THE EXTERNAL MORPHOLOGY AND TAXONOMIC STATUS OF THE ORANGE-FRONTED PARAKEET

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ABSTRACT

Size and shape differences between museum specimens of the Orange-fronted Parakeet *(Cyanoramphus malherbi)* and the Yellow-crowned Parakeet *(C. auriceps)* are investigated using discriminant function analysis. No significant differences were found between the two groups, and the plotted discriminant scores show very poor separation, whereas the technique distinguishes both groups from Red-crowned Parakeets. These results support the view that *C. malherbi* is a colour variant of *C. auriceps.*

INTRODUCTION

The Orange-fronted Parakeet *(Cyanoramphus malherbi),* was first described by De Souance in 1857, and little knowledge of it has been gained since it was redescribed by W. L. Buller in 1868. Many of the earlier notes on this parakeet (for example, Finsch 1870) refer to the possibility that it was the juvenile form of the very similar Yellow-crowned Parakeet, *C. auriceps* (Kuhl). Buller was at one time undecided on this matter but finally reinstated the species (Buller 1884). Since then the Orange-fronted Parakeet has been treated as a rare but distinct species, notably by Harrison (1970) in his re-evaluation of early literature and current knowledge. This view was challenged by Holyoak (1974) with a hypothesis that the Orange-fronted Parakeet is a colour-morph of the Yellow-crowned Parakeet. The questions raised about the biology of these parakeets deserve further consideration, especially now that live birds have been found by Wildlife Service expeditions in the Lake Sumner area (Cox 1981, unpubl.).

Three main features have been used to distinguish *C. malherbi* from *C. auriceps:*

1. Ecology and behaviour, aspects which have become confused (e.g. by Reischek's description of a montane habitat for *C. malherbi* as opposed to the forest-dwelling Yellow-crowned Parakeet, and also Buller's specific name *alpinus*);
2. Coloration, which seems complex but for which Holyoak suggests a simple genetic basis; and
3. Size and shape, quoted by most authorities as important distinguishing features (Buller 1882, Oliver 1955, Falla *et al.* 1970,

Forshaw 1973. Forshaw reconsidered specific status in his later edition).

The present discussion focuses on variations in size and shape. Such variations may reflect genetic differences between sexes and taxa, they may be important as reproductive isolating mechanisms, and they may be indicators of ecological divergence between species which superficially appear to share similar resources in the same habitat.

When distinguishing between *Platycercus alpinus (= Cyanoramphus malherbi)* and the other parakeet species, Buller (1870) suggested that " . . . comparing the bills of the two species the difference is very manifest, that of *P. alpinus* being fully one-third less than that of *P. auriceps.*" He later provided a set of comparative measurements (Buller 1875) which would seem to bear this size difference out. Later authors quote these and other accounts, or simply affirm that a small size difference does exist. On the other hand, Holyoak (1974) presents figures for bill length and wing length of specimens from European and North American museums which indicate no marked difference between species. Why is there such contradictory information? Assuming the measurements have been accurate, either there was a real difference in size, or the samples were biased in some way. Birds raised in captivity may be larger, and perhaps their presence has influenced comparisons.

To clarify some of these points, I have investigated specimens available in New Zealand museums, using multivariate statistical techniques.

METHODS

A series of morphometric measurements was taken from parakeet skins, mounts, and preserved birds from the National Museum, Canterbury Museum, and Auckland Museum. Five live Yellow-crowned Parakeets from an aviary colony were also measured to boost sample size. The inconsistency of measurement introduced by combining specimens of differing state was found to be insignificant compared with inter-group variation. Four groups were considered: Orange-fronted *(Cyanoramphus malherbi)*, wild-caught Yellow-crowned *(C. auriceps auriceps)*, captive-raised Yellow-crowned *(C. auriceps auriceps)*, and Red-crowned *(C. novaezelandiae novaezelandiae)*. The last group was included to give some comparison with a recognised species. The six variables were: wing length, tail length, tarsus (tarsometatarsus) length, bill length, bill width, and crown length.

The Hotelling T^2 test, the multivariate equivalent of the students t-test, was used to test the hypothesis of equality of the vectors formed by the means of the six variables for each group. The BMDP/3D computer program (Dixon 1975) was used to perform this task.

Discriminant function analysis is the multivariate statistical technique used here to describe differences in shape and size between species. When two groups are very similar, the distributions of

measured characters for each group may overlap so that, for any one variable, no clear cut-off point between groups is evident. However, the ability to discriminate between groups may be increased by forming a linear combination of the variables and associated weighting coefficients. Such a function has the form:

$$D_i = d_{i1} Z_1 + d_{i2} Z_2 + \ldots d_{ip} Z_p$$

where: D_i is the score on the ith discriminant function

Z is the standardised variable

d_i is the weighting coefficient

The weighting coefficients are estimated using matrix operations so that the between groups variation is maximised. When the data are projected from many variables on to fewer dimensions, the separation of groups is more easily appreciated. The discriminant function also gives information about the relative importance of each variable in determining this separation. Discriminant function analysis is often used to assign unclassified specimens to one or other of the groups, but in this case no new specimens were included; the derived functions being used simply as canonical variates upon which the distribution of grouped specimens could be plotted.

Two three-group comparisons were made. For both, two discriminant functions were calculated from the six variables using the SPSS computer package. The package offered the option of entering variables into the analysis phase (i.e. the calculation of weighting coefficients) by one of several stepwise methods so as to exclude redundant variables. The " Wilks lambda " stepwise method was used.

If a variable had not been recorded for any specimen, this specimen was excluded from the analysis phase but entered into the classification phase by substituting the overall mean for the missing value.

RESULTS

Nineteen Orange-fronted Parakeets were measured: 4 females, 7 males, and 8 unsexed. Table 1 compares the measurements of Orange-

TABLE 1 — Measurements of female Orange-fronted and Yellow-crowned Parakeets

	ORANGE-FRONTED ♀			YELLOW-CROWNED ♀		
Variable	Mean	SD	Number	Mean	SD	Number
Wing	103.5	3.70	4	103.7	5.09	13
Tail	106.5	10.21	4	110.6	7.29	12
Tarsus	18.67	0.643	3	18.35	0.841	13
Bill L	12.23	1.031	4	11.98	1.527	12
Bill W	7.38	0.562	4	7.65	0.650	13
Crown	17.5	3.87	4	18.4	2.90	13

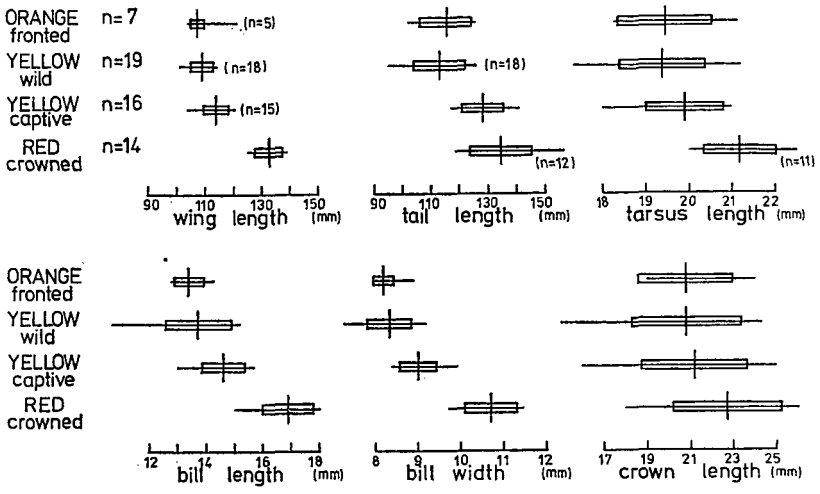

FIGURE 1 — Measurements of males of four species of parakeets.

fronted and wild Yellow-crowned female parakeets. Although the Orange-fronted sample means are slightly lower than the Yellow-crowned, students t-tests revealed no significant differences at the 1% level between the means of these two groups for all six variables. The small size of the sample of females makes further statistical treatment difficult.

Because of the sexual dimorphism in size of parakeets, and the larger sample of males, further analyses were restricted to male birds. Figure 1 shows the measurements of four groups of male parakeets. When the mean vectors were compared for Orange-fronted and wild Yellow-crowned, a Hotelling T^2 test gave a value for T^2 of 2.839 and a corresponding F value of 0.3380, indicating no significant differences between group mean vectors.

The first set of discriminant functions was calculated to describe the multivariate separation of the three supposed species: Orange-fronted, Yellow-crowned (wild), and Red-crowned. The standardised discriminant function coefficients were:

	Wing L.	Bill	Crown L.
FUNCTION 1	0.75030	0.65682	-0.69125
FUNCTION 2	-0.94874	1.24754	0.03513

Only three of the six variables were required to describe the variation that exists between groups. The remaining three variables contribute an insignificant amount of new information.

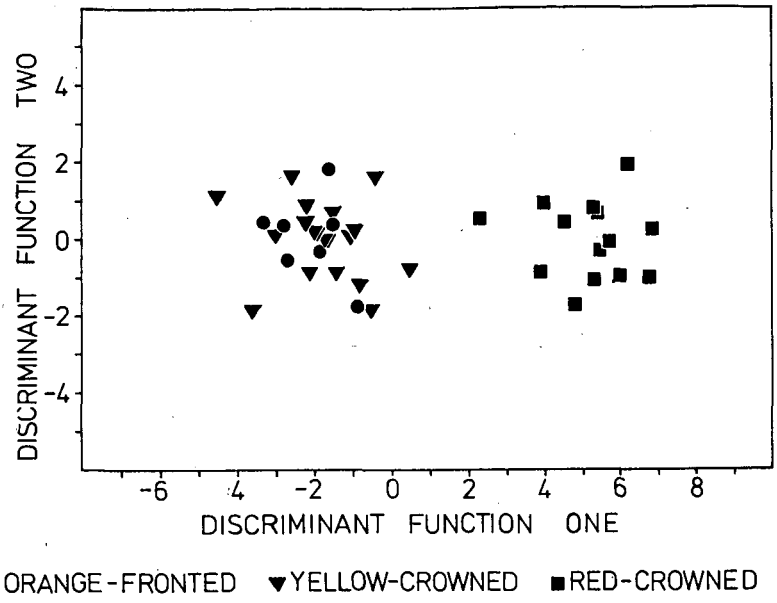

FIGURE 2 — Plotted discriminant scores of male Orange-fronted, Yellow-crowned, and Red-crowned Parakeets.

Figure 2 shows the plotted discriminant functions when the values for each case are inserted. Orange-fronted and Yellow-crowned Parakeets appear to separate very poorly. The Orange-fronted distribution is slightly narrower and lies within that of the Yellow-crowned.

Figure 2 shows that the technique differentiates between known species (Yellow-and Red-crowned) but cannot separate Yellow-crowned and Orange-fronted Parakeets. Therefore, I did a further analysis on these two groups, plus captive-bred Yellow-crowned. If the wild Yellow and the Orange-fronted Parakeets still failed to separate, but the captive birds showed some shift away from these groups, this could represent a possible explanation for the traditional view that a size difference exists.

Again using the method of entering variables into the analysis by a stepwise method, only two of the six variables were retained to give the following coefficients:

	Wing L.	Tail L.
FUNCTION 1	0.47163	0.76845
FUNCTION 2	0.92136	-0.69342

In the first function both coefficients are of similar magnitude. The separation of groups on this function indicates that they differ mainly in size, which might be expected with an intraspecific comparison if growth is not greatly allometric.

Figure 3 shows captive Yellow-crowned concentrated at one end of the multivariate distribution, whereas the Orange-fronted again fall within the wild Yellow-crowned range and are not clearly distinguishable. The assumption that measurements taken from live specimens did not significantly bias the results was substantiated by the even distribution of live specimens through the range of the captive Yellow-crowned sample on the first discriminant function.

Since only two variables contribute to the discriminate functions, Figure 3 is similar to a scattergram of wing length by tail length.

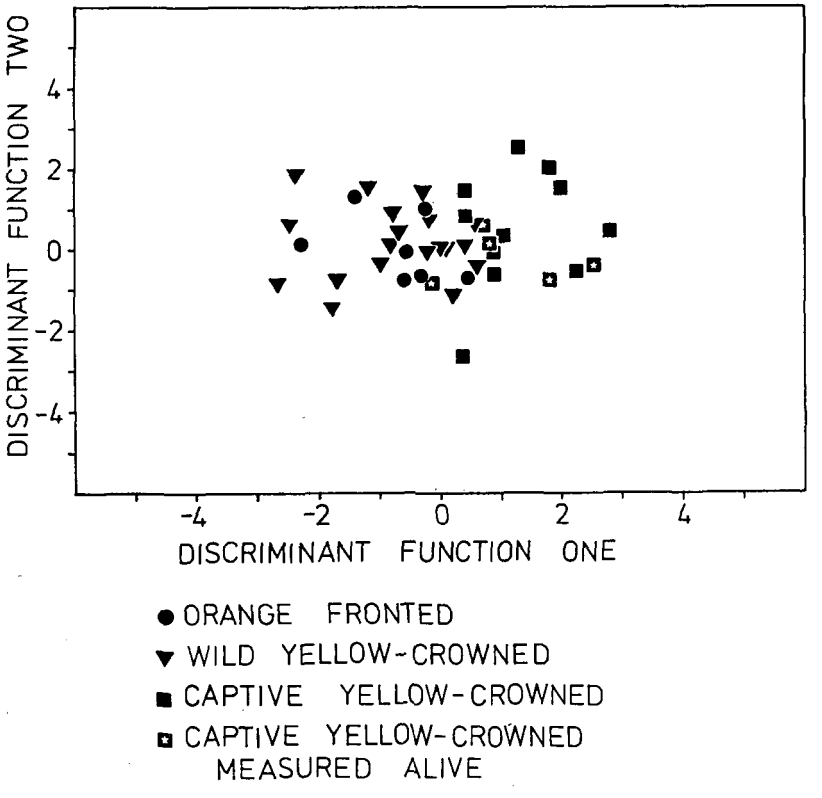

FIGURE 3 — Plotted discriminant scores of male Orange-fronted, wild Yellow-crowned, and captive Yellow-crowned Parakeets.

DISCUSSION

Contrary to what might be expected from the popular view, no marked size or shape differences have been found between the specimens of Orange-fronted and wild Yellow-crowned Parakeets examined. Captive-raised birds, on the other hand, are noticeably larger, and this may perhaps have led to the reported size differences that have been used to support specific status for the Orange-fronted Parakeet. Parakeets were popular cage birds at the time of Buller (Buller 1888) and Buller himself kept Yellow-crowned Parakeets (Buller 1870).

However, other factors are also likely to have confused this question. The size difference between sexes is perhaps the most obvious one; the species concept of the late 19th century is another. Buller and his contemporaries worked on the basis of the typological species concept, and although fascinated by spectacular variants, early ornithologists were not quick to recognise the range of continuous natural variation within a population. Many new 'species' were described from one or a few unusual specimens. *Platycercus aucklandicus, P. forsteri, P. novaezelandiae, P. pacificus* and *P. rowleyi* were all described on the basis of minor plumage and size variation but proved to be synonyms for the one species. Could the size variation within a species have added confusion to a failure to recognise polymorphism in the case of the Orange-fronted Parakeet ?

Holyoak (1974) suggested that the coloration of the Orange-fronted Parakeet can be explained as a partial lack of carotenoid pigment under the control of a single gene or several closely linked genes. But Fleming (1980) raised several other points relating to taxonomic status, which seem to favour specific status for the Orange-fronted Parakeet. In addition to the record he gave of flocking, Fleming cited " its constancy, its apparent restriction to the South Island . . . and its failure to turn up in a century's experience of aviary breeding of *C. auriceps* . . .", and he also alluded to a separate subalpine ecology.

C. malherbi specimens are not entirely constant in colour (Holyoak 1974, J. A. Bartle, pers. comm.), but even so, consistency is not necessarily evidence against colour polymorphism. More or less consistent colour varieties occur in many other platycercine parakeets. For example, pale forms of Scarlet-chested Parrot *(Neophema splendida)* and Bourke's Parakeet *(N. bourkii)* have been bred that appear to have a partial lack of carotenoid but normal melanin pigmentation (Musil 1970).

Although colour morphs showing variations comparable to the differences between *Cyanoramphus auriceps* and *C. malherbi* occur among other closely related species, the absence of the orange-fronted form from breeding aviaries is not surprising. If cage populations have originated from a small and geographically biased sample of birds (and thus genes), they could well lack rare alleles.

Musil (1970) also described apparently non-hereditary colour

variation among rosellas. Given that birds are unable to synthesise their own carotenoids (Fox & Vevers 1960), some environmental effect could be responsible for the coloration of the Orange-fronted Parakeet.

The restriction of Orange-fronted Parakeets to the South Island could be explained by the mutation being maintained in the south and not turning up in areas to which gene flow is cut off. However, there are references to Orange-fronted Parakeets in the North Island (Buller 1882), on Hen Island and Little Barrier Island (Buller 1884), Stewart Island (Harrison 1970), and the Auckland Islands (Gray 1859). These records were discounted by Harrison (1970), who proposed that the Orange-fronted was probably confined to the South Island. We should remember that this was a tentative conclusion drawn from very scant records and there remain uncertainties regarding the former distribution of this bird. For example, Harrison suggested that the specimen in the National Museum from the Wairarapa may be a caged bird referred to by Buller, but the Museum records state the specimen was shot. Buller's (1884) account of Reischek's meeting with Orange-fronted Parakeets on Hen Island and Little Barrier gives the particulars of birds observed and shot. The detail of this record, plus the existence of museum specimens allegedly from Hen Island, infer some reliability.

The question of alpine habitat was settled by Harrison (1970) and there remains no good reason to believe that the Orange-fronted Parakeet was found outside the natural range of the Yellow-crowned Parakeet. The species group may not therefore fit Fleming's model of Pleistocene speciation as well as do other bird groups with alpine members.

Finally, the record of flocking as evidence of specific status must be considered alongside Buller's (1870) quotation from Haast's letter that " these two kinds [Orange and Yellow] occur always together but in some localities the first, and in others the second is predominant." These observations really tell us very little about the behaviour of parakeets; they merely illustrate the poverty of our knowledge, with which we can only speculate.

Now that live Orange-fronted Parakeets have been found, we should be able to learn more by field observation and captive breeding. Should *C. malherbi* be confirmed as a good species, a detailed study of its ecology with regard to the competitive exclusion principle is warranted, given its close similarity in size and habits to *C. auriceps*. But if the colour morph hypothesis is correct, much effort in manpower and money could be better directed to " real " rare species, although breeding experiments in captivity may be of interest in understanding more about the genetics of bird coloration. The differences between Orange-fronted and Yellow-crowned Parakeets appear to be not as great as once thought, but further field and aviary studies are needed to resolve fully the question of taxonomic status.

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