.E.)	

PAMPLEMOUSSES AND RIVIÈRE DU REMPART

Labourdonnais (below junction Rivulet Ripailles);	Crève Coeur; Rivalland; Ripailles, Labourdonnais
Des Calebasses	Boulingrin
Rose (below junction Rivulet Duhamel)	Duhamel (below junction Feeder Les Mariannes)
	Rose
	Villebague; Bocquée (below Feeder junction Hawoldar) Congomat (below junction Feeder Champion)

FOURTH SCHEDULE—*continued*

Rivers	*Rivulets*
Pamplemousses or Citrons (from Arsenal Bridge to the sea)	Citron (from Reilly Dyke to Arsenal bridge); Constance; Pamplemousses
Du Rempart	Praslin; California; Nicolière.
	Jamblon; Chevrettes (Coquinbourg); Chevrettes (Mon Songe).
Eau Blanche	
Figet	Figet (between the two dykes of Ile d'Ambre).
	FLACQ
Coignard, Du Poste de Flacq ...	R. Cere (has 8 metres reserves from Bassin Lou-Loup (Union Regnard) to upper boundary of Bonne Mère Estate).
	St. Louis; Pondard (From source to the crossing of its water course by the La Nicolière Feeder channel) — La Pluie; Thorel (Junction of Feeder Marianina).
Françoise (below Cascade Praude)	Bon Espoir (below Tramway bridge on Belle Vue Estate); Grande Barbe; Pont Blanc or Beau Bois; Francoise (below Terre Coupée Bridge).
	Sèche of Flacq.
Grand River South East ...	Profond;
	St Louis.
Profonde (below Cascade Bœufs on Etoile Estate)	Camaron (below Dyke); La Louise De la Hogue (below Cascade); Profonde (from Source at Petits Paquets to Cascade Bœufs).
	Chevrettes (on Olivia Estate).
	St Martin.
	Terre Rouge; Grand Fond.
Rivière du Rempart ...	R. Jamblong
Rivière du Bois	R. La Digue.
	R. Eau Rouge
	R. Pastourel.
	R. Bois de Natte.
Rivière Boucan or Françoise ...	R. Maurice (below Feeder l'Hopital).

FOURTH SCHEDULE—*continued*

Rivers	*Rivulets*
	MOKA
Du Boucan or Françoise (below Cascade on Melrose Estate)	Maurice (below junction Feeder l'Hopital).
	Françoise (above Cascade on Melrose Estate). } Clément; St. Martin (five metres on Colin property); Jacquart (five metres on Colin property).
	Blanc (on Sans Souci Estate);
Vacoas (on Sans Souci Estate) ...	Bois Clair (below Tramway Bridge);
Du Rempart; Chevrettes; Pharla...	Camarons
Du Bois (on Sans Souci Estate) ...	Pastourel; l'Eau Rouge; La Digue; Train (Midland).
	Cimetière (below Feeder Tarnousky).
	Longouze
	Bois de Natte; Marron
	Midlands; Citron Midlands.
	Pothier
Betty (below junction R. Mare Brune)	Ravanal Dimanche, Mare Hildwert, Mare Brune; Cascade (below Junction of F. Dénudé) (Midlands Estate).
Doudy at Midlands (below junction of Rivulet Planche)	Doudy (above junction Planche); Mandaing.
Francisque; Twinam (flowing in Crown Land); Plateau (flowing in Crown Land).	
Grand River South East ...	R. St Louis (below brigde on Moka Road). R. Pitot Pondard (from source to Goorah's property)
Grand River North West (Moka Balmano)	Chaillet; Agrément. Balmano; Baptiste (junction F. Charlot) Ripailles; Cresson (below Crève Coeur road).
Grand River North West (from junction Terre Rouge and Plaines Wilhems).	Profonde (above Alma Reservoir).
Profonde (below Alma Reservoir).	
Grand River North West, Terre Rouge	
Cascade	Canet (below Mon Désert Reservoir); Dickson; Mare Bouillie (junction F. Desvaux); Pont Bon Dieu (below Valetta Road).

FOURTH SCHEDULE—*continued*

Rivers	*Rivulets*
Tatamaka (below junction Rivulet Magrapoule)	Tatamaka; Magrapoule, Magando; Simathe (below junction F. Assurance)
Aubert (junction F. Charly) ...	Aubert
Terre Rouge	François (below junction F. Pendu)
Monplé (junction R. Monple) ...	Edgar (junction F. Jumelle); Monplé; Hermitage. La Scierie (on Belle Rive Estate, Moka)
	GRAND PORT
	Bambous
	Anse Jonchée
Nyon (on Ferney Estate) ...	Grand Fond
River Champagne, (Le Vallon Estate, Grand Port)	Malgache; Therèse (Junction F. La Hache); Terre Rouge; Grosses Feuilles or Dubois. Des Délices. Tranquille (below Mare Chicose Bridge); Michel (junction F. Sans Souci); Dalais.
River des Créoles	At Cent Gaulettes } Cochon (Junction F. Séjourné) Baptiste (Junction F. Michel)
Gros Ruisseau (St Hubert Rivulet)	Clair; Hareeman. Betty (St. Hubert).
River des Créoles (up to Junction Grande Cressonnière thence River Eau Bleue)	Lovard (junction F. Victor) Bergicourt; Tombeau Gabriel on le Val Estate (Cent Gaulettes) } Perrot G. Duval Phaeton Grande Cressonnière } Petite Cressonnière, Jupiter
Eau Bleue (16 metres reserves from source; 8 metres for underground course Eau Bleue (Gluny Estate).	Osterlog; Mc Gregor (below junction of F. Boulle); Sènèque
River La Chaux	Copeaux; Beau Désert
Bee Varangue	Cascade
Bee Manique	St. Martin (below junction F. du Rempart; Clair de la Pompe (below junction F. Marron) } Mapou (junction F. Shunting)
	Terre Glaise (below junction Eau Bleue); Gr Ruisseau

FOURTH SCHEDULE—*continued*

Rivers	*Rivulets*
Tabac (below main road of Escalier Village)	Tabac
Du Poste (de la Savanne); Citron (Grand Port)	Panier; Daniel; Victoire; Morel. Casse Couteaux (on Nouvelle France Estate) } Canonade Theriau; Latour; Matangue (Savanne).
	SAVANNE
St Amand (below main road to Savannah, Dragon (below junction Feeder Champac)	St Amand Dragon.
Dragon (below junction F. Champac Grand Savanne)	Sevelit; Bon Accueil (junction F. Arnousse).
River des Anguilles	Songe (junction Rt. Dupont);
Songe (junction Rt. Bour) ...	Bohler (junction F. St. Leger); Bour; Pellegrin (junction F. Renaud)
Pipe	De Gaye (junction F. l'Hopital); Pipe (junction F. Nadal)
Gros Ruisseau (junction Feeder Augustin)	Parc; Marron; Gros Ruisseau; Beau Bois (below junction F. Enterrement)
Bain des Négresses (Grande Savanne)	Bain des Négresses (Source to Terre Coupée); Combo
River de la Savanne; Des Chevrettes; Patates	Palmiste
Palmiste (below junction F. Hillcock)	Hippolyte; Songe Blanc (below junction F. Beewa); Faduilhe (below junction F. Fontaine)
	Michel (below Calimaye)
River des Gallets, Fayd'herbe (below junction Rivulet Jacquot)	Fayd'herbe; Jacquot.
La Forêt (below junction F. L'Esport); Mme Bell	La Forêt (below junction F. Verdale) Alexandre (below junction F. Vanille) Antoine (below junction Tendrac) Ruche, Ste Marie (below junction Caza).
Jacotet (below junction River Chérie)	Jacotet (above junction R. Chérie); Jacobie
Chérie	Chevalier
Citronnier (below junction of F. Chapeau)	Citronniers
	Poulailler (below junction of F. L'Etang); Des Créoles (below junction Bois Carré); Ignace

FOURTH SCHEDULE—*continued*

Rivers	*Rivulets*
Rivière du Poste (Savanne) ...	R. Panier R. Daniel R. Victoria R. Casse Couteaux
Rivière Baie du Cap ...	R. Minguel
Rivière Canal (below feeder junction Mapou)	R. Canal
Rivière St. Denis (below junction Rivière Pont Cassé)	R. Catherine R. Pont Cassé R. St. Denis
	BLACK RIVER
	Lavilléon (below F. Anguilles)
River St. Denis (below junction Rivulet Pont Carré)	Lousteau (below junction F. Ruche) } Caverne Tabac (below junction F. Mouna)
Viande Salée (below junction Rivulet Vally)	Cachette (below junction Perline); Vally (below junction Avoine); Viande Salée } Plaine Verte St. Felix
St. Denis (below junction Pont Cassé)	Nourrice (below junction F. Darrick); Pèche (below junction F. Natte); Vanille (below junction Vanillon)
Nourrice (below junction Rivulet Pèche)	St. Patrice Petite Rivière Noire (below Cascade Minguel)
Grande Rivière Noire ...	Petites Gorges (below Bassin Déjeuner)
Tamarin	Boucan (from a point 600 metres below la Coupée Main Road)
Des Gallets	
Dragon ... ... Sèche	Rivulet Ignace
Belle Isle...	Eau Bonne; Vaudagne
Belle Eau	Cabots
	PORT LOUIS
Grand River North West ...	St. Louis; Pitot Latanier (Vallée des Prêtres). Terre Rouge.
"Pouce Stream"	Tranquebar (exclusive of canalised part)

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Report on the Feasibility of Introducing the Mauritius Kestrel Falco punctatus and the Pink Pigeon Columba mayeri to Réunion Island, Indian Ocean.

by

Carl G. Jones[1], Tom J. Cade[2] and Wendy Strahm[3]

I. Introduction: Statement of the Problem and Situation

The Mauritius Kestrel Falco punctatus is a small, forest-adapted falcon (Jones 1987). The current (early 1988) total population consists of about 48 birds in the field (8 territorial pairs, about 10 non-breeders one or more years old, and 22-23 juveniles including captive produced and released birds) and 28 birds held in confinement for propagation. These figures represent an encouraging trend up from the two wild and one captive pairs known to exist in 1974-75 (Temple 1977).

The Pink Pigeon Columba mayeri has had a small population for over a century and the low population is due to habitat destruction and fragmentation (Jones, 1987). Today the truly wild population numbers about 20 individuals plus about another 10 released birds. There are over one hundred captive birds which have all been derived from eleven wild caught individuals.

The increase in the numbers of both species attests to the effectiveness of captive breeding and "hands on" management of endangered species.

Unfortunately on Mauritius very little habitat suited to the existence of the kestrels and pigeons remains. For the kestrel this is perhaps 800 hectares of degraded native forest in the Black River Gorges, Bambous Mountains, and a few other isolated patches. These areas may provide room for no more than 20-25 pairs in territories that can support reproduction sufficient to replace losses in the adult breeding population over an extended period of years.

Similarly there is little habitat available for Pink Pigeons, perhaps 600-700 hectares of degraded native forest around the Black River Gorges that may, with supplemental feeding, support a population of 40-60 birds at most. There may be other areas on Mauritius where the pigeon could live but only with sustained feeding and management.

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[1]Jersey Wildlife Preservation Trust Representative, Forestry Quarters, Black River, Mauritius.

[2]World Centre for Birds of Prey, West Flying Hawk Lane, Boise, Idaho, USA.

[3]WWF/IUCN Project Leader, Forestry Quarters, Black River, Mauritius.

Captive reproduction of kestrels and pigeons has proved successful, and since 1984, 50 kestrel chicks have been reared, sufficient numbers to make significant reintroduction and restocking possible (Cade 1986). Since 1976 over 200 Pink Pigeons have been reared on Mauritius. However, even if captive-raised kestrels and pigeons can become adjusted to modified forest or to exotic plantations, there will remain definite limits on the possible increase in distribution and numbers of these species on the island of Mauritius. Since these are the two main requisites for long term preservation of endangered species in nature, there is a need to find a suitable place to introduce kestrels and pigeons elsewhere.

Réunion has been suggested as a possibility by several researchers, owing to its proximity and general ecological similarity to Mauritius (Cade 1982, Cheke 1975, Temple 1981, Jones and Owadally 1985). Currently there is no kestrel or small falcon on Réunion, although historically there was a very similar species or subspecies, which Dubois (1674) called a "merlin" but which recently discovered sub-fossil bones reveal to be a kestrel (Cowles 1987). Similarly there is no arboreal pigeon although on pristine Réunion there was a closely related, if not identical species. It seems reasonable to consider whether or not the Mauritius Kestrel and Pink Pigeon can occupy the currently vacant niche of the Réunion falcon and arboreal pigeon in a way that would be ecologically compatible with the other species. In fact, the former existence of a Kestrel and a "Pink" Pigeon on Réunion raises the question whether their release there would constitute the introduction of "exotic species" or the reintroduction of new populations of extirpated species.

The question is only academic now because the biota and environment of Réunion are drastically different than in pristine times when the island had its own kestrel and "Pink" Pigeon population. The numerous extinctions of indigenous animals and plants, massive forest degradation and conversion to agricultural crops, and exotic plant and animal introductions have combined to produce a new ecological setting with different and probably simpler and less stable relationships among the coexisting species than formerly was the case. Now the relevant questions are:

1) Do the present ecological conditions on Réunion provide adequate opportunities for populations of Falco punctatus and Columba mayeri to become established and self-maintaining; and

2) What impacts would a population of Mauritius Kestrels and Pink Pigeons have on other species on Réunion?

Visits to Réunion

We made excursions to Réunion in 1986 and 1988 to identify specific topics of concern that require additional investigation in order to answer these two main questions satisfactorily. During 22-30 March

1986, Jones and Strahm made an exploratory visit to Réunion. From 2-9 January 1988, Jones, Strahm and Cade visited various parts of the island, and from 15-20 April, 1988 Strahm returned to the island with Jeff Sayer, IUCN Tropical Forest Programme Director.
During these visits we travelled all over the island. The following sites, with a brief description, were the main vegetation types examined during our visits.

Plaine des Chicots We walked to the Plaine des Chicots from Le Brûlé, passing through humid mid-temperature native forest. This forest and its environs is the only place where the highly endangered Réunion cuckoo shrike Coracina newtoni is found and we were fortunate to see one male. Along the path are stands of the endemic Acacia heterophylla which is used in forestry plantations. The endemic bamboo Nastus borbonicus is also common here. This forest is rich in orchids and many interesting endemics, although degraded by Hedychium coccineum and Fuschia spp. Tree species such as Nuxia verticillata and Aphloia theiformis, favoured food of Pink Pigeons on Mauritius, are common. What is striking is the great number of tree ferns Cyathea spp. present in this vegetation type. On Mauritius tree ferns are rare, partly due to poaching, but more importantly, because the monkey (Macaca fascicularis) eats them. Monkeys are not yet wild on Réunion although there are many captive animals. This area is managed as a hunting reserve and unfortunately deer Cervus timorensis from Mauritius, which cause great damage to native plants, have recently been introduced.

Forêt de Bébour/Bélouve These forests are very interesting areas of mid-temperature humid forest, although unfortunately Bélouve has been highly managed for forestry plantation of the endemic Acacia. Even more unfortunate is that there are plans to manage the forest of Bébour in a similar manner. Bébour is very similar to Mauritian "cloud forest" which is just about extinct on Mauritius. Extremely rich in ferns and orchids, this forest is fairly undegraded although open areas fill up with the exotic Rubus alcaeifolius. Many species, or related species, which are extremely rare on Mauritius, both plants and animals, are common here.

The unmanaged forest of Bébour seems to be highly suitable for Pink Pigeons, as it very closely resembles the favoured habitat of the Plaine Paul/Mt. Cocotte region of Mauritius where the pigeons are found today. Unfortunately monotypic Acacia managed plantations appear unlikely to provide suitable habitat for the Pink Pigeon.

Plaine de Fougères This area is like that of the Forest of Bébour, and is also threatened by clearfelling for forestry and other plantations. It looks like good habitat for Pink Pigeons.

Piton de la Fournaise The volcano located in the southeastern corner of Réunion is still active and is surrounded by a low, high-altitude ericoid vegetation. This vegetation type covers an enormous area and is undegraded by exotic species. It is however unlikely that it could suport kestrels or pigeons.

St. Philippe This is the only native forest which extends to low altitudes, and was the only forest where we saw any Phelsuma geckos.

It is located on the windward side of the island and is hot, humid forest very similar to what the forests of Macabé and Brise Fer must have looked like on Mauritius before they became so degraded by exotic species. Unfortunately this forest is being invaded by guava Psidium cattleyanum and "jamrose" Syzygium jambos, but the Forestry Service is actively weeding the small nature reserve of Mare Longue, which is a beautiful forest. The Forestry Service are also planting mixed native plantations of principally hardwood native species such as Terminalia bentzoë, Mimusops maxima and Labourdonnaisia callophylloides. This forest would seem to be suitable for both kestrels and Pink Pigeons.

Manapany-les-Bains This small coastal town is the only place where the day gecko Phelsuma ornata inexpectata was seen during our trip. It is a coastal vegetation mainly composed of exotic screwpines Pandanus utilis.

Cirque de Salazie We stayed in Hell-Bourg and climbed the Piton d'Anchaing. The vegetation is extremely degraded in this locality, and unfortunately privet Ligustrum robustum var. walkeri has invaded the area. There are patches of native forest which could be suitable for pigeons, but unfortunately this area will become further degraded by privet and is not very suitable for the release of birds.

Cirque de Cilaos This "cirque" is the driest of the three amphitheatres which surround the central and now extinct volcano of Piton des Neiges. Unfortunately most of the vegetation has been cut down, apart from the forests above the village of Cilaos, and we walked through the forest at the Grand Matarum and the Col du Taïbit. Unfortunately privet has also been introduced, planted as a hedge plant in the village where it subsequently escaped to the forest. Large tracts of forest still exist which may be suitable for Pink Pigeons, but unless privet can be controlled, this area will probably become degraded in the near future.

Cirque de Mafate This area was viewed from "Le Cap Noir", and only patches of native forest remain in the virtually inaccessible valley.

Ravine de la Chaloupe This area, similar to the Grande Chaloupe, (which was not visited), is important because it harbours a few very rare lowland dry forest species. The low altitude, dry forest found on the leeward side of Réunion has virtually completely disappeared and no contiguous examples of closed canopy forest remain. This is unfortunate as it is likely that the kestrel used this habitat, as it must have been similar to the low altitude regions in the southwest of Mauritius where the kestrel is found today. Unfortunately, only isolated trees remain and the original vegetation type must be regarded as virtually extinct on Réunion.

In addition to our field visits we had informative discussions with the following local authorities and naturalists.

- M. Pierre de Montaignac, Regional Director of the ONF (Office National des Forêts).
- M. Harry Gruchet, Director of the Museum d'Histoire Naturelle and

Vice President of SREPEN (Societé Réunionnaise pour l'Etude et la Protection de l'environnement).
- Mme. Bernadette Ardon, President of SREPEN.
- M. Théophane Begue, the Game Warden in Plaine des Chicots.
- Joël du Pont, Maxime Fontaine, Jean-Claude Girard, Max Payet and Christoph Thébaud, all keen botanists and members of SREPEN.
- Messrs. Leveneur, Turpin, and other regional foresters

In the January trip we also attended a meeting of a committee which oversees the conservation of the Mare Longue Nature Reserve near St. Philippe and met additional forestry officials and private sector citizens interested in biological conservation.

In general our goal was to search for gaps in the information needed to satisfy the nine criteria for the release of animals to outdoor environments recommended by the World Wildlife Fund-Britain (1976), which are as follows:

1) There should be an intensive study of the species and its environment past and present, upon which to form a firm objective basis for reintroduction.

2) It must not have a disruptive effect on the ecosystem in which it is carried out.

3) The catching, transport and release of the animals should be carried out legally, humanely and sympathetically in the first interest of the animals themselves.

4) A contingency plan should exist to discontinue the program if initial predictions are not satisfactorily fulfilled.

5) The local human population should be informed, on the whole sympathetic, and not subject to serious economic consequences as a result.

6) Appropriate protective legislation should already exist.

7) The program should be carried out objectively, scientifically and sensibly.

8) The animals must be of the closest available stock.

9) The original causes of extinction (extirpation) have been largely removed, and the habitat requirements of the species are satisfied. See Cade (1986) for discussion of this criteria.

II. Do the Present Ecological Conditions of Réunion Provide Suitable Habitat for the Long-term Existence of a Population of Mauritius Kestrels and Pink Pigeons?

The basic requirements are: (1) tropical to sub-tropical climatic

conditions suited to their physiological constitution; (2) suitable nest sites (holes in volcanic rock or tree cavities for the kestrels and suitable nest trees for pigeons); (3) adequate "availability" (includes density and accessibility under local habitat conditions) of prey species for kestrels and a year-round supply of suitable flowers and fruits for the pigeon; (4) freedom or protection from predators and parasites.

1) Climatic Conditions Réunion lies close to Mauritius in the Indian Ocean and has a very similar climate which is mainly influenced in winter by the southeast trade winds and in summer by cyclone systems of the western Indian Ocean. It is unlikely that either the kestrel or the pigeon would be physiologically stressed in any way by the climatic conditions on Réunion, although they would encounter somewhat cooler temperatures in the higher elevation forests of Réunion than they experience on Mauritius.

2) Nesting Habitat Réunion and Mauritius are both volcanic in origin, but Réunion is a much younger formation. Sheer volcanic rocks and cliffs are even more numerous on Réunion than on Mauritius because of its larger size and much greater altitudinal relief (61% of the island lies above 1000 metres, higher than the highest point on Mauritius). Because the rocks are younger and less eroded than on Mauritius, they appear superficially to have somewhat different physical characteristics with, perhaps, fewer holes and cavities than similar formations on Mauritius. This possible difference requires closer study. The suitability of the volcanic rocks on Réunion as nesting habitat for kestrels can easily be determined in two or three days spent examining selected cliffs.

Réunion has more intact native forest than Mauritius and more old trees with potentially suitable nest cavities; however, most of the surviving forest is at elevations higher than any on Mauritius. This fact may have importance in relation to the availability of prey (see beyond), and if so, the abundance of suitable nest-sites at high elevations (above 800 metres) would be of little advantage to the kestrel. Lower elevation native forests are pretty much restricted to the southeastern corner of the island and cover at most a few thousand hectares around St-Philippe. Most of the original lowland forests have long since gone to agriculture or other human uses.

It is unlikely that the pigeon would have any problem in finding suitable nest sites since it will nest in any tree provided it has suitable, well-protected forks in which to build the nest.

3a) Availability of Prey for the Kestrel This is probably the single most important factor for the establishment and long term survival of a kestrel population on Réunion. On Mauritius the kestrels feed most frequently on geckos in the genus Phelsuma and on the other lizard species, but they also prey on small birds, small mammals, such as house mice and shrews, and on large insects (dragonflies, locusts, cicadas etc.) (Jones 1987). On present data

the species must be regarded as a rather specialised feeder on lizards, principally Phelsuma spp., and although some individuals and nesting pairs make significant utilisation of small birds in certain biotopes (territories), it is questionable whether long term maintenance of a population of kestrels would be possible in habitats where lizards are not commonly available.
There are four species of Phelsuma on Réunion just as there are or were on Mauritius, but their distributions and densities appear to be quite different. Three species are highly localised: P. cepediana has been introduced from Mauritius to several places in Réunion in recent years, P. lineata, from Madagascar, has been released in a private garden and house in the vicinity of Sainte-Marie (Bour and Moutou 1982), while the native P. ornata inexpectata appears to be restricted to the immediate environs of Manapay-les-Bains (Vinson and Vinson 1969), despite the fact that similar looking habitat (Pandanus, palm, banana, papaya etc.) occurs much more extensively along the coast. At Manapany on 7 January 1988, we saw 13 adult and four young lizards on a brief walk of about 200 metres along a road in town. The species appears to be common where it occurs, but restricted in distribution. This interesting population deserves a detailed ecological study. The fourth species, P. borbonica, is more widely distributed in native forests at elevations of 400 to 800 metres (Vinson and Vinson 1969), but does not appear to be very common compared with Phelsuma populations on Mauritius. Although we made a special effort to look for it on our walks through the forest, we only saw two individuals on a kiosk in the Forêt de St-Philippe. Apparently this is the standard location where the local naturalists can take visitors to see this species! (noted by Vinson and Vinson, 1969). Its precise range and numerical status are not well known and require study, especially the influence of altitude and temperature on distribution and numbers.

Small native birds are more numerous and diverse in the forests of Réunion than on Mauritius. Potential prey for kestrels include two species of white eye Zosterops borbonicus and Z. olivaceus, the Mascarene Paradise Flycatcher Terpsiphone bourbonnensis, and the Reunion Stonechat Saxicola tectes. In addition there are several exotic species, the Yellow-fronted Canary Serinus mozambicus, Common Waxbill Estrilda astrild, Spice Finch Lonchura punctulata and the recently introduced Red-whiskered Bulbul Pycnonotus jocosus. As previously indicated, there may be a definite limit on the ability of kestrels to survive on small birds in the absence of a dependable supply of the more easily caught lizards, unless it becomes possible somehow to condition captive produced kestrels to hunt small birds more consistently.

The introduced House Shrew Suncus murinus and to a lesser extent the House Mouse Mus musculus, are widely distributed and common in Réunion as on Mauritius. These are supplementary prey items, but the kestrel does not use them as a primary source of food. The same is true of large insects: they are at least as common in Réunion as in Mauritius, but they are not major items of diet in terms of total energy intake.

The crux of the question about food availability lies in the distribution and abundance of geckos on Réunion. We need to know more about the altitudinal limits, which forest types or species of trees are preferred habitat of geckos, and the density of their populations. If P. borbonica is as thinly distributed as current impressions suggest, then we would have to register a serious reservation about the likely success of introducing kestrels.
3b) Year-round Food Availability for the Pink Pigeons Several of the major food plants of the Pink Pigeons are also found on Réunion. For example Nuxia verticillata, Aphloia theiformis, Pittosporum senacia and Antirhea borbonica are all common at Bébour, Plaine des Chicots and St. Phillipe. Psiloxylon mauritiana, Tabernaemontana mauritiana and Cordemoya integrifolia are common at St. Phillippe.

More information needs to be collected on the abundance and distribution of these species as well as fruiting and flowering times. We need to know if there are likely to be any seasonal food shortages, and even if we are able to identify any, it is of course quite possible that the pigeons could avoid them by exploiting other species of food plants. Food shortages may be avoidable by supplementally feeding the pigeons grain at release sites or at well established feeding stations.

4) Predators and Parasites Presently nothing is known about endemic parasites or pathogens on Réunion that might affect kestrels and pigeons negatively. Conceivably the native harrier or "Papangue" (Circus maillardi) or other bird species could harbour harmful parasites or diseases, but the probability of serious effects is low.

The Réunion Harrier is a large, generalized, forest raptor. Once considered rare, it has increased in numbers in recent years, and it can now be seen daily in most forests. It is certainly capable of catching and killing kestrels and pigeons, and it is unlikely that any suitable habitats could be found on Réunion that would be free of harriers. Predation by harriers could be a problem in some areas (Cheke 1978), but the seriousness of this factor can only be determined by releasing kestrels and pigeons in Réunion and observing what happens. The reintroduction of Peregrine Falcons Falco peregrinus in the United States can serve as an example. Great-horned Owls Bubo virginianus and Golden Eagles Aquila chrysaetos have been serious predators on young, released peregrines in some locales, but even so, peregrines have established as breeding pairs in ranges shared with these two other predatory species (Barclay and Cade 1983). It is also worth noting that in pristine conditions kestrels, Pink Pigeons and harriers coexisted on both Mauritius and Réunion, for there is an extinct harrier from Mauritius just as there is an extinct kestrel and Pink Pigeon from Réunion (Cowles 1987). In this respect it is worth noting that the Pink Pigeon has a nest distraction display (Jones 1987) which may have evolved as a consequence of nest-predation by the harrier.

Certain mammalian predators also need to be considered. Human

predation and persecution have been factors of notable importance in the history of extinctions and rarity of bird species in the Mascarene Islands (Cheke 1987). There are fewer human beings on Réunion than on Mauritius, but a higher percentage of them are hunters and bird-catchers (Cheke 1987, Diamond, 1985). This factor would bear some watching and control in areas where kestrels and pigeons are released, especially during the early years of releases before a viable population has been established. Réunion has the big advantage that there are no mongooses or monkeys. Rats and cats cause some problems on Mauritius and would no doubt do so on Réunion, but local poisoning campaigns in the vicinity of release sites can deal effectively with these predators.

III. What are the Potential Impacts of Kestrels and Pigeons on Other Species Inhabiting Réunion?

1. Vegetation and Forest Composition Neither the kestrel or pigeon is likely to have any impact on the vegetation as they are not pollinators or seed dispersers. The Pink Pigeon does feed on native plants but our studies on Mauritius suggest that they do very little damage to their food plants and are certainly not as destructive as many of the exotic vertebrates (Jones and Owadally, 1988).

2. Competitive Interactions with Other Animals None seem likely. The Réunion Harrier is the only native raptor. Although it is secondarily forest-adapted like the kestrel, it is a much larger and different sort of predator. There is no significant overlap in the known food habits of the two, and no overlap at all in nesting requirements. A few other avian species on Réunion are known to eat geckos and small birds to a limited extent, especially their eggs and young. They include bulbuls, mynahs and cuckoo-shrikes, but no serious competition from kestrels is predictable from the known food habits of these species, which include in their diets many other foods not eaten at all by kestrels.

The Pink Pigeon is unlikely to compete directly with any other birds on Réunion except perhaps with the fruit and insect eating Reunion Merle Hypsipetes borbonicus. The merle is however a far more omniverous feeder and from what information we have (Cheke, 1987) there is little overlap in diet preferences. The Pink Pigeon and a merle (H. olivaceus) are sympatric on Mauritius with little evidence of direct competition. The merle on Reunion is able to live in a much wider range of habitats than one would expect the pigeon to survive in.

3. Predation by the Kestrels on Native Fauna The heaviest impact would likely be on geckos and small birds, depending on relative numbers and the escape cover available in particular biotopes

occupied by kestrels. The kestrels make their greatest demands on food resources during the breeding season, and locally within a nesting territory of kestrels numbers of some prey species might be reduced as compared with no kestrel predation. A rough approximation of the magnitude of their impact on numbers can be calculated by considering the food requirements of a pair of adults and two fledged, dependent young. If each bird requires about 30 grams of food per day the total daily intake is 120 grams. If 50% of the total consists of geckos averaging 3 grams each and 50% of birds averaging 10 grams, then at this period of the breeding cycle the family of four consumes about 20 geckos and six birds per day, taken from a hunting area of 150 - 250 hectares. Falcons tend to take particular prey species in proportion to their relative abundance and availability among all suitable species, so that rare species are less likely to be taken in proportion to their total numbers as frequently as abundant species (comparing geckos to geckos or birds to birds). Also, predators more often prey on less fit individuals that are likely to die for one reason or another before reproducing. Because there would only be a few pairs of kestrels widely dispersed in the available habitat, the impact of their overall predation on numbers of other animals can be predicted to be insignificant in terms of exerting any long term reduction in their populations. The greater worry is that numbers of suitable prey - especially geckos - will be too sparse to support successful reproduction by pairs of kestrels.

It should also be noted that the Reunion Cuckoo-shrike Coracina newtoni which is the only endangered passerine on Réunion, is beyond the upper size range of birds that kestrels can catch. Occasionally Kestrels take Red-whiskered Bulbuls (@ 25 grams), but experiments with released and wild kestrels indicate that they are reluctant to grab and kill birds the size of House Sparrows Passer domesticus and Village Weaverbirds Ploceus cucullatus (35 - 40 grams). Their preference is for birds the size of white-eyes, waxbills, serins and spice finches (7 - 10 grams) (Jones et al. in press).

4) Incidental Introduction of Alien Parasites or Pathogenic Organisms to Réunion Little is known about the parasites or diseases of either the Mauritius Kestrel or the Pink Pigeon (Cooper et al. 1981) or whether they are potential carriers of pathogenic organisms that would be new to Réunion.

To avoid any possible problem of this sort, birds to be introduced to Réunion can be screened ahead of time for the presence of parasites and pathogenic organisms in samples of blood, faeces and throat cultures. Or, fertile eggs could be sent to Réunion and hatched, and the young reared on the island, thus greatly reducing the possibility that parasites or diseases alien to the island would be secondarily introduced, as eggs are virtually free of pathogens.

IV. Conclusions and Recommendations

Most of the nine World Wildlife Fund (Britain) criteria for the release of animals into outdoor environments can be met by the proposal to introduce Mauritius Kestrels and Pink Pigeons to Réunion; however, significant questions remain to be answered before all the criteria can be satisfied. We therefore recommend that further detailed studies should be conducted to ascertain:

(1) the suitability of the volcanic rocky crags and cliffs on Réunion as nesting sites for Mauritius Kestrels;

(2) the distribution and abundance of Phelsuma day-geckos on Réunion, especially with regard to altitudinal limitations and types of forest.

(3) The seasonal availability of known and probable food items for the Pink Pigeon with studies on the distribution and abundance of these food plants in different forest types. Most of these data are probably already known, but needs to be collated.

(4) The geographic range within which ecological conditions appear to be most favourable for the establishment of kestrels and pigeons.

The first recommendation can be quickly and easily fulfilled. Ideally the second should be undertaken by a Phelsuma expert whose main interest is the lizards themselves and their ecology, and it should be carried out over an entire year. Many intriguing questions remain to be answered about the biology of the day-geckos on Réunion.

We would like to make some other recommendations which are not directly related to the introduction of kestrels and pigeons to Reunion but are of very great conservation importance.

(5) The eradication or strict control of all captive monkeys on the island; it only seems to be a matter of time before they escape. Wild monkeys on Réunion could cause inestimable damage to the native forest by destroying flowers, fruits and young plants and could threaten the long-term survival of pigeons, kestrels and other birds by stealing their eggs.

(6) The control of privet from areas where it is wild. Although it is probably impossible to totally eradicate this pest, efforts must be taken to reduce its spread, as it will irreversibly degrade the native forest.

(7) The exclusion of deer from areas of native vegetation. The deer are extremely detrimental to native plant regeneration since they browse on seedlings, and their presence will further degrade the little suitable habitat which remains for the proposed introduction of the pigeon and kestrel.

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Information Paper for Establishment of Black River Gorges National Park

Introduction

In 1988, the Government of Mauritius in conjunction with the World Bank held a Seminar on the Mauritius Environmental Protection Programme. One of the recommendations of this Seminar was the establishment of a National Park in the Black River area.

2. The choice of the Black River area is fully justified for many reasons. The area is the only contiguous native forest area of the island which includes several types native ecosystem and is the home for many endangered species of birds and plants. This area has the highest priority for bird conservation in all of Africa, ranking first among 75 forest areas surveyed in 1988 by the International Council for Bird Preservation. It has also been the site for the last fifteen years of a programme of preservation of extremely rare, endangered endemic species of both fauna and flora.

3. Apart from being of paramount importance for conservation, the area possesses high scenic value and is one of the few places in Mauritius where people can go to enjoy nature and learn about the natural environment. It offers abundant opportunity for environmental education and recreation as well as expansive of the country tourism

base. Additional benefits occur through watershed management and research.

Feasibility studies

4. Following up on the World Bank/Govenment of Mauritius environmental ~~program~~ report, the FAO in 1989 funded Natural Park Consultant Melvin Bolton to conduct a feasibility study for establishment of the park. He identified the boundaries of the park, zoned the areas for various uses, determined measures to be taken to preserve native flora and fauna and prepared a conceptual implementation program and schedule. Bolton also determined the manpower necessary to operate the park and recommended training requirements for the park personnel. Another FAO Consultant Ms T. Young prepared a report on the legal aspect of the park and produced a draft National Park Act for the establishment of the Park.

5. In May 1990 the World Bank organised an appraisal mission to Mauritius to review the proposals of Bolton and Young report. In this connection a World Bank Consultant J.W. Bright submitted the final report.

6. The Ministry of Agriculture, Fisheries and Natural Resources (MAFNR) set up a steering Committee composed of officials of the conservation Unit, Forestry Service of the Ministry, Environment Protection Department and international scientists working in Mauritius to assist the

World Bank Consultants during their work. The Steering Committee also then analysed the three reports and made recommendations on its implementation.

7. The purpose of this paper is to inform the Government on the proposed project and the recommendation of the Steering Committee on the implementation of the project.

Aims of the Park

8. Consequently the establishment of a National Park for the Black River area has been proposed with the following main aims:

- Conservation of the natural resources of the park with special regard to the highly endangered native plants and animals

- Restoration of the park's natural communities which have been disrupted by past exploitation and present competition from introduced plants and animals.

- Recognition and protection of park's scenic beauty for the benefit of local people.

- Promotion of environmental education.

Implementation

9. The location of the proposed park area is indicated on Maps 1 & 2.

10. Bolton's proposed boundaries enclose about 5000 ha of crown land and about 450 ha. of privately owned mountain reserve on the southern aspect of the Savanne Range (Bassin Blanc and adjoining areas). Bright proposed an area of about 7630 hectars by including of a further 1000 ha. of crown lands, 500 ha. of mountain reserve, 250 ha. of privately owned lands and the acquisition of interests to prevent non-agricultural development on 390 ha. of sugar-cane lands.

11. The Conservation Steering Commitee feels that though it would be highly desirable to have the Bright recommendation within park, the acquisition of privately owned lands apart from being costly may also involve lengthy legal procedures and delay the implementation of the project. Consequently, it has been proposed to start off the project only within crown lands and to acquire the recommended areas in the following priority:

(1) About 454 ha. at Bassin Blanc (Mountain Reserve)

(2) 500 ha. land belonging to Bel Ombre Sugar Estate (Mountain Reserve)

(3) 100 ha. at entrance of the Gorges belonging to Mr. Senneville earmarked for facilities development eg. picnic areas, day camps etc. (Private land)

(4) A block of 140 ha. at Gorette above Chamarel belonging to Mr. G. Merven, Bel Ombre Sugar Estate and others. (Private land).

12. Out of the all the proposed acquisition, Bassin Blanc and the surrounding area should have the highest priority as this area has a very high conservation and scenic value. While the other areas proposed for acquisition are also important, they may be acquired at a later stage. These areas will have to be evaluated by Government valuers.

13. The boundaries of the park enclose 6036 ha. of Crown Land, about half of which (2972 ha.) are leased for fishing and guardiennage. All these leases are coming to an end on the 7th September, 1993. The lessees should be informed that their leases will not be renewed.

Zoning of Park

14. The proposed park consists of areas which can be put to different uses. There are some areas of special importance for rare birds and endemic plant communities.

Other areas are particularly fragile and require protection. Some areas are very degraded and are beyond redemption on the conservation point of view and yet are of outstanding scenic beauty. A system of zoned development is therefore essential if the aims of the park are to be met.

15. It ~~is recommended that~~ 3 zone types have been organised.

15.1 Reserved Zone

This is a Zone of minimal disturbance reserved for critical wildlife habitat and scientific research. The management will be directed towards improving the status of endangered flora and fauna.

15.2 Natural Zone

Here public activity would be less restricted and the natural conditions would be sustained or restored. This will include also the Eucalyptus and Pine plantations. Foot paths and nature trails will be provided.

15.3 Recreation Zone

The Recreation zone within the park will include the Conservation Centre Site, the lower gorges area and the public road from Petrin to Chamarel.

16. Structure

Bright recommends that a National Park and Conservation Service (NPCS) be set up which would deal with management of protected areas for their inherent and esthetic value and terrestrial conservation work in general. He further recommends that the staff for the new agency at the Ministry level begins with the present Conservation Unit.

17. Staff Development and Training

The Steering Committee feels that the number of posts identified for the eventual running of the park is insufficient at the middle management. The hierarchy proposed by Bright leaves a void between top management and lower supervisory staff. There are no technical and scientific support to the post of Reserve Specialists for effective conservation of the natural resources of the park. Consequently, the staff structure for the park is proposed at Appendix I.

18. Infrastructure

Four major development sites are proposed. The first and largest is the Conservation Centre which would include a combination visitor centre with parking facilities. The Captive Breeding Centre at Black River

will be expanded and improved. (Sites within the Gorges will be developed for recreation and education)

Three substations for rangers will be constructed at three strategic points to control entrance in the park and these facilities will be used as information centres for the visiting public.

A network of roads, paths and trails will be set up with in the park by upgrading existing ones.

19. Legislative ~~Infrastructu~~re framework

The legislative aspect has been drafted by a FAO Consultant Miss T.R. Young. It provides for, in a single legislation

(a) the establishment of

(i) National Park Board of Trustees
(ii) A National Park Trust Fund
(iii) A National Park Service

(b) (i) the declaration of a National Park
(ii) The Preservation of areas of outstanding scenic, natural, scientific, recreation, conservation

and other values.

(c) The promotion of education about wildlife of nature conservation through the establishment of other national parks, both terrestrial and marine; and to provide for other matters connected with those purposes.

20. Funding

The funding of the project for the initial five years, is as follows:-

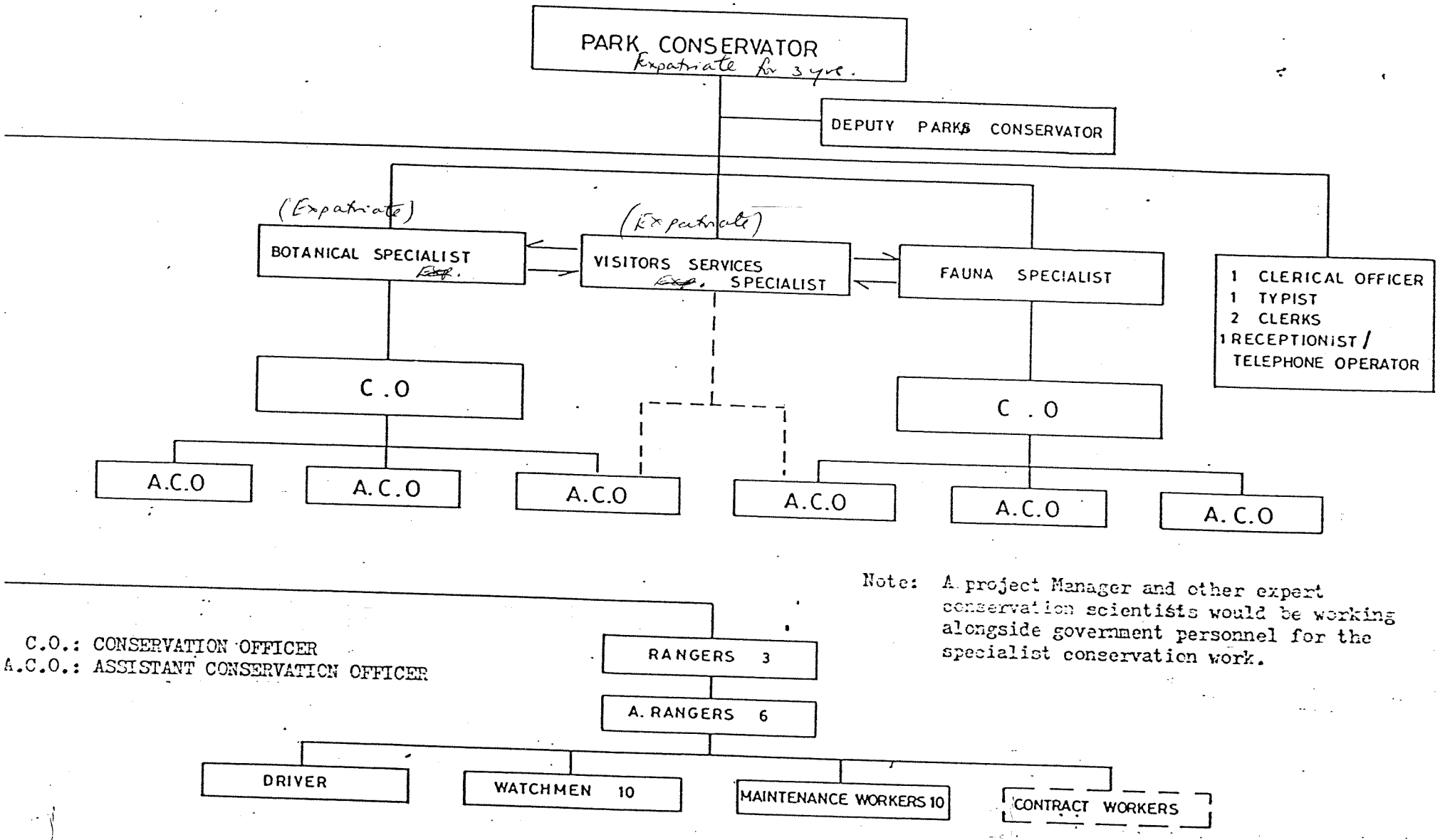
	Local	Foreign
	in '000 US $	
Consultants/~~Staff~~	82	499
Civil Works	572	861
Training		116
Equipment	36	297
Recurrent	618	55
Total Five Years	1308	1828

With the Committee's recommendation for the creation of additional posts, the recurrent costs and cost of replacement of vehicles and equipments will be around 500,000 US$ as from the sixth year. Wages costs have been based on the salaries structure proposed by the World Bank Consultant.

The Committee supports the recommendation made by Bright that the running cost of the Park may be met by increasing the airport tax to tourists by Rs 50/=.

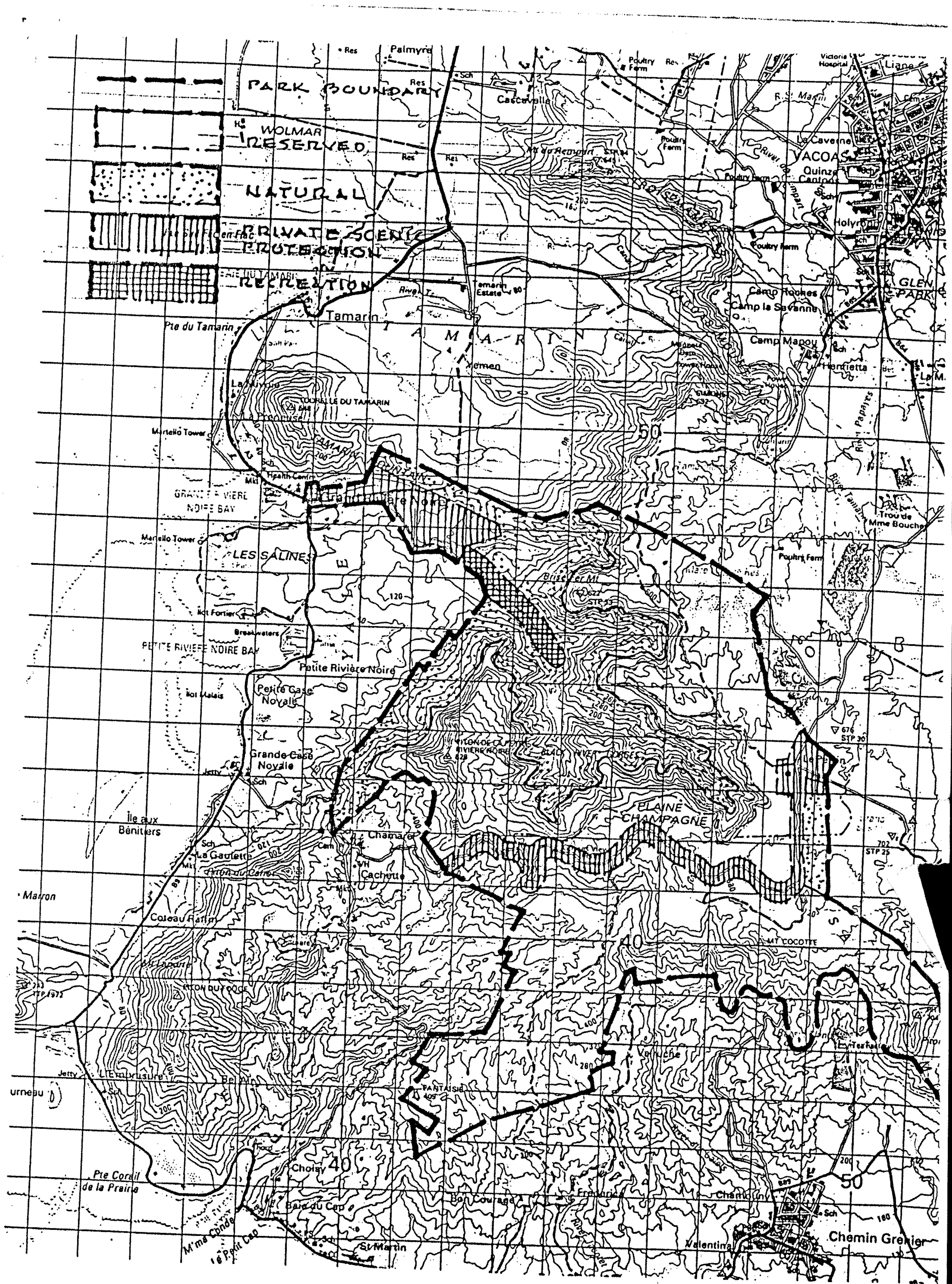
APPENDIX I

PROPOSED STAFF STRUCTURE FOR BRGNP



C.O.: CONSERVATION OFFICER
A.C.O.: ASSISTANT CONSERVATION OFFICER

Note: A project Manager and other expert conservation scientists would be working alongside government personnel for the specialist conservation work.



...THE PARK

MAP 1.