SCIENCE AND RESEARCH INTERNAL REPORT N0.14

PRELIMINARY GENETIC ANALYSIS OF NEW ZEALAND PARAKEETS

by

SUSAN J. TRIGGS AND CHARLES H. DAUGHERTY*

Science and Research Directorate,
Department of Conservation,
P.O. Box 10-420
Wellington, New Zealand

May 1988

* Zoology Department, Victoria University of Wellington

INTRODUCTION

Until recently, the genus was believed to comprise the following four species and their subspecies:

C. unicolor, the Antipodes I parakeet

C. auriceps, the yellow-crowned parakeet
- *C. a. auriceps*, the mainland yellow-crowned parakeet
- *C. a. forbesi*, the Forbes (or Chatham Is. yellow-crowned) parakeet

C. malherbi, the orange-fronted parakeet

C. novaezelandiae, the red-crowned parakeet
- *C. n. novaezelandiae*, the mainland red-crowned parakeet
- *C. n. cyanurus*, the Kermadec Is red-crowned parakeet
- *C. n. chathnmensis*, the Chatham Is red-crowned parakeet
- *C. n. hochstetteri*, the Antipodes Is red-crowned parakeet

However, the status of the orange-fronted parakeet has been a subject of debate (Holyoak 1974, Fleming 1980). Taylor et al. (1986) conclude that the orange-fronted parakeet is only a colour type of the yellow-crowned parakeet and not a separate species. This view is accepted by Bell (1986), thus drastically reducing the conservation status of the orange-fronted parakeet by removing it from the list of endangered New Zealand species.

The Forbes parakeet has alsp been the subject of special attention. Due to widespread cross-breeding with Chatham Island red-crowned parakeets posing an apparent threat to the survival of the remaining Forbes parakeets (Taylor 1975), a management programme to remove hybrid (cross-bred) and red-crowned parakeets from Mangere Is was instituted. Despite the removal of large numbers of these birds, the numbers of hydrids and red-crowned parakeets remains high on Mangere Is, but numbers of Forbes also seem to be increasing.

Other than the work of Nixon (1982), no comprehensive analysis of the parakeets has been undertaken recently, despite the importance of resolving the relationships between species as a basis for determining conservation requirements.

AIMS

We initially undertook this study to examine genetically the results of the Island programme to save the Forbes parakeet. Of particular interest was to determine if the two types of parakeets on could be distinguished genetically despite the history of cross-breeding.

As a basis for comparison, we also sampled as widely as possible from red-and yellow-crowned populations on offshore islands around New Zealand, including locations where only one species occurred (Chetwode Is--yellow-crowned only; Poor Knights Is --red-crowned only) and where both occurred (Little Barrier Island). Because of their generally low numbers, mainland populations were not sampled.

Additionally, we included samples from orange-fronted parakeets held in captivity because of the recent controversy surrounding their specific status.

METHODS

We analysed genetic relationships using electrophoresis, a biochemical technique that estimates genetic variation from proteins. Genetic variation was estimated at 22 protein loci in New Zealand *Cyanoramphus* parakeets from the following populations and species:

Species	Location	No. of individuals
Red-crowned parakeet	Poor Knights Is, Northland	27
"	Little Barrier Is, Hauraki Gulf	12
"	Southeast Is, Chatham Is	10
"	Antipodes Is	2
"	Captive	6
Yellow-crowned parakeet	Chetwode Is, Marlborough Sounds	22
"	Little Barrier Is, Hauraki Gulf	3
"	Captive	3
Forbes parakeet	Mangere Is, Chatham Is.	10
Hybrid red/yellow	Little Barrier Is, Hauraki Gulf	2
Hybrid red/Forbes	Mangere Is, Chatham Is	18
Orange-fronted parakeet	Captivity	7

The analysis was conducted on blood from live birds which were immediately returned to nature, except in the case of hybrid

individuals from Mangere Is.

SUMMARY OF RESULTS

1. Genetic Variation: Levels of variation are similar to those found in other vertebrates. Six of the 22 genes were variable in at least one population. Thus, sufficient genetic markers exist to allow resolution of genetic relationships among populations and species in this group.

The genetic difference between groups is measured by D, the standard genetic distance. A low D between two groups means they are closely related. Between species of birds within a genus D averages 0.044, between subspecies of bird species, D averages 0.005, and between populations D averages 0.002. The greatest genetic difference identified in our study was between red-crowned and yellow-crowned parakeets (D = 0.05; fig. 1), thus correctly identifying their known taxonomic relationship as separate species within a genus. Populations within each species were virtually identical for the genes examined (between yellow-crowned parakeet populations D = 0, between red-crowned parakeet populations D = 0.003). Between the three red-crowned parakeet subspecies examined D = 0.006.

2. Forbes Parakeet: Forbes parakeet is genetically most similar to red-crowned parakeets (D = 0.007) and shows species-level genetic divergence from yellow-crowned parakeets (D = 0.05) (fig. 1). This surprising result is supported by the finding of Nixon (1982) that Forbes parakeet is morphologically distinct from mainland yellow-crowned parakeets, but not from Chatham Island red-crowned parakeets.

The similarity between Forbes and Chatham Is red-crowned parakeets could be the result of extensive cross-breeding, but this interpretation is strongly opposed by the presence of genotypes in Forbes that do not occur in Chatham Is red-crowned parakeets, and vice versa. This finding indicates that Forbes parakeets have maintained their genetic identity despite cross-breeding.

We believe the most likely explanation is that Forbes parakeet is not, as presently classified, a subspecies of crowned parakeet, but instead is a unique Chatham Is form independently derived from red-crowned parakeets.

An argument can be made for species-level divergence of the Forbes parakeet on the basis of its unique genetic identity. Forbes parakeet is also distinguished from I red-crowned parakeets by voice, colour, slight morphological differences, and possible ecological and behavioural differences. Additionally, Forbes apparently mate preferentially with other Forbes, and hybrids appear to backcross with red-crowned parakeets but not commonly

with Forbes, thus protecting the integrity of the Forbes genetic type.

3. Orange-fronted Parakeet: Orange-fronted parakeets are genetically most similar to yellow-crowned parakeets, but at a level commonly associated with subspecific or higher level genetic divergence (D = 0.015). In comparison, yellow-crowned populations from Little Barrier and Chetwode Is are genetically identical (D = 0), subspecific divergence between mainland and Chatham I red-crowned parakeets occurs at a level of D = 0.005, and Forbes are separated from red-crowns by only D = 0.007.

The level of divergence, however, is not conclusive and is compatible with either of two explanations:

(a) The orange colouration is a simple within-species variant (roughly comparable to, for example, blue vs brown-eyes in humans) of no special taxonomic significance. This is the view of Taylor et al. (1986), on the basis of which they conclude that the orange-front belongs to the yellow-crowned parakeet species. The genetic divergence we have documented would be explained as a regional difference within yellow-crowned parakeets.

(b) The orange-fronted parakeet is a separate species. This has important conservation implications, as, if this is correct, the orange-fronted parakeet will have to be reinstated as a threatened species. The status of the orange-fronted parakeet could be definitively tested by analysis of blood samples of yellow-crowned parakeets from the Hope River area, where our orange-fronted samples originated.

The genetic findings do not necessarily disagree with the conclusion of Taylor et al. (1986) that the orange colouration is produced by a single variable gene. However, Nixon (1982—pp 181-184) observes that colour differences are often encoded by only a few genes, whether within or between species. Our data strongly indicate that orange-fronted and yellow-crowned parakeets are distinguished by other genetic differences as well as colour. Species-level distinction of the orange-fronted parakeet is also supported by apparent differences in behaviour, colouration, and possible preferential flocking and mating (P. McKenzie and B. Heather, pers. comm.; Fleming 1980).

4. Verification of Hybrid Status: During December 1985, 28 parakeets were mist-netted on Mangere Is. Of these, 10 were Forbes, five appeared to be F1 hybrids (offspring of pairs), 11 appeared to be hybrids backcrossed to reds (offspring of hybrid/red pairs), and only 2 appeared to be pure reds. Of importance is the fact that no apparent backcrosses between hybrids and Forbes were found, as also suggested by Nixon (1982--p. 184).

Birds identified as hybrids on morphological criteria on Little Barrier Is were also indicated as hybrids genetically. Genetic data thus support the morphological data indicating that hybridisation among native parakeets occurs where two forms are in contact.

5. Captive Stocks: Captive yellow-crowned parakeets were genetically identical to wild yellow-crowned parakeets. Captive red-crowned parakeets, on the other hand, were genetically identical to hybrid birds from Little Barrier Island, which are more similar to wild yellow-than to wild red-crowned parakeets. Thus, captive red-and captive yellow-crowned parakeets were also genetically very similar.

These findings strongly indicate that at least some stocks of captive parakeets are hybrid. Some captive stocks also showed very low levels of genetic variation, probably as a result of the small number of individuals in some captive breeding programmes.

MANAGEMENT RECOMMENDATIONS

These data provide new insights into the population and species structure of NZ parakeets which challenge present concepts of taxonomy and, hence, management. On the basis of our findings thus far, we make the following recommendations for the management of these taxa:

1. Forbes Parakeet: Our findings indicate that the present taxonomic status of the Forbes parakeet is incorrect. Genetic data indicate that the Forbes parakeet is a unique Mangere Is form, most closely related to the red-crowned parakeets and clearly not a yellow-crowned parakeet. The Forbes parakeet retains its genetic integrity despite the history of hybridisation.

The continuing genetic distinctness of the Forbes parakeet and its possible change from subspecific to specific status argue for continued special conservation treatment, but do not provide obvious guidelines to future practice. The integrity of the Forbes genetic type may have been maintained due to natural ecological, behavioural, and genetic mechanisms rather than the management regime. Interbreeding between Forbes and red-crowned parakeets is still widespread, despite a decade of intensive management.

On the other hand, under the present regime the number of Forbes has been increasing. This could be due to reduced competition for resources and mates as a result of removal of hybrids and red-crowns. Therefore, the present management programme seems benign to Forbes parakeets. Continued removal of red-crowned and hybrid parakeets until the number of Forbes is higher is thus a defensible strategy. If the removal programme continues, we recommend that carcasses of red-crowns and hybrids be made available for continued genetic monitoring.

2. Orange-fronted parakeets: Our findings call into question the conclusions of Taylor et al. (1986) regarding the orange- fronted parakeet. It is a genetically distinct form which is at least as differentiated as a number of other taxa, including the Forbes parakeet, presently afforded high conservation status. Thus, we recommend that the status of the orange-fronted parakeet in nature be a subject of immediate attention. Most importantly, samples of yellow-crowned parakeets from the Hope River should be obtained immediately for comparison with orange-fronted samples from the same region.

Additionally, we strongly recommend that samples of blood be obtained immediately from all orange-fronted parakeets in captivity for inclusion in this analysis, not only to sample sizes and therefore certainty of our conclusions, but also to help design captive breeding programmes in order to inbreeding in this dangerously small gene pool.

3. Mainland Red- and Yellow-crowned Parakeets: Our data indicate that hybridisation is likely where birds of two taxa occur sympatrically. The extent of this hybridisation is undocumented in mainland locations and could, if extensive, be a matter of conservation importance. We therefore recommend that efforts be undertaken to identify the extent of hybridisation of parakeets in mainland New Zealand and on any islands where two forms occur sympatrically. We note the absence in our analysis of any samples of red-or yellow-crowned parakeets from mainland NZ and recommend that such samples be obtained as soon as possible. (This programme should begin with the Hope River populations, as indicated above.)

4. Transfer Programmes: In the past, captive stocks of crowned parakeets have been used for liberations on island reserves. We strongly recommend that this practice be discontinued. The prevalence of hybridisation between red-and yellow-crowned parakeets in captivity and the loss of variation in these stocks make captive parakeets totally unsuitable for establishment of new populations in nature. It is likely that the stock already liberated on one important sanctuary, Cuvier Is, contained hybrids.

SUMMARY OF MANAGEMENT RECOMMENDATIONS

1. Continued removal of hybrid and red-crowned parakeets from Mangere Is seems warranted in light of the increasing numbers of Forbes parakeets and the maintenance of their genetic integrity under this regime. The newly indicated taxonomic status of Forbes parakeet supports a continued high conservation importance. The genetic status of I populations should continue to be monitored.

2. Genetic comparisons of yellow-crowned and orange-fronted parakeets from the Hope River area should be undertaken immediately in order to confirm the taxonomic and thus conservation-status of the orange-fronted parakeet. At the same time, blood samples should be obtained from all captive fronted parakeets for use in this study and to provide guidance for captive breeding programmes.

3. Studies to assess the prevalence of hybridisation in parakeet populations on mainland New Zealand and offshore islands should be undertaken as soon as feasible.

4. Use of captive stocks of parakeets for establishment of new populations in nature should be terminated immediately due to the hybrid origin of many of these stocks and their reduced genetic variability.

LITERATURE CITED

Bell, B.D. 1986. The conservation status of New Zealand wildlife. Wildlife Service Occasional Publication No. 12, Dept. of Internal Affairs.

Fleming, C.A. 1980. Orange-fronted parakeet: record of flocking. *Notornis* 27: 388 -390.

Holyoak, D.T. *Cyanorhamphus malherbi*, is it a colour morph of *C. auriceps*. Bull. Brit. Ornith. Club 94: 4 -9.

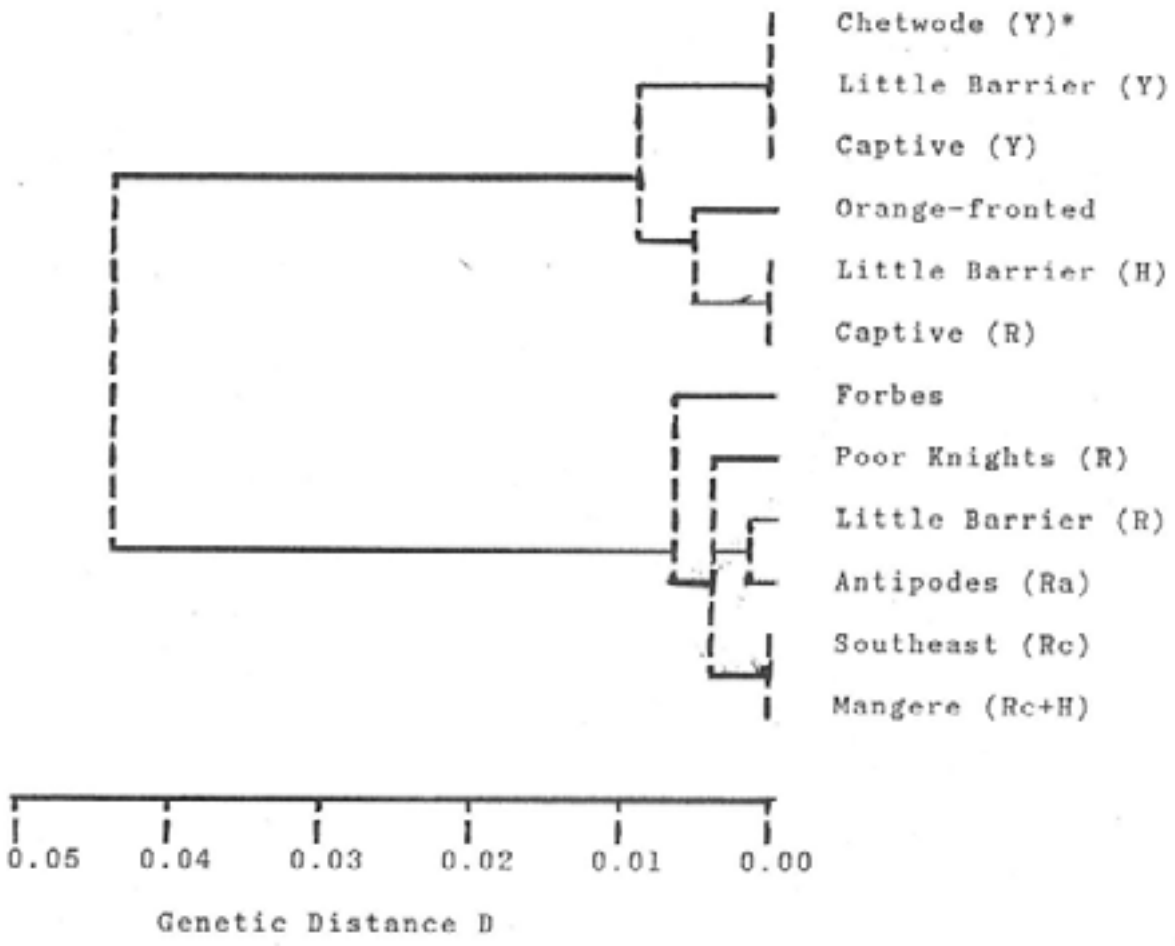
Nixon, A.J. 1982. Aspects of the ecology and morphology of *Cyanorhamphus* parakeets and hybrids from Mangere Island, Chatham Islands. M.SC. (Hons) Thesis, Victoria University of Wellington.

Taylor, R.H. 1975. Some ideas on speciation in New Zealand parakeets. *Notornis* 22: 110 -121.

Taylor, R.H., E.G. Heatherbell, and E.M. Heatherbell. 1986. The orange-fronted parakeet (*Cyanorhamphus malherbi*) is a colour morph of the yellow-crowned parakeet (*C. auriceps*). *Notornis* 33: 17 -22.

Fig. 1 Genetic relationships among NZ parakeet populations

(Short horizontal lines link closely related groups; long lines link more distantly related groups).



Y - mainland yellow-crowned parakeets
H - hybrid red-/yellow-crowned parakeets
R - mainland red-crowned parakeets
Ra - Antipodes red-crowned parakeet (Reischek's parakeet)
Rc - Chatham Is red-crowned parakeet