# Reasons for decline, conservation needs, and a translocation of the critically endangered upe (Marquesas imperial pigeon, *Ducula galeata*), French Polynesia

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# Reasons for decline, conservation needs, and a translocation of the critically endangered upe (Marquesas imperial pigeon, *Ducula galeata*), French Polynesia

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## ABSTRACT

The upe, *Ducula galeata*, is a critically endangered large frugivorous pigeon restricted to the island of Nuku Hiva, Marquesas (French Polynesia). In May 2000, five upe were transferred to Ua Huka Island (c. 50 km distant) as part of a conservation project aimed at conserving French Polynesian pigeons and doves. This report details the translocation of upe from Nuku Hiva to Ua Huka, some notes on upe gathered during fieldwork, including possible reasons for the decline, and some recommended conservation actions. All five birds are known to have survived the translocation; the recent discovery of an un-jessed bird suggests that breeding has occurred.

Keywords: translocation, Marquesan imperial pigeon, Marquesas


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# 1. Introduction

Oceania (which includes French Polynesia) has, in relation to the number of native species, land area, and population size, the highest number of endangered birds for any area in the world (Dahl 1984; Hay 1985), and the most extreme record of recent extinctions (Steadman 1989). Eighteen of the 26 endemic land-bird species of French Polynesia are threatened with extinction. Globally, island land-bird species compose 93% of known recent extinctions (King 1985). Several reasons have been proposed for the decline or extinction of the Polynesian avifauna, including: hunting, habitat loss, predation, and disease (Holyoak 1975; Hay 1985; Thibault 1988; Steadman 1989; Seitre & Seitre 1992).

The upe (*Ducula galeata*), a large frugivorous imperial pigeon of the south-eastern Pacific, is listed as Critically Endangered (Stattersfield et al. 1988). Discovered in 1855, the only extant population is on the island of Nuku Hiva, Marquesas (Holyoak & Thibault 1984) (Fig. 1), where its range seems to be decreasing: now only inhabiting several sites in the west (Terre Deserte), north, and the Caldeira Principale (crest) of the island (Thibault 1988; Evva 1998, pers. obs.). Subfossil remains of this large frugivorous species have been found on the Cook Islands, Society Islands, Pitcairn Island, and Hiva Oa, Ua Huka, Tahuata and Nuku Hiva Islands in the Marquesas group, indicating a previously widespread south-eastern Pacific distribution (Steadman 1986, 1989), although the remains found outside the Marquesas may be of another, undescribed, species (Gibbs et al. 2001).

The status of the population is uncertain: estimates of numbers conflict. In the 1970s, estimates ranged from 45–50 to 200–400 individuals. Recent estimates are of 150–300 individuals in 1993 (Everett et al. 1993) and 250 individuals in 1998 (Evva 1998), possibly indicating the population is stable. However, according to P. Villard, who conducted a 4-month field study in June–September 2000, fewer than 100 birds remain.

Due to the isolation of the Marquesas group much of the current knowledge of the upe is from studies of limited duration.

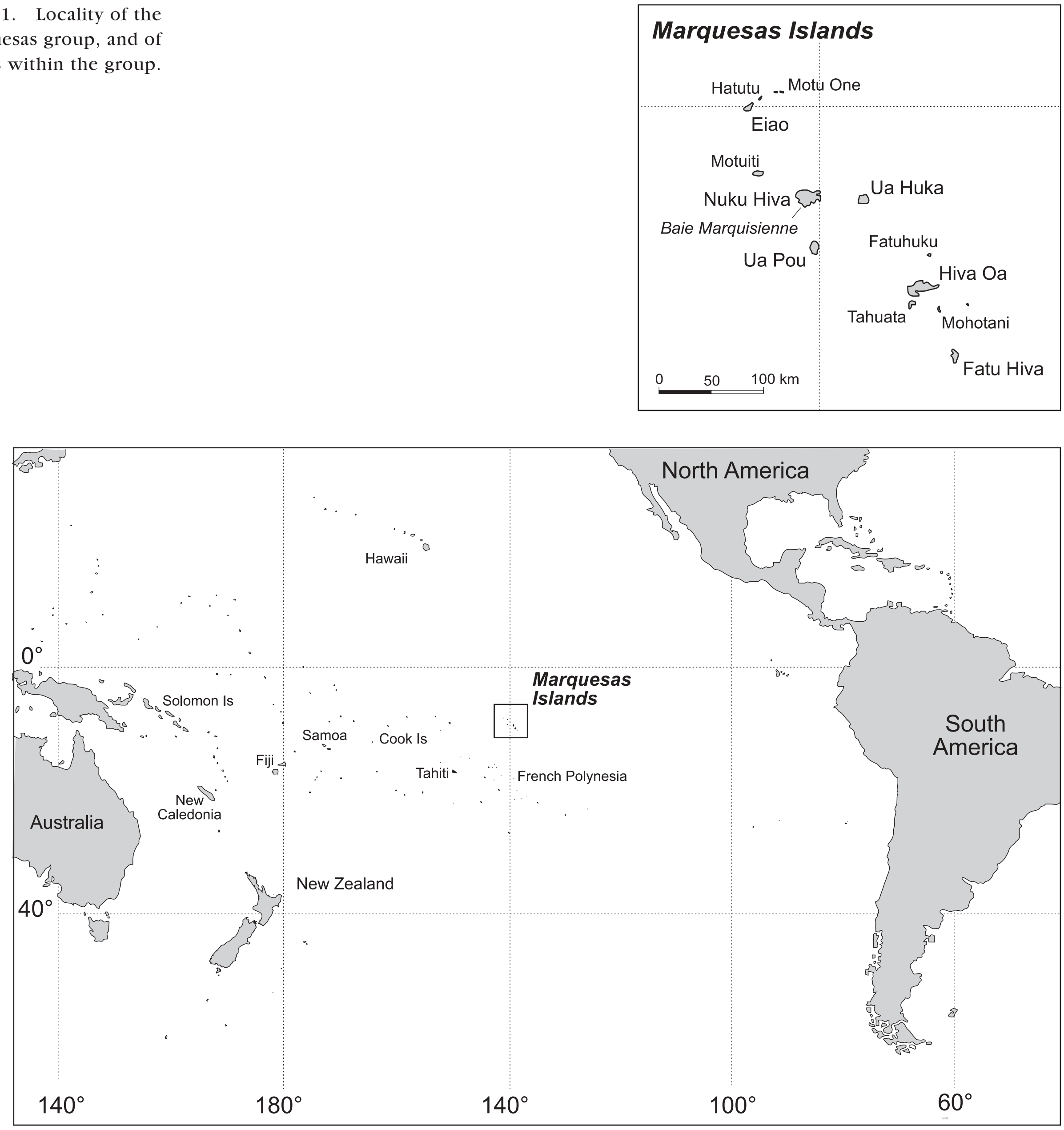
Sexes are identical in appearance. Measurements from Holyoak & Thibault (1984) indicate that females may have shorter wings and tails.

Recorded foods are fruits of both native and exotic plants. Upe have an extensible mandible allowing them to swallow fruits up to 7 cm in diameter (Holyoak & Thibault 1984). In the Pacific, pigeons have an important role in the dispersal of seeds (Hay 1985), and in areas where they are the only large frugivore present they are critical for the regeneration of large-fruited species (M. Thorsen, unpubl. data).

Virtually nothing is known about their habitat usage, or movements between and within habitats.

Very little is known about courtship and reproduction. Fifteen birds shot in September and October had gonads at all stages development, one female with an egg in the oviduct, and another female whose crop contained pigeon-milk (Holyoak & Thibault 1984). The breeding season is thought to be long,

Figure 1. Locality of the Marquesas group, and of islands within the group.




extending at least from mid-May to December (Holyoak 1975). Several nests have been found since then, but like all nests found to date, the fates are unknown. Nests are situated as low as 5 m, but usually between 13 m and 20 m (Holyoak 1975; Holyoak & Thibault 1984).

# 2. Location

The Marquesas are an arc of islands 1000 km north-east of Tahiti (Fig. 1). The islands are the eroded remains of shield volcanoes rising from depths of over 4000 m (Duncan & McDougall 1974).

Nuku Hiva is the oldest island, at 4.23 million years (my) old, and was still active until at least 2.99 my before present (Duncan & McDougall 1974). The island (337 $km^2$) rises to a maximum elevation of 1185 m, and consists of three concentric calderas created by volcanic eruptions. These calderas give rise to deeply eroded knife-edged ridges separated by deep gorges and ravines descending to coastal cliffs.

Ua Huka is 50 km east of Nuku Hiva and was formed about 2.7 my ago (Duncan & McDougall 1974). It has similar terrain to Nuku Hiva, but is smaller (81 $km^2$), and lower (855 m).

# 3. Notes on the upe

As our knowledge of upe is very limited, ecological and behavioural observations were collected whenever possible in this study. Time budget analysis, diet, interactions between individuals, call rates, activity patterns, roost sites, nest description, and habitat utilisation data were collected. Interesting observations included the first record of courtship, nest descriptions, juvenile/adult interactions, and inclusion of leaves, flowers, and invertebrates in the diet. These observations are being described elsewhere (Blanvillain & Thorsen, unpubl. data).

The upe appears to have the morphology and behaviour of a species adapted to foraging amidst the forest canopy. It seems uncomfortable and ungainly when in small shrubs such as guava (*Psidium guajava*). It is not an agile flyer, so does not move between shrubs easily (often upe climb within a tree rather than fly). This indicates it is maladapted to the current environment.

## 3.1 POSSIBLE CAUSES OF DECLINE

Considering the prehistoric range of upe revealed by subfossil deposits, and their extirpation or decline correlating with Polynesian arrival, it seems certain that hunting by Polynesians is the primary reason for its current restricted range (Steadman 1989). The long period of Polynesian occupation has resulted in major changes to the environment inhabited by Polynesian birds. Probably no islands in Polynesia can be considered pristine (Steadman 1989). Repeated burning of forests, intensive hunting, introduction of kiore (*Rattus exulans*), dogs (*Canis familiaris*), pigs (*Sus scrofa*), and exotic plant species by Polynesians, and following the discovery of the area by Europeans, the introduction of cats (*Felis catus*), black (or ship) rats (*Rattus rattus*), and Norway rats (*Rattus norvegicus*), goats (*Capra hircus*), further weed species, and conversion of land for agriculture, has resulted in islands with very different vegetation and a depauperate fauna and flora compared to that recorded originally. It is likely that numerous plant species have become very rare, or extinct, further restricting the original niche of some birds. Adaption to this very different environment has allowed the survival of the species still present. The degree of adaption seems to vary between species: on Nuku Hiva the warbler (*Acrocephalus caffer*) and kuku (*Ptilopus dupetithouarsii*) have a wide range, while the upe, monarch (*Pomarea mendozae*) and ultramarine lorikeet (*Vini ultramarina*) are very restricted in range—these two last species may now be extinct on the island.

We suggest that the probable current causes of decline of the upe are (in likely order of importance): habitat loss and degradation; predation; disease and competition.

### 3.1.1 Habitat loss and degradation

If the upe is a dedicated frugivore of mature forest, then loss of this type of habitat is likely to have a large impact on the distribution of the species. Even the remaining natural habitat on Nuku Hiva is severely degraded. Intact canopy of native species is rare, the native understorey and shrub layers are almost absent, and habitat composition is heavily biased towards browse-resistant species.

Currently on Nuku Hiva, areas of native forest containing fruit-bearing trees are restricted to the base and tops of some valleys, predominantly in the Terre Deserte and northern sides of the island. Causes of habitat loss in this area are probably several: the long period of Polynesian occupancy, importation of mammalian herbivores, clearance for agriculture and forestry, and fire. In Baie Maquisienne, free-living goats and pigs were common due to their remoteness from human populations, and more than 100 goats were detected from our observation point during the fieldwork period. Free-living cattle were common until their eradication by hunters about 10 years ago. These species will have been preventing regeneration of favoured food species and allowing the proliferation of hardy species (usually exotic) such as guava, and the herbs wild basilic (*Ocimum gratissimum*) and fotapa (*Elephantopus mollis*). These two species of herb alone cover over 50% of the ground area in the study area and probably inhibit regeneration of trees by suppression of seedlings. Goats are well known for destroying habitats on islands, for example: New Zealand (Atkinson 1964; Blaschke 1992), the Galapagos Islands (Calvopina 1985), Great Island (Cameron et al. 1987), Raoul Island (Sykes 1969; Parkes 1984), and Auckland Island (Campbell & Rudge 1984). Cattle, horses and pigs will also be compounding the effects of goats. Invasive weed species, such as guava, also alter habitat composition through out-competing native flora in altered environments.

Rats will also be causing habitat degradation by inhibiting regeneration via predation of flowers and fruits. Seed caches (probably created by kiore) were common, and contained many seeds, especially of badamier (*Terminalia catappa*), *Ficus* spp., kohuu (*Sapindus saponaria*), and pandanus (*Pandanus tectorius*). The food supply for frugivores will also be much reduced after consumption of fruits on trees by both black rats and kiore. Many guava fruit bore signs of rat feeding.

The abundance of fruit is critical in determining the breeding success of frugivorous birds. Some examples are parea (*Hemiphaga chathamensis*) (Powlesland et al. 1997) and kukupa (*Hemiphaga novaeseelandiae*) in New Zealand (Clout et al. 1995; Pierce & Graham 1995); pink pigeon (*Nesoenas mayeri*) (Jones 1987) and echo parakeet (*Psittacula eques*) (Thorsen & Jones 1998) on Mauritius, an island with a similarly devastated environment.

### 3.1.2 Predation

Predation is undoubtedly an important factor in the decline of the upe. Many island inhabiting birds are maladapted to the presence of mammalian predators (Kepler 1967; Atkinson 1977, 1985; King 1985). Some species are more vulnerable to rat predation due to nest site location, habitat usage, feeding and roost characteristics (Atkinson 1985). Inhabitants of tropical islands do not seem to be as adversely effected as those on temperate islands, possibly due to the presence of land crabs (Atkinson 1985), native snakes, or other native species that compete for similar resources, such as nest sites (M. Thorsen, pers. obs.).

However, predators are undoubtedly having a dramatic effect on French Polynesian species, especially those restricted in distribution and/or evolutionarily ancient species with a specialised niche.

Hunting by people probably currently restricts upe distribution to areas remote from habitation. While it is illegal to hunt upe, it is widely known that this still occurs, and that the law is very rarely enforced. Some hunters deliberately target upe, which are sold to local inhabitants. Presently most kills of upe are opportunistic by people hunting goats and pigs. The use of rifles facilitates hunting of pigeons (Hay 1985) and, despite restrictions on possession of firearms in the Marquesas, they are available from visiting boats.

Predation by cats of adults and juveniles will be occurring when upe are feeding in low shrubs, such as guava.

Black rats will also be predating eggs and nestlings, even if nests are in the tops of the highest trees. The frequency of this predation will depend on the composition of the rat fauna in the area—if black rats are relatively uncommon then predation will occur less often.

Some upe nests are obviously successful as juveniles were observed in the study area.

### 3.1.3 Other

Avian malaria is probably not present on the Marquesas. The upe and other endemic bird species are common within the mosquito-infested lowlands, a pattern different to that found on Hawaii where avian malaria and pox restricts endemic birds to higher altitudes (Warner 1968). Other endemic diseases (e.g. trichomaniasis, botulism) introduced in exotic birds may cause episodic declines.

Competition with kuku may be occurring during periods of limited fruit availability, possibly affecting breeding output, fledgling survival, and adult survival.

The above factors probably also act in combination, e.g. cat predation would be increased at certain times of the year if upe were forced to feed at a lower level (i.e. on guava) due to absence of an alternative natural food source in the damaged remnants of habitat.

# 4. Recommended conservation actions for the continuing survival of upe

- Effective protection from human hunting

As continual hunting has been the reason for the decline of many Pacific Island pigeons (Steadman 1989; Pierce et al. 1993), it is important to protect the remaining population. Probably the only feasible methods of achieving this are either by getting agreement from the inhabitants of Nuku Hiva to cease hunting upe, or the appointment of a Ranger whose task would be enforcing the relevant laws. Anti-poaching activities have slowed the loss of New Zealand pigeon from some forests in New Zealand (R. Atkinson, pers. comm.).

- Protection and restoration of remaining habitat

It is vitally important to protect the core habitats utilised by upe. The remaining habitat has the capacity for restoration to a healthier state. It is important that the remaining habitat is regenerating to offset losses to storms, and to senescence. A reserve encompassing Puua to Putata Valley could be established. This reserve, or at least important components, should be fenced. Horses and cattle should be excluded and goats and pigs controlled by hunting. Some weed control may be needed, but this could wait on the results of fencing and goat and pig control.

This reserve will need to be supported and managed by local people, and adapted to island circumstances (Dahl 1984). The authors recommend that it should not be a ‘locking-up’ of resources, but a blend of sustainable protection and use. Activities such as goat and pig hunting could be encouraged under a permit system.

The effectiveness of habitat protection is shown by the results of fenced enclosures on Mauritius. Here the regeneration of native species has been staggering, and even species thought to be extinct have grown from the seed bank (Mauritian Wildlife Foundation, unpubl. data.).

- Protection from predation by rats and cats

While the upe population is at such low numbers, predator control will be necessary until the population has recovered in size. Predator control in New Zealand has been an important component in the recovery of the endangered parea (Grant et al. 1997; Flux et al. 2001), and has benefited local kukupa populations (James & Clout 1996; pers. obs.). Cats can be controlled by trapping and poisoning and rats can be effectively controlled using appropriate poison bait.

- Better understanding of upe ecology, behaviour and relative importance of different factors of decline.

This is critical for effective management of the upe population. Research does not need to precede management activities. This is illustrated by the recovery of kokako (*Callaeas cinerea*) in New Zealand through a judicious blend of management and research (Innes et al. 1999).

- Establishing other populations

All efforts should be made to establish an upe population on Ua Huka Island. Once this has been accomplished then a further population should be established on an uninhabited and predator-free island.

- Education of local populations

Local people could be educated on the rarity of the upe, and the effects this rarity is having on the spread of native trees that could be used for other purposes, such as for timber.

- Captive breeding

This can be an important adjunct to other management activities and can also provide answers to research questions. A captive population could be established by removal of late-stage nestlings (allowing the parents to attempt another nest). Location of the captive population, necessary resources and quarantine would need to be addressed.

- Formation of an upe Recovery Group

Recovery groups incorporate key individuals involved in the conservation of a species and have been instrumental in the conservation of many threatened New Zealand species. Their role is to determine best management practices, facilitate management activities, and coordinate efforts and information with other agencies. Preparation of a specific Recovery Plan is usually one of the primary activities of Recovery Groups.

# 5. Translocation

## 5.1 JUSTIFICATION AND AGREEMENTS FOR THE TRANSLOCATION OF UPE

A huge prehistoric and historic decline in range has left the upe with one small remnant population on one island, where several threats are present. A proposal for the conservation of all threatened French Polynesian pigeons and doves was prepared by the Société d'Ornithologie de Polynésie (Blanvillain 1998). Translocation was proposed as a conservation measure for the upe to remove this insecurity of being restricted to a single island. Translocation of the upe was also recommended at the 1999 Polynesian Avifauna Conservation Workshop (Sherley & Tiraa 1999).

Translocation when applied to endangered species is a valuable tool. In New Zealand the success rate for translocations of forest birds is nearly 95%

(Lovegrove & Veitch 1994), but internationally there is only a 46% success rate for endangered species of all taxa (Griffith et al. 1989).

Factors that can increase the chance of a successful translocation are: habitat quality, release within known range, number of animals released, duration of programme, and knowledge of species ecology (Griffith et al. 1989).

Ua Huka was considered the most appropriate destination for a translocated population of upe for the following reasons:

- The species was previously present on this island until excessive hunting by early Polynesians led to its extinction (Steadman & Olson 1985). There is a local agreement in force not to hunt translocated upe.
- The Vaiviki valley on Ua Huka has been classified as protected area since 1997, and is thought to represent suitable habitat.
- The Mayor and the Ua Huka population, following their participation in the successful ultramarine lorikeet (*Vini ultramarina*) project (Kuehler et al. 1997), support the project, and a qualified person is resident who can follow the fate of the released birds.
- There are no black rats or Norway rats on the island. As there is no wharf on this island, they are unlikely to establish. Although feral cats are present, there is a smaller predator suite compared to Nuku Hiva.
- The human population size is relatively small compared with that of the other large Marquesan islands.

The number of birds available for a release is highly dependent on the size of source population, and for the upe this is very small. The twenty birds planned for this translocation is the minimal number thought to be needed to establish another population, and it is possible that more are needed. These additional birds could be obtained if conservation measures in the original population (see recommendations above) are successful.

Little is known of upe ecology, and it was expected that this could create problems for the translocation.

Generally accepted procedures and planning (including feasibility analysis) were adopted for this programme (e.g. Atkinson 1990; Towns et al. 1990; Black 1991; Saunders 1994). The specific methods used were modelled on reintroductions of the pink pigeon in Mauritius (Swinnerton 1998) and kukupa in New Zealand (Powlesland & Willans 1997; M. Thorsen, unpubl. data).

Approvals for the translocation were gained from the appropriate local government agencies.

## 5.2 PRE-TRANSFER ACTIVITIES

In April 2000, G. Sanford (Société d'Ornithologie de Polynésie) undertook two one-week trips to Nuku Hiva and Ua Huka to assess feasibility of the translocation, and to build the two aviaries. On their arrival on Nuku Hiva, J.M. Salducci (Société d'Ornithologie de Polynésie) and C. Blanvillain organized logistics for the project with the Mayor of the island and the head of the local Service du Développement Rural.

## 5.3 CAPTURE OF BIRDS ON NUKU HIVA

The first objective of the capture team, after arrival in Nuku Hiva, was finding an appropriate locality to attempt the capture of upe. After 3 days of survey and discussions with locals, a site was chosen in the valley leading into Baie Maquisienne, in the Terre Deserte region. This area had an estimated 13 upe, good food sources for upe, less extreme terrain and open sites allowing the setting of nets. A rudimentary camp was established at the site.

During 26 days over five weeks (5 May – 8 June) we attempted to capture upe. Five birds were captured: a pair simultaneously (on 11 May), a juvenile (on 22 May), a female (on 2 June) and a male (on 7 June). In addition, on seven occasions birds escaped capture (1 on 11 May, 2 on 16 May, 1 on 24 May, 1 on 27 May, and 2 on 28 May).

Birds were captured in mist nets. Sixty-millimetre mesh nylon mist nets were used in two sizes: three 2.6 × 6 m four-bay, and four 2.6 × 9 m five-bay. Side-lines were shortened to deepen the bays to increase the retention of birds in the net (with these large birds entrapment is not by entanglement but by hitting the net and then falling into the bays). Nets were set in a variety of configurations depending on site and bird behaviour (a flight route or feeding area). Nets were either slung from pulleys on lines between trees, off a 30 m high rope slung across the valley, attached to branches, draped over food sources, or bent around poles. Nets were elevated from 0.5 m to 25 m above the ground. Sometimes two nets were slung one under the other. Net sites were constantly modified to improve their performance. Eighteen different net sites were used.

After capture, birds were removed from the net, placed in wooden transfer boxes, and then transported by foot to the crest of the Caldeira Principale (approximately 1.5 hours), and then by vehicle (approximately 1 hour) to the holding aviary at Toovi.

In the holding aviary birds were housed in flights separated by mesh and white cotton. Fresh water, guava and bananas were offered on a feeding tray and also presented on branches of perches. Birds were held in this aviary until transfer to another aviary on Ua Huka.

While in captivity the birds were measured (Table 1), and regularly weighed (Table 2), and their food intake and health monitored.

Two wing covert feathers were collected from each individual for confirming sex using DNA analysis of feather pulp by Massey University, Palmerston North, New Zealand.

## 5.4 TRANSFER AND RELEASE OF BIRDS ON UA HUKA

For the transfer, birds were placed in transport boxes and moved by air to Ua Huka in two groups. Three birds were transferred to Ua Huka on 25 May, and two on 8 June.

On Ua Huka they were held in the release aviary for several days to recover from any transfer stress, and to familiarise themselves with their new surroundings.

TABLE 1. RANGE OF MEASUREMENTS (mm) OF CAPTURED BIRDS (AVERAGE IS IN PARENTHESIS).

| BIRDS | SEX | WINGS | TAIL | EXPOSED CULMEN | TARSUS | WING SPAN | BODY LENGTH |
|---|---|---|---|---|---|---|---|
| Collected in 1921 | Male, n = 6 | 306–321 (317) | 213–230 (226) | 23–27 (25.5) | 43–46 (45) | – | – |
| | Female, n = 9 | 295–305 (301) | 206–223 (213) | 22–26.5 (23.5) | 41–45 (43) | – | – |
| Captured in 2000 | Male, n = 2 | 310–315 (312.5) | 207–223 (215) | 22.3–24.0 (23.15) | 53.2–53.5 (53.35) | 918–975 (946.5) | 557–560 (558.5) |
| | Female, n = 2 | 292–295 (293.5) | 205–219 (212) | 22.1–21.6 (21.85) | 51.6–52.7 (52.15) | 910–952 (931) | 530–540 (535) |
| | Juvenile, n = 1 | 291 | 200 | 22.3 | 50.0 | 870 | 510 |

TABLE 2. WEIGHT CHANGES (g) OF INDIVIDUALS DURING CAPTIVE PHASE. D = DAY FROM CAPTURE.

| BIRD | CAPTURE DATE | FIRST RECORD | SECOND RECORD | THIRD RECORD | FOURTH RECORD | FIFTH RECORD | RELEASE DATE |
|---|---|---|---|---|---|---|---|
| Red (male) | 11 May 00 (D0) | 600 (D3) | 570 (D9) | 560 (D12) | 590 (D14) | 580 (D29) | 10 June 00 (D30) |
| Orange (female) | 11 May 00 (D0) | 550 (D3) | 510 (D9) | 490 (D12) | 500 (D14) | 510 (D29) | 10 June 00 (D30) |
| Blue (male) | 22 May 00 (D0) | 440 (D1) | 430 (D3) | 425 (D18) | | | 10 June 00 (D19) |
| Yellow (female) | 2 June 00 (D0) | 590 (D1) | 560 (D6) | 544 (D10) | | | 13 June 00 (D11) |
| White (male) | 7 June 00 (D0) | 660 (D1) | 650 (D5) | | | | 13 June 00 (D6) |

A coloured jess was affixed to one leg of each bird to aid identification in the field. Jesses were constructed from plastic coated nylon weave and had an internal circumference of 38 mm with a tail of 50 mm. No metal bands were used as it was thought that they would interfere with the function of a fleshy pad on the ventral surface of the tarsus.

Transmitters, incorporating a weak link in the body harness, were affixed to one bird (red right) in the first release group and one bird (yellow right) in the second release group.

Birds were released by opening a hatch in the external wall of each flight of the aviary allowing individuals to leave the aviary in their own time. The first group were held for 16 days before being released at dusk on 10 June. The second group were held for 5 days and released on 13 June at 10 a.m. The release of the second group was delayed as one bird was not eating and another displayed symptoms of stress (repeatedly being found on the ground with a wing clutched in one foot); it also had a throat infection. This bird was treated for stress by intramuscular injection of 1 mg of Dexamethazone for 2 days and force-feeding water and vitamins. Its throat infection was treated by orally administered, dissolved Terramycine for 3 days. Both birds were force-fed until release.

Birds were followed for as long as possible immediately after release, and whenever they could be relocated during the following 2–7 days. After release the first release group roosted in separate locations, varying from 20 m to over 300 m from the aviary. All three birds were seen the next morning. After this, only two birds were seen together that afternoon about 1 km from the release point. Of the second group, white stayed immediately adjacent to the aviary for 4 hours and roosted 100 m from the aviary. Yellow immediately started moving away from the aviary, sometimes pausing in one tree for over 2 hours. It is unknown where this bird roosted. None of this group was seen during the days following release.

All birds were silent and relatively immobile for the period immediately following release. This made it difficult to locate birds and hindered post-release observation.

## 5.5 PROBLEMS ENCOUNTERED DURING CAPTURE, CAPTIVITY, AND TRANSFER

We expected to encounter problems during the translocation due to the capture location (remote and relatively undeveloped), the birds (their rarity, little knowledge of behaviour), weather, and terrain (steep). Particular problems were:

- Lack of transport due to varying political climates.
- Poor communications due to terrain.
- Small team size (two–three people).
- Difficulty catching birds owing to:
  1) insufficient knowledge of behaviour (rectified as time passed),
  2) bird wariness (possibly due to hunting pressure) and intelligence (they seemed able to detect and avoid nets and were wary in areas of disturbance,
  3) features of capture location: steep terrain, few possible net sites, strong winds (nearly constant), sunshine, and heavy rain (for five days).
- Maintenance of birds in captivity. Due to the small team size, after the departure of R. Sulpice, this was undertaken by a local person with no prior avicultural experience; this had an impact on the feeding behaviour of birds in captivity, mainly in the second group.
- Difficulty in obtaining materials not brought to the islands by the transfer team.
- Incorrect mesh size of the mistnets. We used the largest available.

## 5.6 POST-RELEASE RESEARCH AND ACTIONS

The transferred birds are monitored by R. Sulpice, and data is collected on survival, range, habitat utilisation, foods, and breeding.

At 14 months post transfer, survival of translocated birds has been good. All four adult birds are regularly sighted, and there has been a possible sighting of the single juvenile male. The two birds that were captured as a pair have retained their pair bond, and the other adult male and female have also formed a pair bond. No breeding is known as yet. The two pairs have been seen in valleys adjacent to, and up to 3 km distant from, the release site. The sighting of the juvenile male occurred about 5 km from the release site.

In order to verify the absence of black rats on the island, several snap-traps will be set in different areas of the island. To protect the island against black rat invasion 15 permanent bait stations, stocked with bromadiolone treated grain in plastic bags, are situated around the wharf area.

***Note added in proof***: During a visit in May–June 2002 to Ua Huka, Mark Ziembecki of the University of Adelaide found the missing juvenile accompanied by an un-jessed bird. This suggests that breeding in the translocated population has occurred.

# 6. Acknowledgements

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