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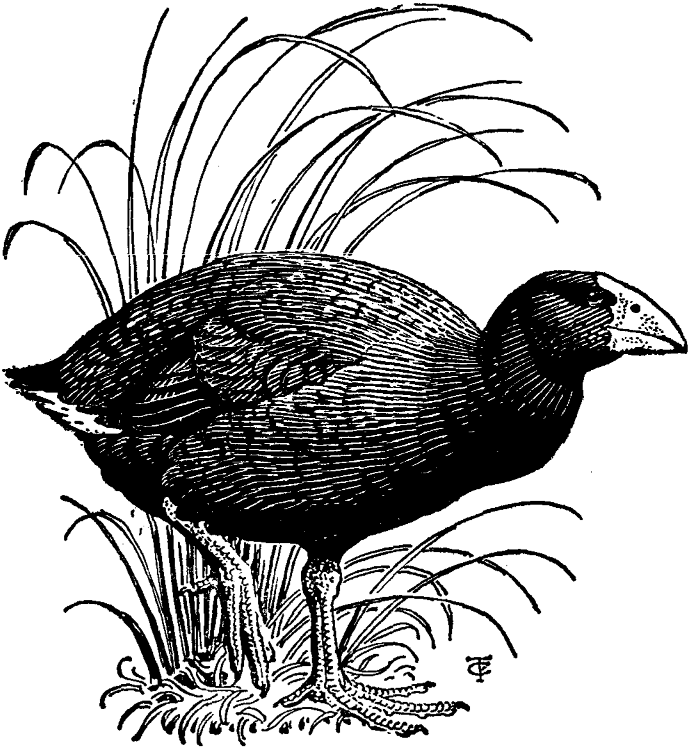

Volume 29 Part 3 September 1982

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ISSN 0029-4470

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NOTORNIS

is the journal of the Ornithological Society of New Zealand (Inc.)

Editor: B. D. Heather,
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VOLUME 29 PART 3 SEPTEMBER, 1982

AND THEN THERE WERE TWELVE: THE TAXONOMIC STATUS OF Anomalopteryx oweni (AVES: DINORNITHIDAE)

By P. R. MILLENER

ABSTRACT

Re-examination of the type material of *Anomalopteryx oweni* (Haast) indicates that this taxon should be synonymised with *A. didiformis* (Owen).

In his recent reassessment of moa taxonomy Cracraft (1976) accepted only 13 species as valid, in marked contrast to earlier taxonomic schemes (e.g. those of Hutton 1892, Rothschild 1907, Archey 1941, Oliver 1949), in which as many as 38 species had been accepted.

In this paper *Anomalopteryx oweni,* one of the taxa admitted by Cracraft, is reduced to junior synonymy with *A. didiformis,* thus leaving just 12 species in the family (see also Millener, 1981).

The species *Anomalopteryx oweni* (Haast, 1886) was founded upon an incomplete skeleton collected by T. F. Cheeseman in 1878 from a limestone cave near the Pataua River, Whangarei district — not, as Oliver (1949: 8) implied, from sand dunes at Pataua Beach. This type skeleton is held by the Auckland Museum (Cat. no. AM 9.9/384).

There has been considerable disagreement over the generic assignment of this species. Since Haast (1885, 1886) placed it in *Dinornis,* it has alternated between *Anomalopteryx* (e.g. Lydekker, 1891; Oliver, 1949; Cracraft, 1976) and *Pachyornis* (e.g. Archey, 1941; Brodkorb, 1963) depending apparently on whether cranial or post-cranial features were given diagnostic priority. A close re-examination

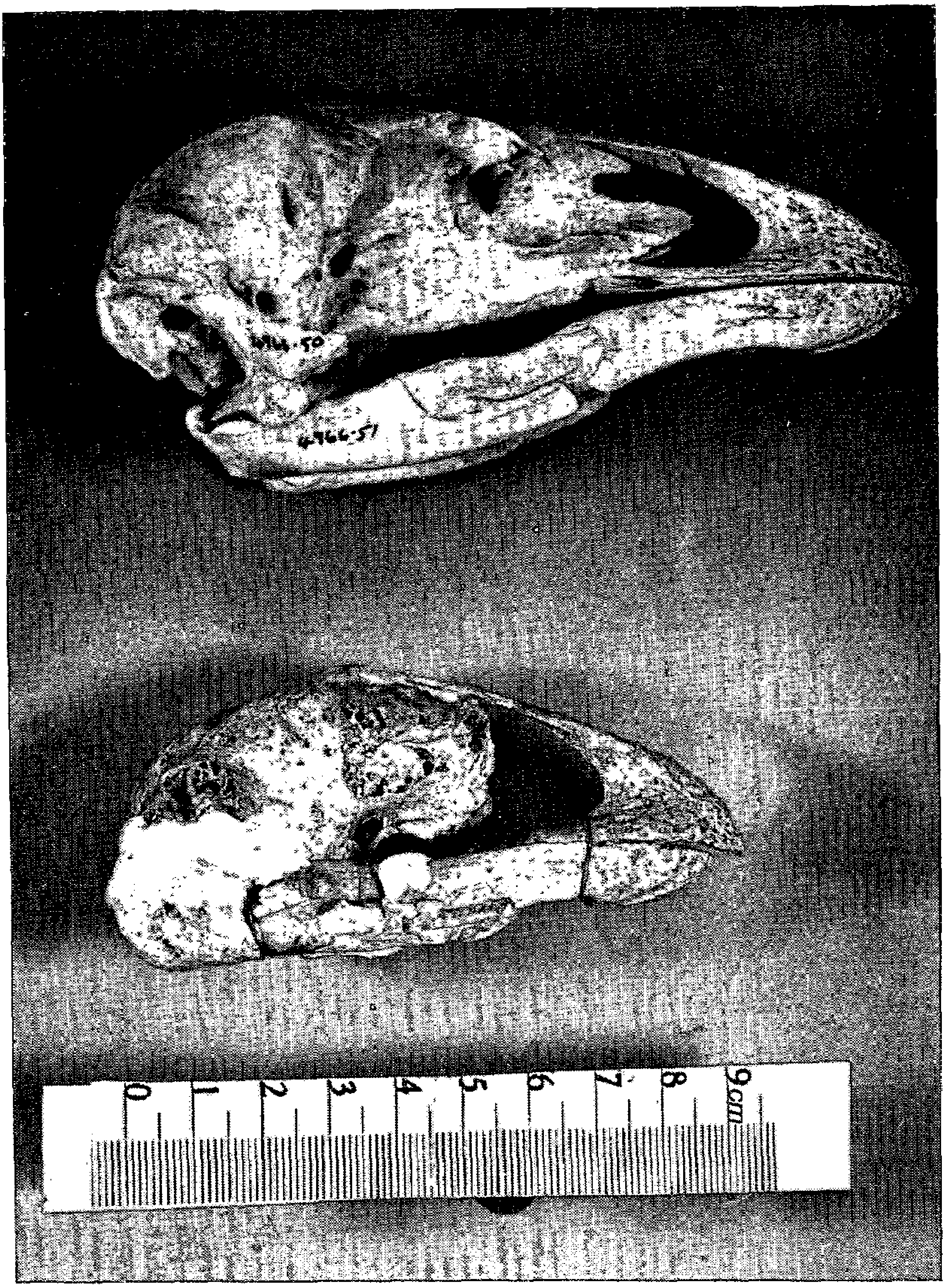

FIGURE 1 — **Anomalopteryx didiformis** skulls, lateral view.

Upper: AU4966 Gardner's Gut Cave, Waitomo

Lower: AM 9.9/384 Pataua River, Whangarei — skull of type **A. oweni.** Faulty reconstruction of this specimen has resulted in its being markedly foreshortened and dorsoventrally compressed (cf. Fig. 3)

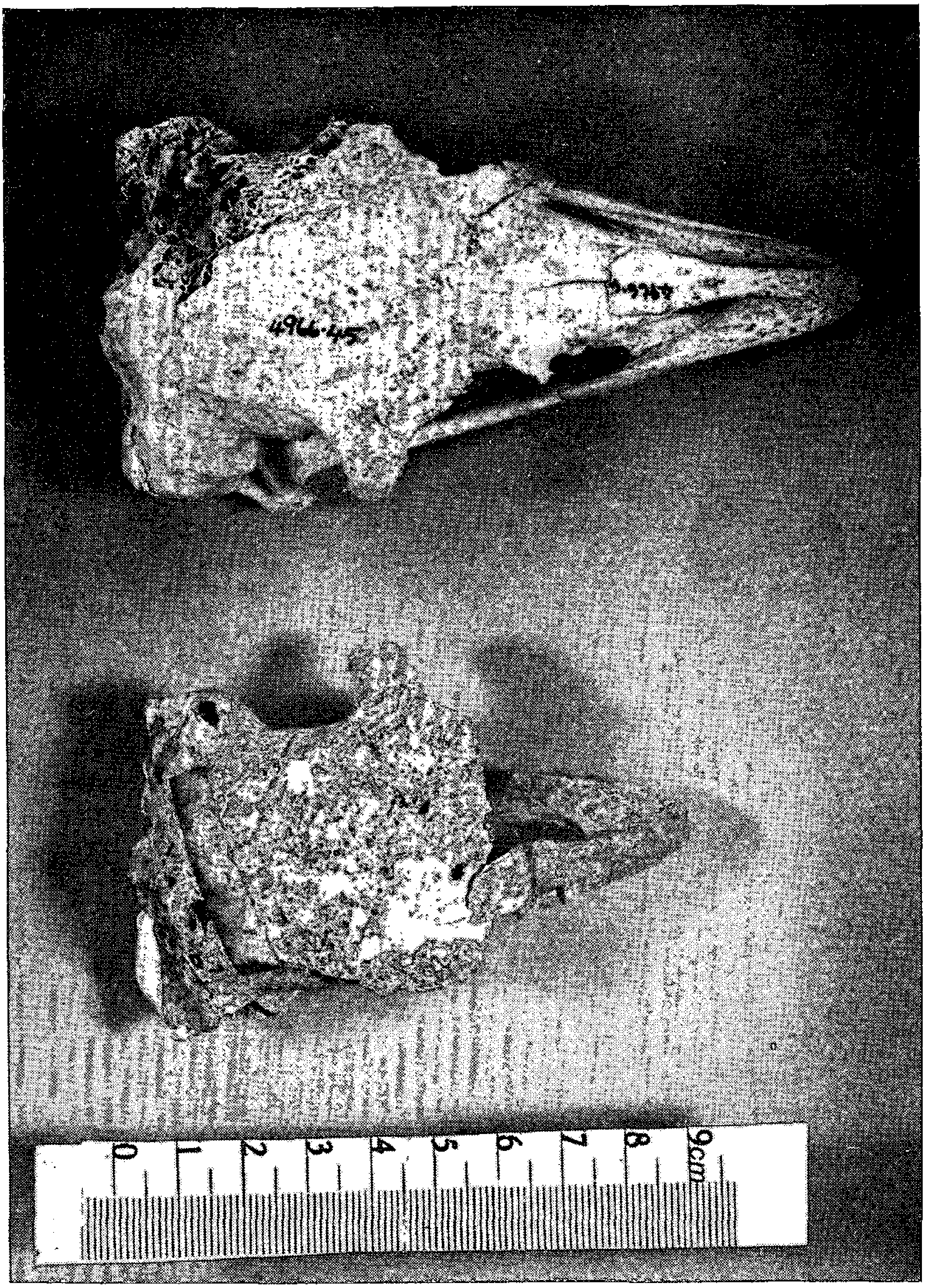

FIGURE 2 — **Anomalopteryx didiformis** skulls, dorsal view. Details as for Figure 1.

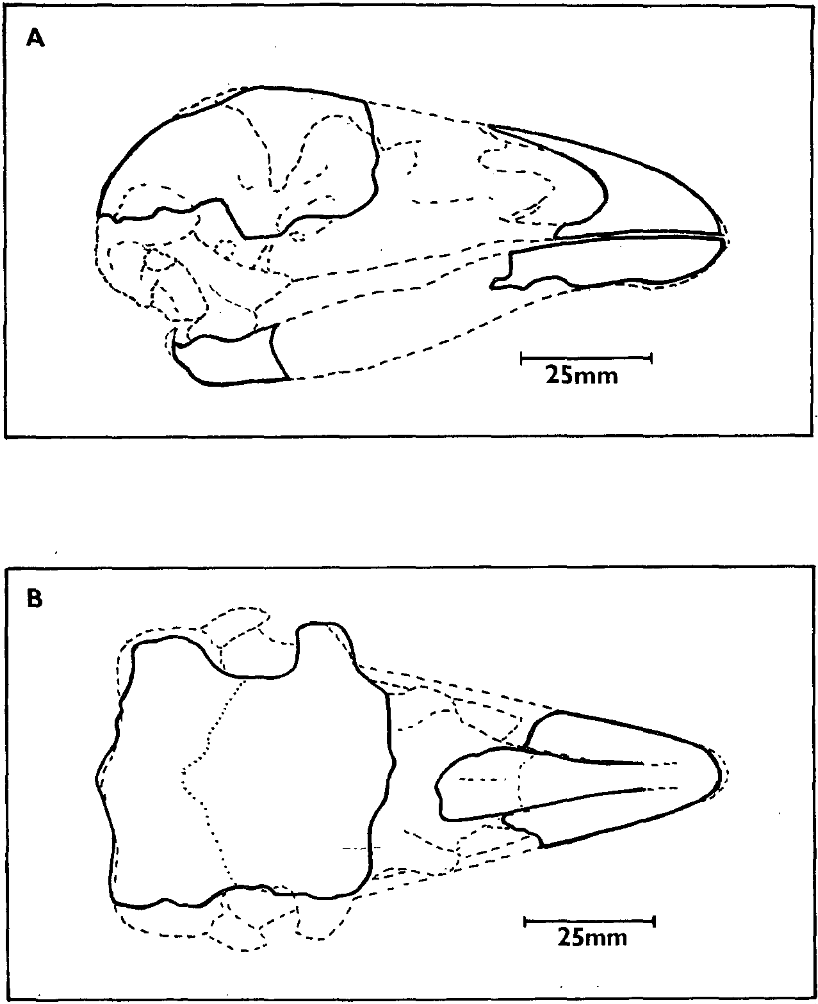

FIGURE 3 — A: Lateral view of skulls of **Anomalopteryx didiformis.** Dashed line —outline of AU4966. Solid line — superimposed outline of AM 9.9/384 (Type of **A. oweni**)

B: Dorsal view, as above. The incompletely fused frontoparietal suture of AM 9.9/384 is indicated by the dotted line across the cranium

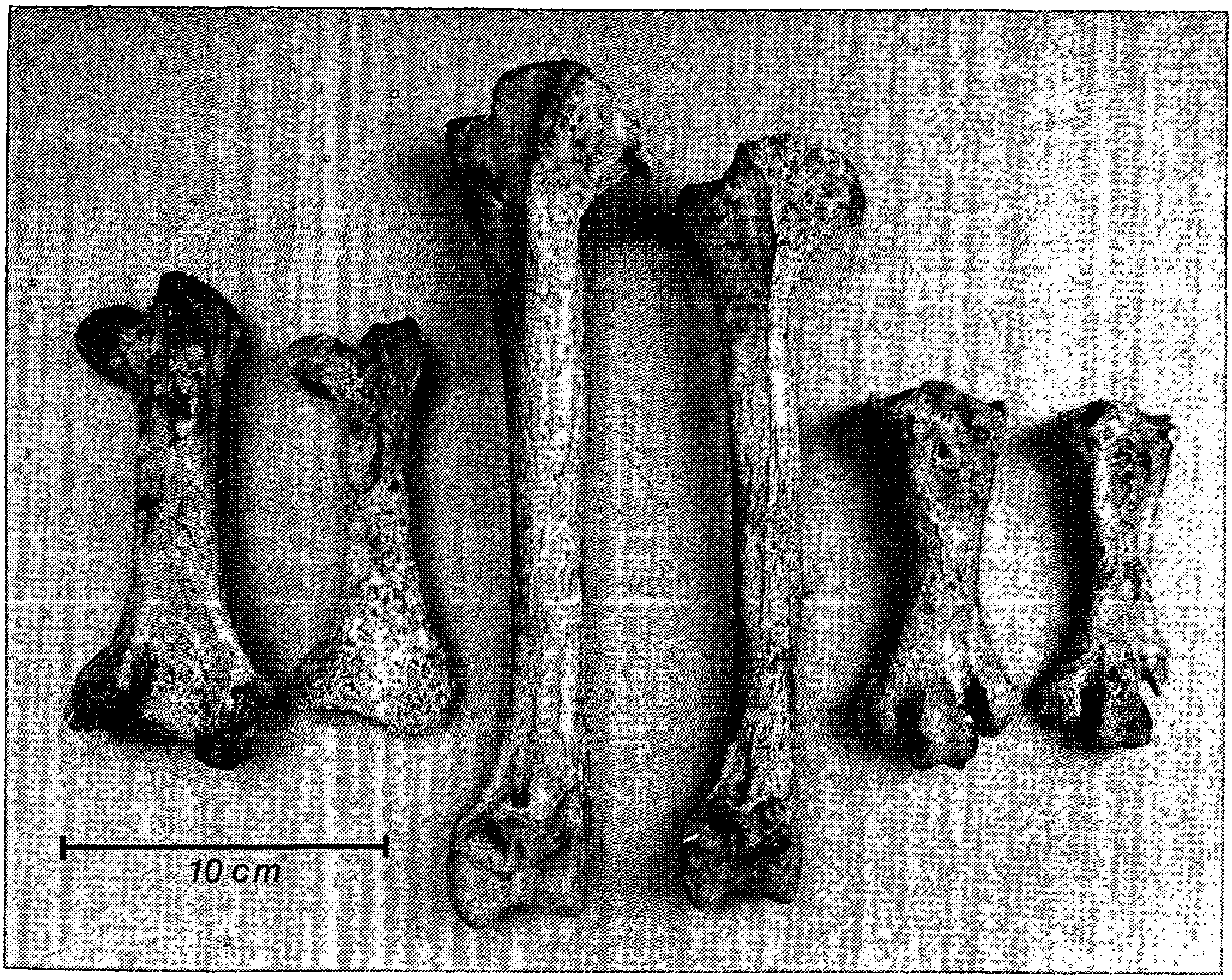

FIGURE 4 — **Pachyornis mappini**: femora, tibiotarsi, tarsometatarsi.
Left of each pair: AM 8.6/84 Cave M, Waikaremoana
Right of each pair: AM9.9/384 Pataua River, Whangarei
(Type of **Anomalopteryx oweni**)

of the type material and comparison of it with numerous examples of *Pachyornis* and *Anomalopteryx,* I believe resolve the dilemma.

The cranium, which most authors have chosen to show the diagnostic features of *Anomalopteryx,* has, as was noted by Haast (1886) in his type description, cranial sutures which are not fully fused, showing that it is from a subadult bird. Significantly, Haast (1886: 174) also noted that the cranium seemed disproportionately large for the rest of the skeleton. In contrast to the skull, the hind limb elements, which show all the essential features of *Pachyornis,* are without doubt from a fully mature individual as their epiphyses are completely fused to their shafts: again this was a feature noted but not further commented upon by Haast. Further, close examination of the skull and the post-cranial skeleton reveals that they differ noticeably in bone colour and texture, and that even traces of sediment adhering to them do not seem completely comparable.

Clearly, then, the skull (Figures 1-3) and the post-cranial skeleton (Figure 4) seem not to have come from the same individual, and indeed might not even be from the same site.

TABLE 1 — Lengths (mm) of legbones of **Anomalopteryx 'oweni'** and **Pachyornis mappini** (data from Archey 1941, Oliver 1949, Millener 1981). The suggested range for **mappini** was given in Millener (1981: 492).

	TYPE 'oweni' (AM 9.9/384)	Previously listed as 'oweni' [= mappini of this paper]	Previously listed as mappini or 'septentrionalis' [= mappini of Cracraft 1976]	Suggested range for mappini
Femur	143	135-163	139-224	135-c.230
Tibiotarsus	243	230-285	273-417	230-c.420
Tarsometatarsus	113	101-128	127-168	101-c.180

The type of *Anomalopteryx oweni* comprises a partial skeleton, of which the skull was the first element mentioned in the type description. As shown above, however, the type material is composite, and I have chosen the syntype skull as the lectotype of *oweni*. As this skull shows all the essential features of *A. didiformis* and indeed falls readily into the size range for that species, I propose that *A. oweni* be synonymised with *A. didiformis*, leaving the latter as the only species now recognised in the genus.

All the post-cranial elements appear to be from the one individual and on form and size can readily be assigned to *Pachyornis mappini* (see Table 1).

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SEXUAL DIMORPHISM IN SNOW PETRELS
Pagodroma nivea

By J. P. CROXALL

ABSTRACT

By means of data in the literature and a large sample of sexed birds from Signy Island, South Orkney Islands, Snow Petrels are shown to be sexually dimorphic in size and especially in body weight and bill length. By these characters alone, over 80% of Signy birds can be correctly sexed.

It is suggested that the true status of the so-called large and small forms of the species can best be resolved by comparing birds of known sex and status. The sexual dimorphism in weight in Snow Petrels is amongst the greatest in the Procellariiformes and might relate to the extensive use of vocalisations in individual and sex recognition.

INTRODUCTION

The range of variation in size of Snow Petrels *(Pagodroma nivea)* at breeding stations on the Antarctic continent has received considerable attention. Prevost (1969) and Isenmann (1970) provided extensive quantitative reviews of the literature and of their own specimens collected in Adelieland and adjacent regions. Prevost (1969) concluded that a large form of the species *(Pagodroma nivea major)* bred in Adelieland and probably at the Balleny Islands and a distinctly smaller form *(Pagodroma n. nivea)* bred elsewhere. A more qualitative review by Cowan (1981) recorded the existence of an apparently intermediate population at Casey and concluded that size variation in Snow Petrels is essentially of a continuous nature and that recognition of infraspecific taxa based on variation in size is not desirable.

None of these authors took into account the marked sexual dimorphism in size in this species, which is clearly of potential importance in this context. My purpose here is to review the nature and extent of this sexual dimorphism, with the aid of recent data from Signy Island, South Orkney Islands (60°43'S, 45°36'W), and to comment briefly on its implications for analysis of morphometric variation in Snow Petrels.

MATERIALS AND METHODS

The data used from the literature are mainly from samples where a reasonable number of sexed mature specimens from a single breeding locality had been measured and where at least the weight, wing length, tarsus and bill length had been recorded. Unfortunately

TABLE 1 — Measurements of Snow Petrels. Mean values with standard deviation in parentheses. Weight in grams; other measurements in millimetres

Location and sample size	Weight			Wing			Tarsus		Bill length			Bill depth			Reference
	Male		Female	Male		Female	Male	Female	Male		Female	Male		Female	
Cape Hunter (3 ♂ 5 ♀)	317 (85)		291 (48)	276 (12)		271 (21)	35.2 (2.7)	34.1 (3.3)	22.5 (1.8)		21.4 (2.0)	11.6 (1.6)		11.7 (1.2)	Isenmann *et al*, 1969
Cape Denison (7 ♂ 4 ♀)	332 (18)	***	244 (17)	268 (4)	**	255 (5)	33.7 (4.1)	31.6 (1.9)	22.5 (1.1)	***	19.0 (0.8)	11.9 (0.5)	***	10.5 (0.2)	Isenmann *et al*, 1969
Cape Hallett (10 ♂ 4 ♀)	290 (20)		276 (19)												Maher 1962
Bluff I. (6 ♂ 6 ♀)	268 (19)	*	246 (16)	264 (3)		259 (7)	32.4 (0.8)	32.3 (0.8)	20.9 (0.5)	*	19.8 (0.6)				Brown 1966
Anchorage I. (6 ♂ 6 ♀)	293 (18)	*	246 (21)	264 (4)	*	256 (3)	33.4 (1.5)	32.3 (1.0)	20.5 (0.6)	***	18.8 (0.6)				Brown 1966
Signy Island (18 ♂ 21 ♀)				278 (6)	**	270 (6)	38.2 (1.3)	37.2 (1.2)	22.3 (1.1)	***	20.2 (1.1)				This paper
Adelieland (79-91)	400 (range 242-525)			290 (range 242-320)			37.3 (range 30.0-42.5)		23.8 (range 19.0-27.8)			12.6 (range 9.8-14.7)			Prevost 1969
Casey (178)				c276 (range 240-320)			c36.3 (range 31-44)		c22.1 (range 18-27)						Cowan 1981, Fig. 4

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

in many large samples, especially those from Adelieland and Casey, no attempt was made to sex birds.

At Signy Island, the occupants of up to 50 marked nest sites are all ringed and are checked annually. Many of these birds have been sexed by cloacal inspection, by observed egg-laying, by presence at the nest on the day on which the egg was laid, or by vocalisation (see Isenmann 1970, Guillotin & Jouventin 1980). For ecological purposes (see Croxall & Prince 1980, 1982), some of these birds were measured for weight, bill length and wing area between 2 and 9 January, near the mean date of hatching (8 January), when incubation shifts are short and a good sample of birds of both sexes can be quickly obtained. Other measurements (but not weight) are available for birds measured at various times in several seasons.

Sets of data are compared using 't' tests.

RESULTS

Table 1 gives data from the small samples available of sexed birds from six sites and, for comparison, data for the unsexed samples from the important sites at Casey and Adelieland.

Except for bill depth at Cape Hunter, males are larger than females in all dimensions. The differences are statistically significant most frequently for weight and bill length (four sites); wing length differences are significant at three sites; tarsal length differences are significant only at Signy Island. Based on the Cape Denison sample and Prevost's (1969) comments, bill depth is probably also usually significantly different between sexes.

Data for the Signy Island breeding pairs are given in Table 2. At 19 nests at least one member of the pair was already sexed by

TABLE 2 — Snow Petrel measurements at Signy Island. Conventions as in Table 1

Sample size	Weight			Bill length		
	Male		Female	Male		Female
1. 20♂ 20♀	341 (30)	***	293 (25)	21.7 (1.8)	***	19.9 (1.5)
2. 23♂ 23♀	339 (20)	***	281 (24)	21.8 (1.5)	*	20.4 (1.9)
3. 43♂ 43♀	340 (25)	***	286 (25)	21.7 (1.6)	***	20.1 (1.7)

TABLE 3 — Weights (grams ± one standard deviation) of sexed Snow Petrels from Adelieland. From Guillotin & Jouventin (1980, Table 5)

Sample size	Male		Female
a. 8♂ 9♀	460 ± 43	***	380 ± 42
b. 12♂ 13♀	459 ± 35	***	358 ± 32
c. 9♂ 9♀	443 ± 49	***	339 ± 49

TABLE 4 — Sexual dimorphism index (♀/♂ x 100) of Snow Petrel populations

Site	Weight	Wing	Tarsus	Culmen
Cape Hunter	92	98	97	95
Cape Denison	73	95	94	84
Bluff I.	92	98	100	95
Anchorage I.	84	97	96	92
Signy*	84	97	97	91
Adelieland+ (a)	83			
(b)	78			
(c)	77			

* From Table 1 and Table 2 sample 3

\+ From Table 3

the non-mensural characteristics listed above and weight and bill length data were available for both birds of the pair. At two nests the sexed birds, but not their partners, could be caught. These data form sample 1. To increase the sample of reliably sexed birds, individuals at other nests were assigned to a sex only if their weight or bill length exceeded the range of values for the 20 birds of each sex in sample 1. The 23 birds directly sexed in this way will obviously show a bias towards large males and small females. However, the size of the partners of these birds should not be biased in any way. The data for these 23 pairs, which form sample 2, are not statistically different from the birds in sample 1, and they are combined to form sample 3. Except for bill length in sample 2, all differences between sexes are highly significant. Signy birds are all significantly heavier ($p = 0.01 - 0.001$) than those from any other site, except Cape Hunter and except for males from Cape Denison and females from Cape Hallett.

Recent data from Adelieland (Guillotin & Jouventin 1980) show similar highly significant differences in weight between the sexes for three samples from different types of breeding site (Table 3). These birds are very significantly heavier ($p << 0.001$) than those from any site in Table 1, being 25-30% heavier even than Signy birds.

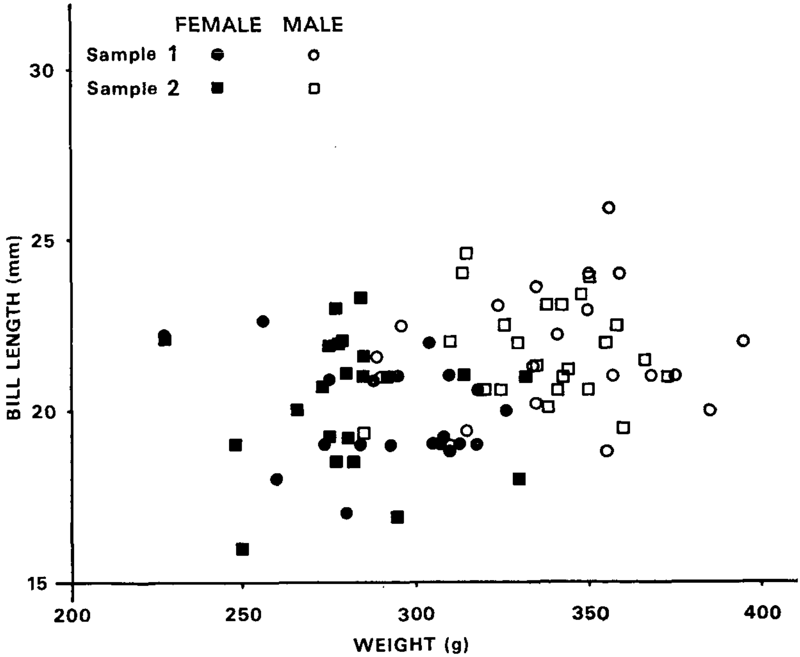

FIGURE 1 — Bill length and weight of sexed Snow Petrels from Signy Island, South Orkney Islands. Sample numbers refer to Table 2.

TABLE 5 — Index of sexual dimorphism in weight for various Procellariiformes

Species	Index	Reference
Northern Giant Petrel *Macronectes halli*	76.3	S. Hunter, pers. comm.
Southern Giant Petrel *M. giganteus*	77.9	Conroy 1972
Wandering Albatross *Diomedea exulans*	78.2 78.7	Croxall & Ricketts in press, Table 3; Tickell 1968
Waved Albatross *D. irrorata*	81.1	Harris 1973
Snow Petrel*	83.0	This paper
Royal Albatross *D. epomophora*	84.4	Sorensen 1950
Northern Fulmar *Fulmarus glacialis*	79.9-84.7	Mougin 1967; Cramp & Simmons 1977
Cory's Shearwater *Calonectris diomedea*	86.5	Zino 1971
Laysan Albatross *D. immutabilis*	87.5	Fisher 1967
Antarctic Fulmar *F. glacialoides*	88.2	Mougin 1967
Grey-faced Petrel *Pterodroma macroptera*	90.2	Imber 1976
Cape Pigeon *Daption capense*	92.1	Pinder 1966
Grey Petrel *Procellaria cinerea*	92.2	Barrat 1974
Sooty Albatross *Phoebetria fusca*	92.3	Berruti 1979
Black-browed Albatross *D. melanophrys*	94.2	Prince *et al.* 1981
Short-tailed Shearwater *Puffinus tenuirostris*	94.3	Palmer 1962
Antarctic Prion *Pachyptila desolata*	95.6	Tickell 1962
Grey-headed Albatross *D. chrysostoma*	96.6	Prince *et al.* 1981
Manx Shearwater *Puffinus puffinus*	97.3	Brooke 1978
Audubon's Shearwater *P. lherminieri*	98.5	Harris 1969
Dark-rumped Petrel *Pterodroma phaeopygia*	99.8	Harris 1970
Great Shearwater *Puffinus gravis*	100.6	Hagen 1952
Black-bellied Storm Petrel *Fregatta tropica*	100.9	Beck & Brown 1971
Leach's Storm Petrel *Oceanodroma leucorhoa*	104.1	Palmer 1962
White-bellied Storm Petrel *Fregetta grallaria*	121.3	Hagen 1952

* Mean weighted by sample size from each site

The degree of sexual dimorphism is summarised as an index in Table 4, where the Bluff Island and Cape Hunter populations stand out as least dimorphic (especially by weight). Weight and bill length are clearly the best discriminators between the sexes.

The use of weight and bill length data in sexing Snow Petrels is shown in Fig. 1, where these characters are plotted together for the Signy Island birds in Table 2, samples 1 and 2. Although there is clearly some overlap between the sexes, weight and bill length alone will allow correct sexing of 85% of the birds. Better discrimination would undoubtedly be achieved by use of a third character, and bill depth is likely to be the best measurement to use.

DISCUSSION

The Snow Petrel shows a remarkable degree of sexual dimorphism in weight, being proportionately one of the most dimorphic species of the Procellariiformes, data for 25 species of which are summarised in Table 5. Snow Petrels are sexually dimorphic in other mensural characteristics, but particularly so in bill length (and possibly bill depth). With the use of weight and bill length, probably over 80% of adult birds at any locality can be correctly sexed. If pairs of breeding birds are measured even better results are likely because at Signy it is very rare for the female of a pair to be larger than her mate. Thus, the smallest male (285 g; bill 19.3 mm) was still appreciably larger than his partner (248 g; 19.0 mm).

Cowan (1981) advocated that wing length should be the main standard for comparison of Snow Petrels. This may be desirable when comparing unsexed material because wing and tarsal length show least differences between sexes, but if birds are to be sexed — and this must surely make comparisons both more accurate and more relevant biologically — a full set of measurements should be made. Undeniably, weight is the most variable measurement, and so it is the more remarkable that the sexual dimorphism in weight of Snow Petrels is so clear. If, however, sampling is restricted to breeding birds, weights will be much more comparable and variations will relate mainly to changes during incubation and chick rearing. As Snow Petrels do not undertake particularly long incubation fasts, with mean values over all shifts 3-6 days (Mougin 1968, Isenmann 1970), the mean weight loss per day at this time would be about 7 g (Croxall 1982) and this degree of weight variation is unlikely to cause serious problems with comparing and analysing data.

Wing length, being invariably the longest linear measurement made, is perhaps the most accurate, but in other studies of Procellariiformes it is also a poor indicator of sexual differences (see Tickell 1968 Table 4, Conroy 1972 Table 4 — but note that in this the mean female wing length is incorrect, as are most 't' values —, Brooke 1978). Despite their small absolute size, bill dimensions are commonly used to sex a wide range of seabirds, e.g. Northern Fulmar (Dunnet &

Anderson 1961), Wandering Albatross (Tickell 1968, Fig. 9), Southern Giant Petrel (Conroy 1972, Fig. 2), various penguins (e.g. Warham 1975) and shags *Phalacrocorax* spp. (J. C. Coulson, P. Shaw, pers. comm.), and they appear to be equally useful in the Snow Petrel.

What significance, then, does the recognition of substantial sexual dimorphism in Snow Petrels have for interpreting their morphometric variation? If we take first the accepted view (i.e. before Cowan 1981) that a large form breeds in Adelieland and a smaller one elsewhere, then Guillotin & Jouventin's (1980) graph of the distribution of wing length measurements portrays this situation adequately by showing two distinctly separate peaks but with substantial overlap. Recognition of the degree of sexual dimorphism (even in wing length) means that most overlap consists of large males of the small-sized population and small females of the large-sized population. Thus the two populations are much more distinct than hitherto appreciated.

The nature of the population at Casey, however, complicates matters and it is unfortunate that weight data are lacking and that precise summary statistics are not explicitly stated and have to be derived from text-figures. In mean wing length, Casey birds are close to the small Signy sample and about twice as close to the smaller-sized populations than to the Adelieland birds. If they have similar body mass to Signy birds, the disparity in this character from Adelieland birds is greater still. If this was all, we might still conclude that the overlap between Casey and Adelieland birds was the product of large males from one and small females from the other. However, as Cowan (1981) recognised, the ranges of values for all linear measurements from Casey are virtually identical to those from Adelieland, and it is principally the 'centre of gravity' of the populations that seems to be so distinct. The situation at both sites should clearly be examined using only sexed birds of known reproductive status.

If birds of the same sex and status at Casey and Adelieland do prove to span a similar size range, yet the bulk of birds at each site is significantly different in most dimensions, this will be difficult to treat taxonomically but important to study to find out how the situation is maintained and its adaptive significance. Such a study would necessarily involve examining the mating system in the species and looking at the relationship between female dimensions and egg size, hatchling size (usually strongly correlated with egg size — see Croxall, in press) and fledgling size. Although Isenmann (1970) suggested that birds of different sizes favoured different nesting sites, Guillotin & Jouventin's (1980) data did not support this, and habitat differences between Adelieland and Casey are unlikely to be responsible for the morphometric differences of the birds there.

Why Snow Petrels show high sexual dimorphism is still not clear. In Wandering and Royal Albatrosses at least, dimorphism may have arisen by sexual selection operating through the potential for mate selection offered by the aggregation at display sites of large numbers of immature birds of both sexes. In giant petrels, the dimorphism may be significant in terms of the different feeding strategies of the sexes (S. Hunter, in prep.) and may have arisen through conventional intraspecific competition for food.

Neither explanation seems particularly plausible for Snow Petrels. Guillotin & Jouventin (1980) showed that in Snow Petrels body weight is correlated with the sound frequency of vocalisations. Both they and Isenmann (1970) emphasised the extensive role that vocalisations play in recognition of individuals and sexes in this species. In a species so entirely devoid of plumage marking, selection may have favoured the increased development of sexual dimorphism as a simple way of increasing the range of vocal frequencies available within the sexes of a population in order to provide the scope for an extensive intraspecific repertoire, given the very limited variations in phrasing that most Procellariiformes seem able to produce.

ACKNOWLEDGEMENTS

I thank K. Cameron, R. Forster, R. A. Price and other members of Signy station for weighing and measuring Snow Petrels. I am also indebted to J. R. Beck for sexing some of the birds used in this study. S. Hunter kindly allowed me to use unpublished data and he, W. R. P. Bourne and B. D. Heather commented helpfully on the manuscript. S. McInnes and B. Osborne assisted in data compilation.

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SHORT NOTE

TUI FEEDING ON SANDHOPPERS

On 6 December 1981 at the mouth of Sealers Creek on Codfish Island, northwest of Stewart Island, I saw a Tui fly from the adjacent muttonbird scrub and land on the wet sand beside the creek at low tide. The Tui moved around on the sand catching sandhoppers both on the surface and also by probing into the firm sand. This unusual behaviour lasted for about 3 minutes before the Tui flew to a stand of flax which was not then in flower. Inspection of the area where the Tui had been feeding revealed footprints and shallow probe holes over an area of about 4 m^2. Unidentified sandhoppers were numerous both on the surface and in the wet sand. The same feeding behaviour was observed again at low tide on the following day, but on this occasion the Tui, possibly the same bird, fed only briefly on surface sandhoppers before flying off. Tuis, like Bellbirds, have a broad diet of insects, fruits and nectar, but the taking of small marine crustacea from sand below high water is surprising and demonstrates the adaptability of this New Zealand honey-eater.

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A BREEDING STUDY OF THE SOUTH ISLAND FANTAIL (Rhipidura fuliginosa fuliginosa)

By MARY H. POWLESLAND

ABSTRACT

The breeding of the South Island Fantail was studied at Kowhai Bush, Kaikoura, for three breeding seasons from 1976 to 1978. Although 372 birds (nestlings and adults) were banded, few were seen again and very few bred in the study area.

Breeding occurred from August to February. Some pairs raised three broods but attempted up to five if failures occurred. Details are given of nests, nest building, egg laying, clutch size, incubation, hatching and fledging success, and juveniles. Both sexes shared nest building, incubation, brooding, feeding nestlings and feeding juveniles, although the division of labour was sometimes unequal. Some aspects of behaviour differed slightly from that of the North Island subspecies.

Females bred at one year old, but males could breed within one or two months of fledging when paired with an adult. A seemingly unpaired female successfully raised a brood of three young. Juveniles from one family group sometimes joined another family group and were accepted and fed by the foster parents.

Black pairs produced young in the ratio of three black to one pied, and black x pied matings produced approximately equal numbers of black and pied young. Pied pairs produced 97.8% pied and 2.2% black young, which conflicts with the model previously proposed for the genetics of melanism in the Fantail.

INTRODUCTION

The Fantail *(Rhipidura fuliginosa)* occurs in Australia, New Zealand and several other islands in the south-west Pacific. There are three subspecies in New Zealand, the North Island Fantail *(R. f. placabilis)*, the South Island Fantail *(R. f. fuliginosa)* and the Chatham Island Fantail *(R. f. penitus)*. Information on the breeding biology is available for all three subspecies; however, many studies were based on a few pairs only or are anecdotal in nature (Moncrieff 1931, Fleming 1949, Cunningham 1954, Blackburn 1966, Coates 1966, Flux 1974, Ude Shankar 1977 and Dennison *et al.* 1978, 1979). The most detailed studies are those by Blackburn (1965), McLean (1980) and McLean & Jenkins (1980). In the present study, observations were made on over 200 nests of the South Island subspecies at Kowhai Bush, Kaikoura, during the three breeding seasons 1976-77, 1977-78 and 1978-79. Hunt & Gill (1979) described Kowhai Bush and its flora and fauna in detail.

METHODS

As many birds as possible were banded with metal serial bands and size A butt-ended plastic colour bands supplied by the Wildlife Service. Each bird received a unique combination so that it could be recognised. Nestlings were banded at 9-11 days old. Adults and independent young were caught by mist-netting during the non-breeding season, and were banded and weighed. Mist-netting was most successful from March to May. A few adults were caught and banded on the nest. This did not cause desertion of any of the nests. The study area and surrounding areas were searched in the non-breeding season to find banded birds.

Banding was carried out to determine the dispersal and longevity of the birds. It also enabled the sexes to be distinguished. There is no visible difference between the sexes, but males tend to sing more than do females (Ude Shankar 1977, McLean & Jenkins 1980), and if one bird can be recognised (for example, if one or both birds are banded or if one is black), the sexes can be distinguished.

Nests were found by following adult Fantails. Both members of a pair share nest building, incubation, and feeding and brooding of the young, and so nests could be found by following one of the adult birds until it visited the nest. The nests were watched to get information on the different stages of breeding: nest building, egg laying, incubation, the nestling period and the juvenile period.

The South Island Fantail has two colour morphs, black and pied. The colour morphs of parents and their offspring were recorded and the results are discussed in relation to the findings of Caughley (1969) and Craig (1972).

In the following section, average values are given in the form: average ± standard deviation.

RESULTS AND DISCUSSION

Survival and dispersal

Over the three seasons, 372 birds were banded (Table 1). Few were seen again and very few bred in the study area in the following breeding season: 3 out of 132-160 nestlings and 7 out of 88 adults for the first two seasons.

Only three banded birds were found breeding outside the study area. Therefore, dispersal does not account for the absence of banded birds in the study area. Mortality was probably high over the winter, especially among immatures. McLean & Jenkins (1980) found a low survival rate among first-year Fantails on Cuvier Island, and a 66% loss of first-year birds was found in *Rhipidura javanica* in South East Asia (McClure *in* Ude Shankar 1977).

Only two birds banded at Kowhai Bush were known to have bred in two seasons. One of these, a female, was banded as a nestling in 1976 and bred in the following two breeding seasons. The other was an adult male which was banded in the 1977-78 season and which bred again in the 1978-79 season.

Most resightings of banded birds in the non-breeding season were before June. This partly reflects the less time I spent in the bush in winter, but Fantails seemed to be numerous in autumn and decreased in numbers over the winter. Ude Shankar (1977) found a similar pattern in Christchurch in 1975, when the numbers of Fantails seen dropped markedly in June. Likewise, McLean & Jenkins (1980) saw more banded birds on Cuvier Island in May 1973 than in August 1973 or in the subsequent breeding season. The birds may be quieter and therefore less conspicuous in winter, or mortality and dispersal may reduce their numbers. The low number of banded birds that were seen suggests that mortality was the main factor.

Weights

The average weight of 65 birds caught in autumn (March to May) was 7.6 ±0.6 g and the range was 6.4-9.1 g (Figure 1). The weights are for adult and first-year birds because, by March, immature birds had moulted into adult plumage and were indistinguishable from adults. The distribution is skewed slightly to the left but is not bimodal as would be expected if there was any weight difference between the sexes or between first-year birds and adults. Average

TABLE 1 — Summary of banding and resightings of fantails

Breeding Season	1976-77	1977-78	1978-79	Total
NESTLINGS				
No. banded	61	111	108	280
No. fledged*	≥56	76-104	≥ 76	≥ 208
No. resighted in autumn and winter	3	12	16	31
No. present in following breeding season	2	1	-	c.3
ADULTS				
No.. banded	41	47	4	92
No. resighted in autumn and winter	14	14	1	29.
No. present in following breeding season	6	1	-	c.7

* The exact number of nestlings which fledged was not known because some were not seen after fledging.

weights of birds for each month were March, 7.8 ±1.1 g (18 birds); April 7.4 ±0.7 g (4 birds); May 7.5 ±0.8 g (43 birds).

Breeding

The results of banding showed that both male and female Fantails breed when one year old. However, males can apparently breed as immatures, within one or two months of fledging. This occurred twice, in December 1976 and December 1978, when males in immature plumage paired with adult females whose previous mates had disappeared. Both females laid fertile eggs. The 1976 pair were seen together before nest building began. The female's previous nest had been preyed on at the nestling stage and her adult mate had disappeared at the time of predation. The 1978 pair was first seen just after a nest had been completed. Their history was not known

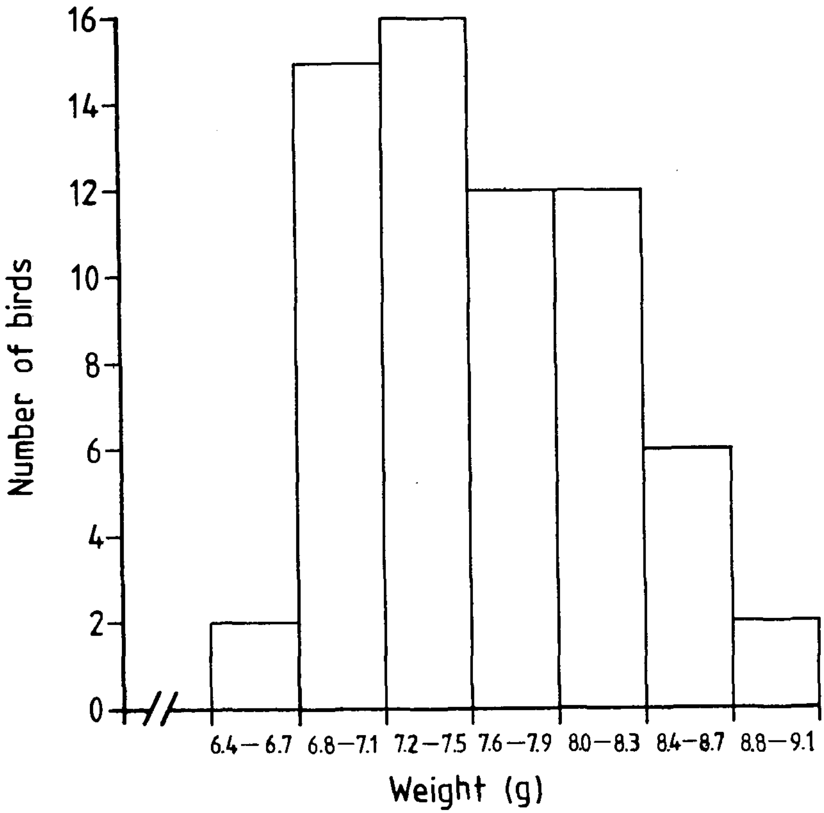

FIGURE 1 — Weights of Fantails in autumn (March-May) 1977 and 1978 (from 65 birds)

and the eggs may have been fertilised by a previous mate rather than by the immature male. The 1976 pair laid three eggs, all of which hatched, but predators took the nestlings at about five days old. The 1978 pair laid four eggs, all of which hatched, but the fate of the brood is not known.

Although the sexes shared breeding activities, birds could rear young alone. Sometimes, usually late in the season, one member of a pair disappeared, leaving the other to feed the nestlings. During mid-November 1978, one apparently unpaired female was found nest building and she subsequently raised a brood of three to fledging. She renested in the same nest and laid three eggs, one of which was infertile. However, the two nestlings were preyed on soon after hatching. I saw no male at any time, although I watched the nest for several one-hour periods during the incubation and brooding of both clutches, as well as making brief visits to check on the nest at other times. During my observation of incubation and brooding, the female came and went from the nest on her own. This contrasts with the behaviour of a normal pair, where one bird usually waits for the other to arrive before leaving the nest.

The number of pairs in the study area was not accurately assessed because only a small proportion of the pairs included a banded bird and not all nests or all pairs were found. Even in the areas searched most thoroughly, I occasionally found a pair where I had previously not heard or seen any birds.

In autumn and winter, Fantails were often in groups of more than two birds. However, when building began in August, they were in pairs and showed aggression to other Fantails. A banded male who bred in two breeding seasons occupied the same territory in both seasons and was seen on the territory in May of the intervening non-breeding season. He had a different mate in each season.

The breeding season extended from August to February. Nest building started in late August and the first eggs were laid in September; on the 10th in 1976, the 17th in 1977 and about the 11th in 1978. In the 1976-77 season, the last brood fledged on 8 February and in 1977-78 on 21 January. In 1978-79, one clutch hatched on about 20 January and chicks were still present in several other nests at this time. All these nestlings were preyed on but otherwise would not have fledged until early February.

The breeding season of Fantails at Kowhai Bush was shorter than that of the North Island Fantail at Gisborne, where the first eggs were laid in August and the last young fledged in March (Blackburn 1965). This may reflect the milder North Island climate. However, the 1981 breeding season on Tiritiri Matangi Island (Hauraki Gulf) did not start until November (I. G. McLean, pers. comm.) and so there is considerable variation in starting time. The shorter breeding season at Kowhai Bush meant that fewer successful broods were possible; two or three compared with three to five in Blackburn's study.

TABLE 2 — Fate of fantail eggs in each month of the breeding season

Month	No. of eggs laid	Per cent hatched	Per cent failed to hatch: Preyed upon	Infertile	Abandoned	Other
September	103	83	8	3	3	3
October	122	89	4	0	0	7
November	207	85	11	1	1	2
December	107	74	24	0	0	2
January	7	100	0	0	0	0
Total	546	83	12	1	1	3

Most pairs had several successive nests during the breeding season. However, the exact number of nests for most pairs in a season was not determined because of the problems of identifying birds and because not all nests were found. In 1976-77, one pair had five nests, of which the contents of at least two were preyed upon. One clutch fledged and another two clutches may have fledged. In 1977-78, no pair produced more than two broods of fledglings, but in 1978-79 one pair raised three broods to independence. Thus a pair was able to raise three broods within a breeding season, but most pairs lost one or more clutches and could build and lay in up to five nests. Predation considerably diminished the breeding success of the Fantails at Kowhai Bush (Tables 2 and 3), where the main predators were mustelids and rodents (see Flack & Lloyd 1978, Moors 1978).

Nests

Nests were built in mahoe *(Melicytus ramiflorus)*, 19% of 202 nests; kanuka *(Leptospermum ericoides)*, 17.8%; karamu *(Cop-*

TABLE 3 — Fate of Fantail nestlings in each month of the breeding season

Month	No. Hatched	Per cent Fledged	Per cent failed to Fledge: Preyed Upon	Died in nest	Other	Per cent unknown
September	85	71	4	0	2	23
October	109	57	11	6	6	20
November	176	55	18	3	1	23
December	79	34	18	3	1	44
January	7	71	29	0	0	0
Total	456	55	14	3	2	26

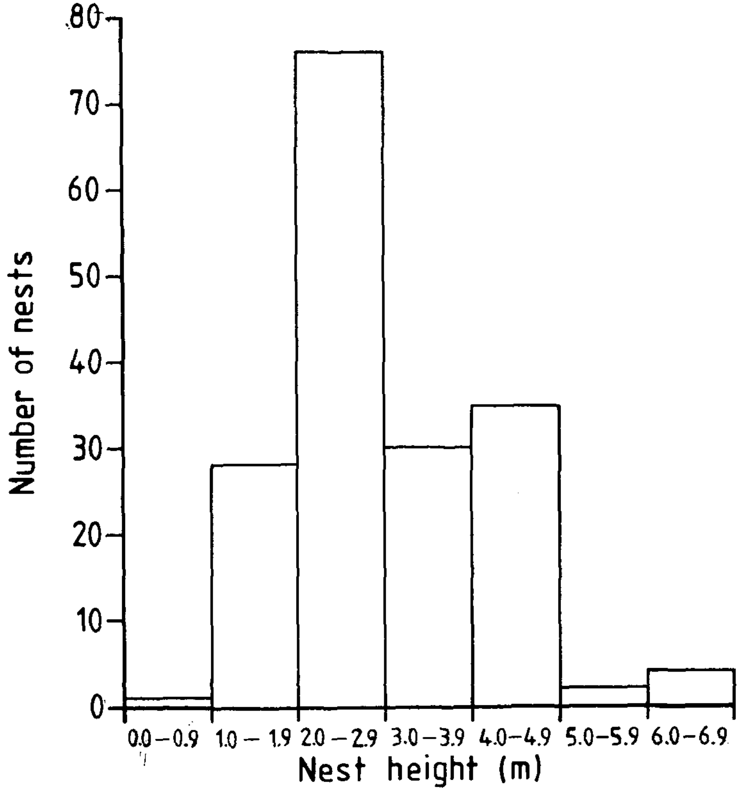

FIGURE 2 — Frequency distribution of nest heights of the Fantail, 1976-1978 (176 nests)

rosma robusta), 8%; tutu *(Coriaria arborea)* and *Coprosma australis*, 4% each; and 22 other species.

Nest height varied from 0.8 to 6.9 m and most nests were between one and five metres (Figure 2). The mean height was 2.9 ±1.1 m (176 nests), as compared with a canopy height of 7-12 m. Average nest height varied little from year to year: 2.9 ±0.9 m in 1976 (52 nests), 3.0 ±1.3 m in 1977 (73 nests) and 2.8 ±1.1 m in 1978 (51 nests). The F-value from a single classification ANOVA is 0.58, which is not significant. Similarly, nest height varied little from month to month: 3.4 ±1.2 m in September (27 nests), 2.6 ±1.1 m in October (38 nests), 2.9 ±1.2 m in November (67 nests), 2.9 ±0.9 m in December (38 nests) and 2.9 ±1.0 m in January (6 nests). The F-value is 1.72, which is not significant.

Nests were usually built around several thin branches, for example, where several branches forked close together in mahoe or the crown of kanuka. Most nests were sheltered from above by foliage. Birds started building by wrapping cobwebs, then other material such as wood fibres and moss, around a branch. This was extended below into a ' tail ' (though this was not always present) and built up above to form a base. Then the cup was added and finally the nest was lined with fine material such as dried grass, rootlets, moss setae, fern hairs or wool. Material was sometimes carried several hundred metres, although it was often gathered near the nest.

Both sexes built, although the amount done by each varied. Often one bird, apparently the female, did all the building when there were dependent juveniles from a previous nest, but in at least two such cases both birds built. Ude Shankar (1977) at Christchurch, found that the female played a greater role in nest building than did the male. She determined that when juveniles were not present the male assisted the female during the early stages of building, but that he spent more time foraging, feeding the female, and displaying than building. When juveniles were present, he spent even less time building. I. G. McLean (pers. comm.) found that on Tiritiri Island the male of the North Island subspecies did no building, even when there were no juveniles.

Early in the breeding season, there were sometimes false starts at building, a small amount of material being placed at a site and then abandoned. The sites may sometimes have been abandoned because of cold, wet, or windy weather, which occurred most often in 1977, when the weather was particularly variable in late August. Several pairs completed their first nests but did not lay in them and built others.

Nest building took 12-16 days (mean 13.9 ±1.4 days, seven nests) in August, September and early October, and 3-7 days (mean 4.6 ±1.3 days, 11 nests) in late October and November. Thus the time taken to build a nest decreased during the course of the season, as was found by Ude Shankar (1977), perhaps because longer days, warmer weather, and more abundant food allowed time previously spent foraging to be spent building. Furthermore, the nests built early in the season seemed to be larger and bulkier than later ones. During the course of the season, similar decreases occurred in the length of the pre-lay period and the period between fledging and renesting. The time between the fledging of young from one nest and the beginning of building of another varied from up to 14 days in October to only one or two days in November and December.

The same nest was sometimes used for two successive broods. Eight of 70 nests (11.4%) were re-used in 1976, six of 81 (7.4%) in 1977, and five of 51 (9.8%) in 1978, an overall total of 19 out of 202 nests (9.4%). Three nests were re-used after predators had taken their contents, all in September and October. Fifteen were re-used after a brood had fledged: two in October, eight in November, two in December and three in January. For one nest, the outcome before re-use was not known. Therefore, most nests that were re-used were ones in which a brood had been fledged and the largest proportion was in November. An advantage in re-using a nest is the saving in time and energy compared with building a new one, although nests that were re-used were relined. Re-use of nests by Fantails has been reported before, by Stead (1932), Fleming (1949), Cunningham (1954), Blackburn (1966), Coates (1966) and Flux (1974).

A period of a few days usually elapsed between completion of the nest and start of egg laying. This prelay period shortened as the season progressed, from 7-14 days in September (six nests) to 1-5 days in October and November (12 nests). For three nests in December, the birds laid as soon as the nests were completed. While the nest was being built and during the pre-laying period, the male frequently fed the female, and copulation occurred.

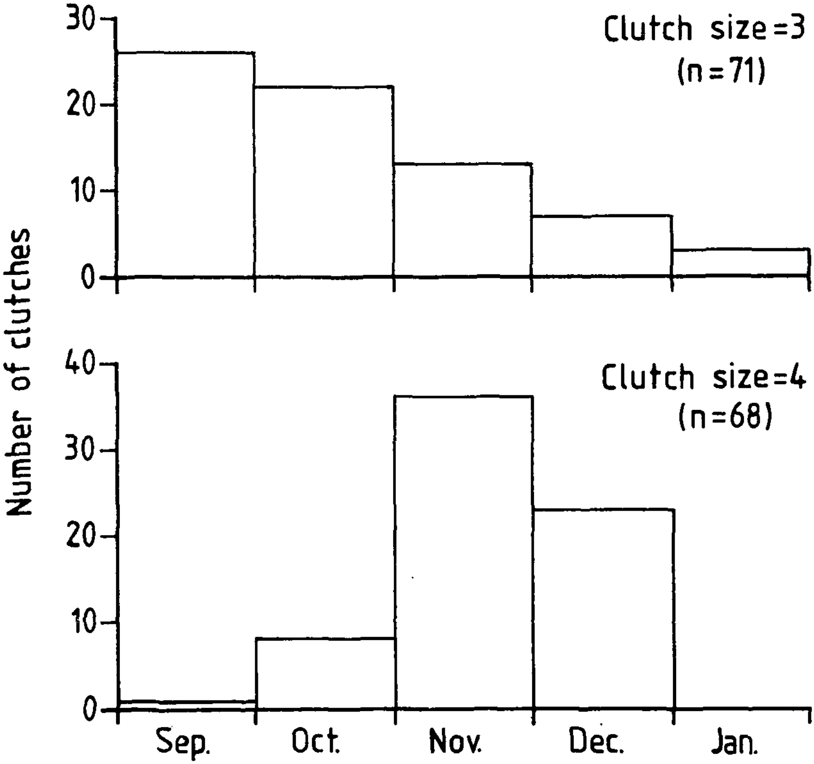

FIGURE 3 — Number of three-egg and four-egg clutches for each month of the breeding season (142 clutches)

Eggs

The eggs of a clutch were laid at daily intervals. This was noted on 48 occasions. Laying was observed once, on 11 December 1976. Both birds approached the nest several times, the male singing. The female went on the nest at sunrise (0430 h NZ Standard Time) and came off 10 minutes later after laying an egg.

Two eggs from an abandoned clutch were 16.1 mm x 12.1 mm and 16.2 mm x 12.2 mm.

Clutch size varied from three to five and the average was 3.5 ±0.5 eggs (142 clutches). Four nests were found with two eggs but these clutches may have lost eggs, as was noted at two other nests. Clutch size of the Fantail is usually given as three to four (Oliver 1955, Falla *et al.* 1979, McLean & Jenkins 1980). However, Moncrieff (1931) and Soper (1976) report five-egg clutches, and three clutches of five were found at Kowhai Bush.

Clutch size varied over the season (Figure 3). Nearly all first clutches were of three eggs. The proportion of four-egg clutches increased as the season progressed but decreased again towards the end of the season. This is similar to the pattern found by Blackburn (1965) and McLean & Jenkins (1980). The average clutch sizes for each month were 3.0 ±0.2 in September, 3.3 ±0.5 in October, 3.8 ±0.5 in November, 3.8 ±0.5 in December and 3.0 ±0.0 in January. Most eggs hatched (Table 2). The main cause of failure to hatch was predation (11.6%), which was highest in November and December. In Table 2, the category ' other ' includes eggs that fell out of the nest, disappeared, or were dented, and eggs that did not hatch for unknown reasons.

Incubation

Both sexes incubated, even when there were juveniles from a previous nest to feed. In contrast, Blackburn (1965, 1966) found for the North Island subspecies that when juveniles were present the male fed them while the female built the next nest and incubated.

At Kowhai Bush, a bird was sometimes seen on the nest the day the first egg was laid and frequently there was a bird on the nest when two eggs had been laid. However, I followed Moreau (1946) in calculating the length of the incubation period from the laying of the last egg. Incubation ends when the last egg hatches, but I seldom noted this date. Therefore the incubation period was calculated from the laying of the last egg to the hatching of the first nestling. In 10 clutches, all the eggs hatched on the same day. In most other clutches, one egg remained to hatch and I do not know when this took place. Incubation periods were 13 days (three nests), 14 days (21 nests), 15 days (seven nests) and 16 days (one nest). The mean was 14.2 ±0.6 days. Thus the incubation period at Kowhai Bush was usually 14 or 15 days, as it was in Blackburn's (1965) study. Dennison *et al.* (1978) gave a period of 15 days for the Chatham Island Fantail, calculated from the laying of the penultimate egg. My observations during egg laying indicated that, although the birds spent much time on the nest before all the eggs were laid, full incubation did not occur until the clutch was complete.

The time spent incubating was timed with a stopwatch for 13 nests, including two nests which involved an immature male and two at which only the female seemed to be present. The total observation time was 22.3 h. Many factors could influence the time spent incubating, for example, time of day, time of the breeding season, weather, sex of the bird and the stage of the incubation period. My sample is too small to take account of all these factors, but the results give a general indication of the pattern of incubation. For 'normal' pairs (both members adult and both sharing incubation) there was a bird on the eggs for 91.4-99.2% of the time and the average value was 96.8% (10.1 h observation). In three cases where the sexes were known, the female incubated more than did the male: 47.9% of the time compared with 43.5% (1.5 h of observation), 58.8% compared with 33.0% (1.2 h) and 53.2% compared with 45.9% (3.3 h). The average incubation spell was 17 min 26 s, but one pair incubated for spells of 40 min or more at a time. The incubating bird usually remained on the nest until the other bird relieved it, and the eggs were left unattended for a few seconds only.

For one nest, incubation was timed during the egg-laying stage. Incubation increased from 40.3% for two eggs (1.0 h of observation) to 73.8% for three eggs (1.5 h) and 98.2% for four eggs (the full clutch, 1.0 h).

For adult-immature pairs, the time spent incubating was similar to that of adult-adult pairs, about 97%, but immature birds spent less time than adults on the nest; 24.7% compared with 71.9% (5.8 h of observation). The average spells on the nest were 17 min 6s for immature birds and 31 min 5 s for adults. The longest incubation spell was 75 min 11 s by an adult.

A lone female spent 79.7% of her time incubating (2.9 h of observation), less than the time spent by a pair. The average time on the nest for the lone female was 34 min 23 s and the average spell off was 3 min 53 s.

Nestlings

At hatching, nestlings were sparsely covered in brownish down. The feather quills soon became visible and by four days of age (day of hatching = day zero) those on the wings were 5-10 mm long and those on the back and underside were 1-2 mm. By seven days of age, the feathers had begun to protrude from the quills and by the tenth day they were well developed over most of the body, except the tail where the feathers protruded only about 5 mm.

The average weight on the day of hatching was 1.2 g (n=3).

This increased to 1.3 g on day one (n=6) and then increased in a linear fashion to be 5.7 g at five days of age (n=5). The rate of increase then slowed, the average weight reaching 7.4 g at nine days of age (n=6). A decrease occurred between nine and 10 days of age, to 7.2 g (n=3).

Both sexes brooded and fed the nestlings. Each bird usually fed the nestlings before brooding. At one nest, nestlings about four days old were brooded 98.9% of the time (1.2 h of observation), the effort being divided fairly evenly between the parents. For two other nests, a lone female brooded one-day-old nestlings for 79.0% of the time.

The nestling period (the time from hatching of the first nestling to the fledging of the brood) was 12 days for six nests, 13 days for four nests and 14 days for one nest. This is shorter than the 14-16 days found by Blackburn (1965, 1966) for the North Island subspecies.

In many nests, the nestlings were infested with blood-sucking mites, identified by Dr G. W. Ramsay (Entomology Division, DSIR) as *Ornithonyssus bursa*. Mites were most noticeable after the nestlings had fledged, when they congregated in large numbers all over the nest and swarmed on to anything that touched it.

At least 55% of nestlings fledged (Table 4), but others not seen as fledglings may have survived as the family groups were sometimes very hard to find after fledging. Of the nestlings which did not fledge, most were preyed on, but a few died in the nest, fell out of the nest, or disappeared.

Juveniles

Newly fledged juveniles spent much time perched together, but they were capable of rapid flight if disturbed. As they got older, they spent more time flying about and catching an increasing proportion of their food. At fledging they had very short tails. These grew during the juvenile period, and so tail length provided an indication of how long the juveniles had been out of the nest. McLean & Jenkins (1980) showed the rate of tail growth during the nestling and juvenile periods for the North Island Fantail.

Both adults fed the juveniles, though the female possibly played a lesser role once renesting began. The length of time for which the juveniles were dependent on their parents was not determined. One brood which fledged in October was fed by the parents for at least 24 days after fledging.

Occasionally, juveniles from one family joined, and were fed by, a pair of adults that were not their parents and that had juveniles of their own. This event occurred at least four times and possibly in two other cases, and was detected when one or both groups were banded or when the adopted juvenile was significantly younger than the others, as indicated by the tail length. The newcomer to one banded group was of a similar age to the rest and was apparently

TABLE 4 — Colour morphs of offspring produced by different matings

Parents	No. of Nests	No. of offspring	
		Pied	Black
Black and Pied			
1976 Pair 1	3	7	2
2	1	0	3
3	1	2	1
4	1	1	3
5	2	4	4
1977 Pair 1	1	3	1
2	2	4	3
3	1	1	3
4	2	2	3
5	1	1	2
1978 Pair 1	3	5	5
2	2	2	4
3	2	2	5
4	1	1	2
5	1	4	0
Total	24	39	41
Both Black			
1976 Pair 1	2	1	7
1977 Pair 1	2	3	4
2	1	0	3
1978 Pair 1	1	1	1
Total	6	5	15
Both Pied			
1976 Pair 1	2	4	2
2	2	5	1
All others	20	58	0
1977 Pair 1	1	2	1
All others	26	80	0
1978 Pair 1	2	5	1
All others	20	67	0
Total	73	221	5

permanently adopted. However, in another instance the adopted bird was younger than the rest and disappeared after a few days. Perhaps this adoption occurs when young join a different family group when two family groups come in contact. On one occasion when two groups came close together, one set of parents was seen with five young instead of three. Rowley (1965) reported similar behaviour in the Superb Blue Wren *(Malurus cyaneus)*.

Colour Morphs of Offspring

Among nestling Fantails for which the colour morph was determined, 18.7% were black. Because of the difficulty of distinguishing individuals, the proportion of black adults at Kowhai Bush was not determined accurately, but approximate values were 7 out of 52 (14%) in 1976-77, 10 out of 82 (12%) in 1977-78 and 7 out of 48 (15%) in 1978-79. Values for the South Island as a whole are 13.0% (Caughley 1969) and 11.6% (Craig 1972). However, Craig (1972) found considerable variability in the proportion of black Fantails in different vegetation types, from 5% in *Leptospermum* associations to 21% in hardwood forest.

Caughley (1969) and Craig (1972) proposed that colour in Fantails is controlled by a single gene locus with two alleles, one for pied and one for black, and that black is dominant over pied. According to this model, pied pairs should produce only pied offspring. However, four pied pairs at Kowhai Bush produced black young (Table 4), making up 2.2% of the young from pied matings. There are several possible explanations for this result. Firstly, it could be caused by mutation. However, 2.2% is much higher than the accepted level of spontaneous mutation.

Secondly, the genetical model could be incorrect. However, the other data agree well with the model. Birds homozygous for black will have only black offspring. One out of 15 pied x black matings had only black offspring (Table 4). This gives a frequency of 0.067 homozygous blacks. The average ratio of pied to black adults for the three seasons was 87% pied to 13% black. Using the Hardy-Weinberg law and following the calculations of Caughley (1969) and Craig (1972), the expected value for the proportion of pied x black matings which involve a homozygous black is 3.7%. Therefore the expected proportion of black to pied among 80 offspring is 38.5 pied to 41.5 black, which is close to the observed 39:41 (Table 4). Likewise, the expected proportion of black to pied for 20 offspring from black x black matings is 15.4 black to 4.6 pied, which is close to the observed 15:5. Nevertheless, it is possible that some other model may explain these data and the anomaly of the black young from pied matings as well.

The third possibility is that the pied female copulated with a black male who was not her partner during the raising of the brood. This has been suggested to explain the one previous report of black offspring from a pied pair (Craig 1972). Craig reported several cases where one member of a pair disappeared and was replaced by another bird. For two of the four pairs which produced black offspring in this study such changes apparently did not occur because the birds had been together for previous nests. One pair contained a banded bird and the other pair renested within a few metres of their previous nest. It is possible that these females copulated with black males but remained with their pied mates to raise the brood.

ACKNOWLEDGEMENTS

Many thanks to all those who have provided help and encouragement throughout this project. In particular, Brian Gill and my husband Ralph, who helped with the field work and read early drafts of the manuscript. I also thank Barrie Heather, Ian McLean and John Craig for their valuable comments on the manuscript.

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SHORT NOTE

A REPEAT NESTING OF BELLBIRDS

Over parts of the Marlborough Sounds, the land is rapidly regenerating from pasture back to bush. Kanuka *(Leptospermum ericoides)* is the main canopy tree in this second-growth association, and the most conspicuous native bird is the Bellbird *(Anthornis melanura)*, especially from shoreline to 150 metres a.s.l.

On New Years Day 1981, I found a brood of five newly fledged Bellbirds at Arthur's Bay, Queen Charlotte Sound. I estimated that they had left the nest within the previous 24 to 48 hours. Their gapes were bright yellow, their tails were about 5 mm long and traces of down still adhered to their heads and backs. All five were huddled together on one branch and my careless vibration of their perch made them scatter. However, within 30 minutes, all five were huddled together on a different perch. Both parents were feeding them and food which I saw passed consisted entirely of insects, mainly various Diptera and small cicadas.

From 5 January onwards, only the male parent fed the fledglings, and by 9 January all had grown noticeably larger and more venturesome, but they still uttered the begging call incessantly and towards late afternoon or evening all five would huddle together on one perch.

On 10 January the brood had moved about 50 metres up the hillside. They were actively foraging and feeding themselves but still kept within 30 metres of one another. The male parent was still feeding them, though much less frequently, and begging calls were much less frequent.

By 16 January, when my observations ceased, all five were almost adult size with full-length tails. In foraging and flying they were noticeably less competent than the male parent, who continued to provide each with an occasional meal.

During this 16-day period, the female parent had been far from idle. On 4 & 5 January, I noted both parents making frequent visits to a kanuka tree about 40 metres from the vicinity of the fledglings. On 6 January, I found the female collecting dried grass from the edge of a path. The new nest site was 3 metres up in a spindly but dense growth of kanuka, in the same tree that they had repeatedly visited the previous two days. By 8 January the nest appeared complete, and from the 9th onwards the female sat continuously. The male was a regular visitor to the nest, feeding the sitting female and copulating.

So far I have been unable to find any record of five for either clutch or brood size in Bellbirds, apart from a rather vague reference in Hutton & Drummond (1904, *Animals of New Zealand*) which mentions the clutch size as being 4 or 5. All other authorities give 3 or 4, or occasionally 2.

Stead (1932, *Life histories of New Zealand birds*) strongly implied the productivity of Bellbirds by stating, " They have an extended nesting season commencing in September and rear at least two broods a year." Almost certainly this female had built a new nest and was sitting hard 10 days after the earlier brood had left the nest. Allowing, say, 9 days for nest site selection and construction and 28 days for incubation and rearing, two broods could be fledged within about 70 days (2 months). Was the renesting which I saw the second, *third* or perhaps even fourth attempt at nesting by the pair for the summer ?

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BEHAVIOUR OF THE ANTARCTIC BLUE-EYED SHAG *Phalacrocorax atriceps bransfieldensis*

By NEIL P. BERNSTEIN and STEPHEN J. MAXSON

ABSTRACT

An ethogram for the Antarctic Blue-eyed Shag is described with emphasis on behavioural comparisons with other shags and cormorants. Data regarding mate and nest-site retention are also presented.

INTRODUCTION

Van Tets' (1965) study of social communication of the Pelecaniformes demonstrated the value of behavioural comparisons in evaluating phylogenetic relationships within, as it was then, a poorly known order. Although Nelson (1978) remedied the lack of data for the Sulidae, little is known about the behaviour of most species within the Phalacrocoracidae, especially the lower southern hemisphere representatives of the blue-eyed shag complex *(Phalacrocorax atriceps, P. albiventer, P. verrucosus, P. caruncululatus,* and *P. campbelli).** The taxonomy and phylogenies of these species are in question (Devillers & Terschuren 1978, Bernstein & Maxson 1981), and to help clarify these questions, we gathered ethological data for the Antarctic Blue-eyed Shag *(P. atriceps bransfieldensis),* along with ecological studies (Berstein & Maxson, in prep.) that may form the basis for comparisons within the group as well as with related northern species.

METHODS

A colony of up to 800 Antarctic Blue-eyed Shags was observed from mid-January 1979 to mid-March 1980 at Cormorant Island, 5 km south-west of Palmer Station, Anvers Island, Antarctica (64°46′S 64°03′W), near the Antarctic Peninsula. Travel to the island was limited during the austral winter (April to September) and most data were collected during the remaining months. Additional data were collected in austral summer 1981 by P. Pietz and S. Stone. Behavioural data were recorded by written notes, on magnetic tape, with 35 mm film, super-8 movies and 16 mm movies. In total over 3000 bird-hours of time-budget data were collected. Behavioural notes were taken of birds under direct observation as well as all shags in view from the hide. Therefore, in reality a minimum of 9000 to 12 000 bird-hours

* Although the genus **Leucocarbo** is also used for this group, for ease of comparison with recent literature we prefer to use **Phalacrocorax** in this paper.

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of behavioural data were collected. In addition, we lived for week-long periods near the colony, during which time the shags were under observation most of the day. Since courtship displays occurred synchronously at all nests, observations of this period were conducted from the sea or from high points to view as many of the nests as possible. Approximately 15 hours of intense courtship were observed or filmed.

We sexed birds by body and bill size, behaviour, and vocalisations. Males were larger, more aggressive, and were the only sex that vocalised. Fifteen pairs of shags were colour-ringed in both 1979 and 1980, and a few individuals were marked with indelible black dye on their white chest and neck for identification in film records. We attempted to mark individual nests with numbered metal markers and colour-coded dowels, but most were incorporated into nests by the birds. Nests were mapped to help locate them within the colony between years. In 1980, all juveniles received numbered strainless-steel rings, as did all adults captured throughout the study.

Nomenclature of the blue-eyed shags follows that of Watson (1975) for reasons presented in Bernstein & Maxson (1981), and the trinomial scientific name is used to prevent confusion with other species or subspecies. Most displays discussed are illustrated in van Tets (1965) for other cormorants and shags. Except when noted, we follow his terminology.

HABITS

Locomotion

Like the other cormorants and shags, the Antarctic Blue-eyed Shag walks with a high-stepping gait or waddle. The Cormorant Island colony is relatively free from rocks, and the shags can easily walk from the nest to the cliff edge. However, when moving across rocks by the sea edge, they hop with both feet together. Both feet are also used simultaneously when " running " across the water for take-off at sea and when swimming (cf. van Tets 1965: 16-17).

Bathing

As described for Double-crested Cormorants *(P. auritus)* (e.g. Lewis 1929, Mendall 1936) Antarctic Blue-eyed Shags bathe regularly. Bathing usually took place daily in groups of 5 to 20 shags before the birds left the colony. The slapping of wings on the water and splashing appeared to create a social stimulation for other birds to bathe, and once a shag 5 km away from the colony began bathing near two Southern Black-backed Gulls *(Larus dominicanus)* that were splashing in the water during a fight.

Spread-wing behaviour

The Antarctic Blue-eyed Shag does not display the Spread-wing behaviour typical of the Phalacrocoracidae, which is thought to dry waterlogged plumage. Explanations for this unusual behaviour are outlined in Bernstein & Maxson (in press). The spread-wing behaviour also does not occur in the New Zealand species of the blue-eyed shag complex (van Tets, in press).

Nest-building

Antarctic Blue-eyed Shags build their nests on level cliff tops and rocky outcrops in the Antarctic Peninsula region. Males collect algae from the ocean floor in nearby littoral waters at midday daily during the first part of the breeding season. *Desmarestia menziesii* composed over 95% of all nests, but *Plocamium cartilagineum* and *Gigartina skottsbergii* were also used.

The alga is presented to the female, who incorporates it into the nest with quivering motions of the bill. Gradually, as guano is deposited, the nest becomes cemented together and resembles a clay pot. Moulted feathers may also be incorporated into the nest. Although there are no sticks or twigs in Antarctica, the shags proved adept at using wooden-dowel nest markers as nest materials, and the daily migrations of these purloined markers testified to the frequency of nest material theft within the colony.

Mate retention

Mate retention between breeding seasons is common for seabirds (see Cuthbert 1981 for a review). However, several authors (e.g. Snow 1963, Kepler 1972, Harris 1979) have noted high incidence of mate changes between consecutive breeding seasons for Pelecaniform birds.

Of the 30 colour-ringed pairs, 18 shags (30%) were not seen the following year and were presumed dead. While this is high adult mortality, Potts (1969) stated that high mortality may follow a low food year, and 1980 was believed to be such a year (Maxson & Bernstein 1980). However, this makes mate retention hard to analyse since loss of a mate is good reason to re-mate.

A central question of mate retention studies is whether past reproductive success influences mate fidelity in the next breeding season. Unfortunately, both members of the pair survived in only 12 nests, all previously successful. Therefore we cannot compare effects

TABLE 1 — Mate retention and nesting success 1979-1980 and 1980-1981

	Successful	Unsuccessful
1980		
Pairs that switched	2	2
Pairs that did not	1	3
1981		
Pairs that switched	2	1
Pairs that did not	0	1

TABLE 2 — Site fidelity in the Antarctic Blue-eyed Shag

	Same	Nest Site Different	Unknown
Pairs that do not switch mates	5	0	0
Males that switch	18	0	1
Females that switch*	6	1	0

*Females were considered at the same nest site if they nested within 5m of previous nests, thus within a nest area, rather than on a nest site.

of successful or unsuccessful nesting. Of the 12 surviving pairs, 7 switched mates.

Another important question is whether birds that switch are more successful than those that do not. Although sample sizes were small, data in Table 1 indicate no significant difference in nesting success between pairs that switch and those that do not.

Nest-site retention

As noted by Nelson (1978) and by Morse & Bucheister (1979), nest-site retention in seabirds may be as strong as if not stronger than mate retention. Our data on nest-site retention (Table 2) indicate that, except for one female, there was a strong tendency to nest each year in the same area of the colony. A similar pattern was noted by Derenne *et al.* (1976) in the King Shag *(P. albiventer),* although sexes were not positively distinguished. Shags were on territory and paired throughout the non-breeding season, which certainly contributes to site tenacity.

DISPLAYS

Take-off from land

Van Tets (1965) divided the take-off into three phases: Look, Crouch, and Leap. Movies show that Antarctic Blue-eyed Shags do raise their heads with the bill slightly elevated in a Look phase, but the Crouch is greatly reduced and inseparable from the Leap. Owre's (1967) description of a cormorant diving into flight seems more appropriate. No calls were made before take-off.

Post-landing

As van Tets (1965) noted, the Post-landing display is a combination of recovery after landing and submissive posture. However, the display for the Antarctic Blue-eyed Shag is more exaggerated than that of some other species. Immediately upon landing they extend their inflated head and neck forward and lower than their back, which is held horizontal to the ground (Fig. 1a). This display differs slightly from the arched neck position described for the Great Cormorant or Black Shag *(P. carbo).*

Although van Tets (1965) mentioned that the display may partially be preparation for attack, he and Dorward (1962) believed that the display reduces chance of attack by promoting individual recognition among neighbouring birds. However, shags in adjoining nests gave little attention to one another until they were immediately adjacent to the nest. Furthermore, the display was used when birds landed on rocks by the sea, where non-neighbours were present and individual recognition would have been unlikely. For these reasons, we prefer to consider the display as mainly having a submissive function. Moreover, whenever shags landed precisely at the edge of their nests, as they often did, the Post-landing display immediately graded into Pair-bond maintenance, a derivative of appeasement behaviour. No Gape display during Post-landing was observed in the Antarctic Blue-eyed Shag similar to Snow's (1963) observations for the Shag *(P. aristotelis)*.

Hop

The Hop is described by van Tets (1965) as an abbreviated symbolic flight that can grade between short hops around the nest to Circle-flying, short flights away and back to the nest. Once a male slightly bounced in place before departing the nest site, but a distinct Hop was never seen. Circle-flying, however, was common. Although its function was not apparent, van Tets (1965) believed that it may familiarise the bird with its nest location early in the breeding season. This is not a totally satisfactory explanation since Circle-flights occurred throughout the breeding season.

Stepping

This display is an exaggerated, often rapid, high-stepping walk that a shag used while moving through the colony (Fig. 1b). Females held the bill tightly against the chest during the walk, whereas males did not depress the bill directly against the chest and their steps were slower and less exaggerated. When the shag stopped, it performed the low neck extension typical of the Post-landing display. Stepping was most often observed in females during the courtship period when they

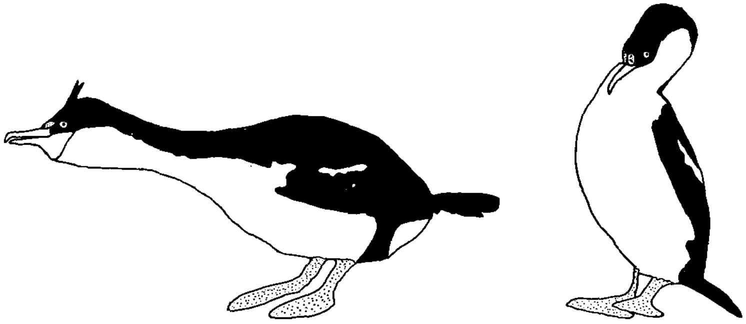

FIGURE 1 — (a) Post-landing posture, (b) Stepping

had to move close to nests in choosing mates, during which time it served as an appeasement function. The display was observed less often during other periods as the spacing of nests allowed movement through the colony without certainty of attack.

Kink-throating

At no time was the display regularly noted during Pre-landing, although photographs show that a few shags were in the Kink-neck posture as illustrated in van Tets (1965, Fig. 37). Van Tets (pers. comm.), however, has noted the behaviour in New Zealand species of blue-eyed shags and believes that we may have failed to recognise the behaviour.

Fighting

The three fights seen were quite violent and in two instances ended with the loser bloody. One shag would clamp its bill around the neck or wing angle of another and jerk and twist while forcing its narrow beak tighter. The aggressor often persisted in the attack long after its opponent was trying to escape. Fights were uncommon and none was seen after territories had been established. One fight lasted 8 minutes and involved up to four male shags. The other fights, however, lasted less than 3 minutes and involved two males contending for a nesting territory.

Threatening

Threat displays were directed not only at other shags but also at other birds and at humans. Antarctic Blue-eyed Shags are extremely tenacious to the nest site, unlike the King Shags *(P. albiventer)* in Tierra del Fuego (pers. obs.). Instead of fleeing the nest site, they oriented the head toward an intruder in a Threat display with the throat and head expanded and the mouth opened to expose the orange gape. The head was waved slowly from side to side. As females had no vocalisation, they hissed, while males uttered the *aark*. The plumage was raised during the display with the nuptial crests extended, and the wings were often partially opened. The nest site must be defended because, early in the breeding season, an unguarded nest is subject to immediate dismantling by neighbours and later, small chicks or eggs in unattended nests may be taken by Brown Skuas *(Catharacta lonnbergi)*, South Polar Skuas *(C. maccormicki)*, Greater Sheathbills *(Chionis alba)*, or Southern Black-backed Gulls.

Male advertising

The male advertising display of cormorants was termed Wing-waving by van Tets (1965). The wing movement is thought to enhance the white dorsal patches present in some species. In this display, the wing tips are raised simultaneously upwards and outwards with the primaries folded behind the secondaries. Despite a prominent white dorsal patch in the Antarctic Blue-eyed Shag, only slight wing movements were noted for a few individuals; most shags kept their wings

FIGURE 2 — (a) Gaping, (b) Gargling

motionless. This conforms to van Tets' (1974) update of his behavioural descriptions in which he described the male advertisement display of the King Shag as Gargling with no mention of wing movements. The King Shag is closely related to the Antarctic Blue-eyed Shag (Watson 1975) and may be conspecific (Devillers & Terschuren 1978, Bernstein & Maxson 1981). Although some birds began the display in a semi-upright position (van Tets 1965), most started in a squat position with the back horizontal and the head elevated in the Gape position (Fig 2a). The Throw-back component of the display occurs when the head is rapidly jerked backwards so that the bill is pointed upwards and the neck lies across the bird's back (Fig. 2b). The tail is raised to varying degrees with the most intense display indicated when it points toward the head of the shag (van Tets 1965). Any wing movement is synchronised with the Throw-back. Only male Antarctic Blue-eyed Shags vocalise, and a characteristic *aark* is sounded during each Throw-back. The display is performed only by males at the nest site while they stand on one or both legs.

Recognition

Van Tets (1965) noted that during courtship male cormorants deterred unacceptable females by threat displays, and the female could be thrown from the nest. Females were, therefore, cautious in approaching an alternately advertising and threatening male, but if they persisted, the male's threats became less intense. Van Tets (1965) thought that the above behavioural sequence was responsible for the ritualisation of threat into recognition displays.

In cormorants, the recognition is known as the Gape, a bisexual display of the " in " bird at the nest (van Tets 1965). We did not observe the gradation from male threat to courtship behaviour described above. Pair-bond maintenance began immediately after chicks fledged in mid-March. At this time, females departed the nest shortly before males each day and would display with several males while walking through the colony. Many birds continued pair-bond maintenance and site fidelity throughout the austral winter (Glass 1979 and pers.

obs.), and, in contrast to van Tets' (1965) description, pairs appeared well established at onset of courtship in mid-September, as Poncet (pers. comm.) also noted.

Pointing and Darting are behaviours described by van Tets (1965) as recognition displays in some cormorants but were not observed in this context in Antarctic Blue-eyed Shags. Darting, however, the rapid, horizontal, back and forth movement of the head, often with the mouth open, was noted in threat (see above). This supports van Tets' (1965) hypothesis that recognition and threat behaviours are closely related in some cormorants.

Nest-indicating

Van Tets (1965) and Snow (1963, 1966) regarded nest maintenance and movements such as drawing nearby objects, worrying nest material, or prodding the bill into the nest as Nest-indicating movements that emphasise ownership. Tinbergen (1953) and Berry (1976), however, thought that these may be redirected fighting movements. At no time during our observations were these movements associated with threat or intrusion. While they could be redirected aggression, we conclude that they were merely nest maintenance behaviour. In the New Zealand species of blue-eyed shags there are also no Nest-indicating movements associated with threat or intrusion, although in some species they serve as recognition displays (van Tets, in press).

Bowing

Bowing is thought to be a recognition display derived from nest maintenance behaviour (van Tets 1965). Antarctic Blue-eyed Shags did not have a Bow display. This is in agreement with Berry's (1976) observations of the Cape Cormorant *(P. capensis)* and those of van Tets (in press) of New Zealand species of blue-eyed shags.

FIGURE 3 — (a) Head-wagging, (b) Pair-bond maintenance display (see text for details)

Head-wagging

Head-wagging in Sulidae is believed to be derived from chick food-begging (van Tets 1965). A typical sequence of Head-wagging would begin with the shags slowly crossing their necks back and forth, usually without any vocalisation. Simultaneously, they would fully extend their necks in one direction, often immediately followed by another extension 180° away from the first (Fig. 3a). Their necks were usually parallel during the extension but sometimes crossed. Head-wagging was primarily a pair-bond maintenance and courtship behaviour. Although we saw it all year when the pair was present on the nest, it was most common during courtship and nest building.

Other pair-bond maintenance behaviours

Throat-clicking (Snow 1963) was similar to another pair-bond maintenance behaviour observed in the Antarctic Blue-eyed Shags. The behaviour resembled van Tets' (1965) description for Kink-throating in the Anhinga *(Anhinga anhinga)*. Both birds wave their heads rapidly back and forth with the female holding her bill wide open and the male maintaining a slight gape (Fig. 3b). Unlike the Head-wag, where the head and neck are moved, only the head is moved in a horizontal plane during this display. Van Tets (1965) correctly noted the resemblance to chick begging in the Anhinga. As Snow (1963) observed in the Shag, we noted the display before, during, and immediately following copulation, as well as before one member of the pair departed or arrived at the nest. In addition, it was a common pair-bond maintenance behaviour during courtship. At this time, the female seemed to initiate the display, which often resulted in the male shag's departure to gather nest material. Van Tets (pers. comm.) does not believe we observed a single display, but, rather, several displays. Although van Tets' interpretation may be valid, the same patterns were observed repeatedly in the same behavioural contexts that Snow (1963) observed.

Allopreening

Another form of pair-bond maintenance that may serve a useful function was simultaneous Allopreening. Allopreening was directed to the head and neck regions, and, unlike Snow's (1963) description, Allopreening was often directed close to the eyes. While Allopreening might remove feather and skin parasites, Nelson (1978), who found no evidence to support this hypothesis in sulids, considered Allopreening an appeasement behaviour between members of a pair. Nelson's (1978) explanation is plausible, but bouts of Allopreening were interspersed between bouts of individual preening, and so it probably also functions to a degree in feather maintenance.

Juvenile water-begging

Both van Tets (1965) and Nelson (1978) noted that juvenile cormorants begged for water, which was supplied by the parent. The juvenile Antarctic Blue-eyed Shags did not use this behaviour, which probably reflects physiological adaptations, but we have no supportive evidence. Nor do the chicks of other species of blue-eyed shags that have been studied beg for water (van Tets, in press).

CONCLUSIONS

With few exceptions, Antarctic Blue-eyed Shags conformed closely with the basic behavioural patterns described for the Pelecaniformes by van Tets (1965).

While our data on mate fidelity are limited, they suggest several tendencies. Males tended to breed on the same nest each year and females rarely moved farther than 15 m away from the nest where they had bred the previous year. Mate switches appeared common, but did not necessarily result in greater reproductive success.

Phylogenetic relationships are difficult to determine from behaviours because of lack of similar studies. Observations of morphological characters such as plumage and skin colour do not provide conclusive answers to these questions either (Bernstein & Maxson 1981), and we encourage future researchers of the blue-eyed shags to collect ethological data for comparison. Such fundamental data are sorely needed before questions of taxonomic and phylogenetic relationships within the group can be fully answered.

We wish to thank F. D. McKinney, G. F. van Tets, and B. D. Heather for their criticisms of the paper and R. L. Moe and P. C. Silva for identifying the algae. Field work was assisted by M. Faust, G. Kiewatt, P. Tirrell, and members of the Palmer Station winter-over crew, 1979. The study was supported by National Science Foundation grant DPP77-22096 to D. F. Parmelee, who provided encouragement and advice.

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SHORT NOTE

A WHITE-NECKED HERON IN THE FAR NORTH

On 3 October 1981, I was called by Mrs Mae Petera to identify a strange bird seen near her house on the Land and Survey farm of Onepu, 16 km north of Houhora.

The heron was feeding in a shallow weed and rush covered pond near a raft of fish floats. Also feeding in the pond were two Pied Stilts *(Himantopus h. leucocephalus),* which the heron avoided; yet it ignored two horses feeding nearby.

From notes and photographs which I was able to take the bird was identified as a White-necked Heron *(Ardea pacifica).* It was about the height of a White Heron *(Egretta alba)* and later, after it was disturbed, it moved toward a standard seven-wire fence where I was again able to photograph it and also get a good estimate of its height.

Its legs and bill were dark grey to black and its head and neck were wholly white. Each wing had in flight two white patches, the larger one just inside the carpal bend. I gained the impression, in flight, a reddish-brown tinge was on the inner wing and the secondaries. The bird was very like that shown by Slater (1970, *A field guide to Australian birds,* Vol. 1) but lacked the dark spots down the neck and the chestnut patches mentioned as being on the crown, hind neck and upper breast.

All these observations were made during mid-morning in perfect sunlight without any wind. In the weeks before, bad weather with predominant south-west winds to 35 knots had prevailed.

The heron disappeared later the same day and despite my best efforts has not been seen since.

V. H. HENSLEY, *Pukenui, RD4, Kaitaia*

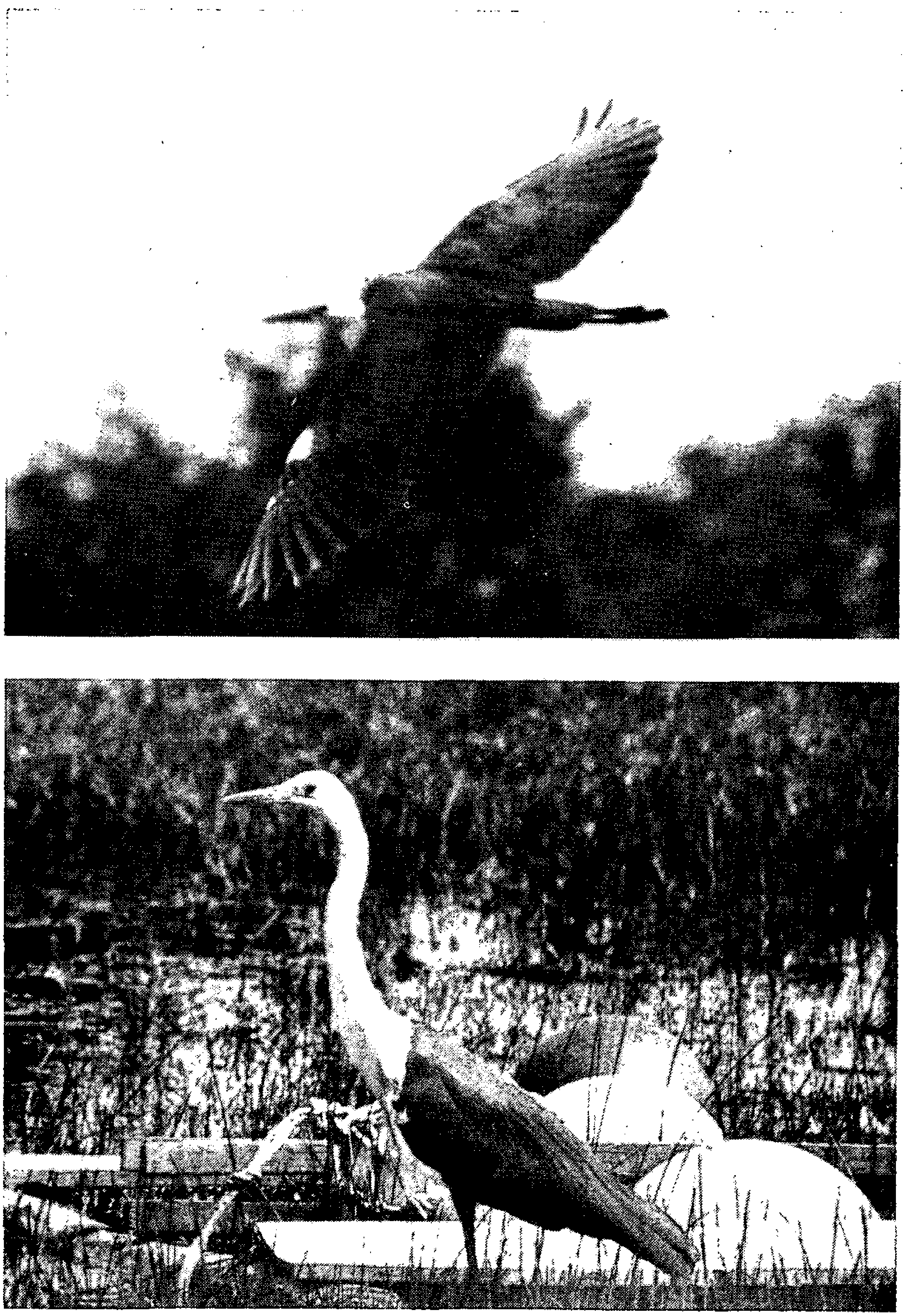

FIGURE 1 — White-necked Heron, from colour photos by V. H. Hensley

THE FOOD OF HONEYEATERS (MELIPHAGIDAE) ON LITTLE BARRIER ISLAND

By P. D. GAZE and B. M. FITZGERALD

ABSTRACT

The food of honeyeaters (Stitchbird, Bellbird and Tui) was studied on Little Barrier Island in April by collecting droppings and pollen from mist-netted birds. All three species were taking nectar from puriri and climbing rata. Stitchbirds were the most frugivorous and Bellbirds the most insectivorous of the three species.

INTRODUCTION

Since the Stitchbird *(Noticmystis cincta)* became extinct on the mainland almost 100 years ago, New Zealand's three endemic honeyeaters, the Stitchbird, the Bellbird *(Anthornis melanura)* and the Tui *(Prosthemadera novaeseelandiae)* have survived together only on Little Barrier Island (36°12′S, 175°7′E), where they differ in their degree of dependence on different nectar-producing plants and on fruit and insects (Gravatt 1970, 1971). Craig *et al.* (1981) emphasised the need for more data on the food of honeyeaters.

In early April 1980, a joint Wildlife Service/Ornithological Society party visited Little Barrier Island to capture Stitchbirds for transfer 40 km north-west to Hen Island as part of a programme to establish populations on other islands. The opportunity was taken to add to Gravatt's observations by collecting droppings and pollen samples from all three species of honeyeater.

METHODS

All birds were captured by mist-netting within 1 km of the ranger station on the western side of the island. After each bird had been freed from the mist net a microscope slide, thinly smeared with vaseline, was pressed to the bird's crown and then covered with a cover slip. The bird was then placed in a cloth bag for 1-2 minutes for droppings to be collected. The samples were stored in glass vials in 70% alcohol and later examined; seeds were identified by comparison with reference material. Microscope slides were later systematically scanned under a microscope at 100x magnification, pollen grains were identified by comparison with reference slides, and the amount of pollen of each species was scored on a five-point scale of abundance, as follows:

Category 0 — no pollen found
1 — a few pollen grains noted
2 — few grains at any one place but over slide sometimes several in view
3 — more than in 2, also occurring in clumps, always several in view
4 — many clumps, pollen abundant
5 — continuous skeins of pollen grains across field of view

This scoring system has been used by BMF for birds in the Orongorongo Valley, Wellington (unpub. data).

RESULTS

Pollen samples were taken from eight Tuis, eight Bellbirds and 20 Stitchbirds. Pollen from only two plant species was recorded, puriri *(Vitex lucens)* and one of the Myrtaceae, almost certainly climbing rata *(Metrosideros fulgens)*. Both pollens were recorded from all three species of bird (Table 1). Pollen scores of 2 to 4 for puriri were recorded from seven of eight Bellbirds but only seven of 20 Stitchbirds (chi-square with Yates correction = 5.6, $p \leq 0.5$). The difference between Bellbirds and Stitchbirds in pollen scores for climbing rata was not significant. Comparison of pollen scores between bird species or for the same bird species feeding on different plant species is risky as the pollen load carried by a bird depends largely on bird and flower morphology. However, Bellbirds and Stitchbirds are about the same size (Table 2) and so probably pick up similar amounts of pollen from the same species of flower.

The incidence of seed and insect remains in the droppings is shown in Figure 1. Droppings were obtained from 14 Stitchbirds,

TABLE 1 — Pollen scores from Tuis, Bellbirds and Stitchbirds. (Figures refer to the number of birds with the pollen-score rating)

Pollen	Tui		Bellbird		Stitchbird	
score	puriri	rata	puriri	rata	puriri	rata
0	1	0	0	2	7	8
1	5	7	1	4	6	9
2	2	0	3	0	3	3
3	0	0	3	0	2	0
4	0	1	1	2	2	0
5	0	0	0	0	0	0
Total	8		8		20	

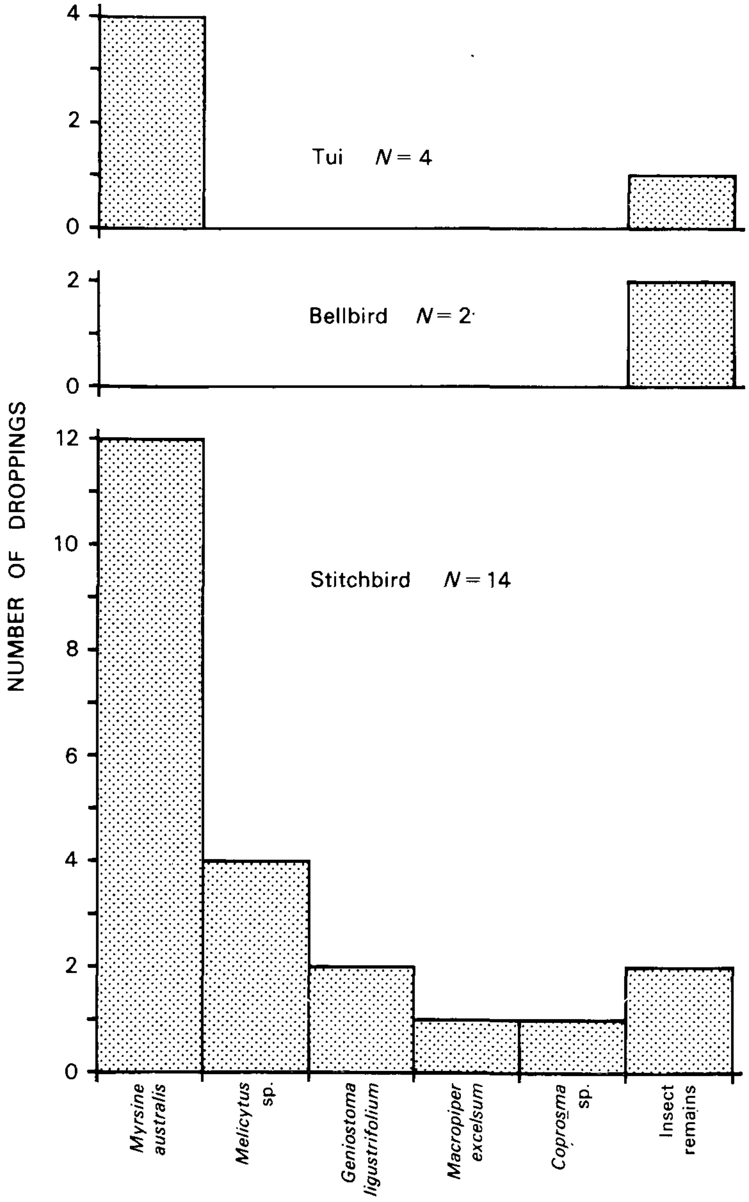

FIGURE 1 — The incidence of seeds and insect remains in droppings collected from honeyeaters on Little Barrier I., April 1980

TABLE 2 — Average measurements of Bellbirds and Stitchbirds (from Gravatt 1971 and Craig et al. 1981)

	Bellbird		Stitchbird	
	♂	♀	♂	♀
culmen length (mm)	13.3	12.6	14.8	14.4
head and bill length (mm)	41.1	38.4	43.6	41.4
weight (g)	30.7	25.0	40.2	30.3

four Tuis and two Bellbirds. All Stitchbird droppings contained seed. Twelve of the 14 contained mapou *(Myrsine australis)* seeds, and eight droppings contained seeds of four other plants: mahoe (*Melicytus* sp.), hangehange *(Geniostoma ligustrifolium)*, kawakawa *(Macropiper excelsum)* and *Coprosma* sp. Insect remains were found in only two of the Stitchbird droppings. All four Tui droppings contained mapou seeds and one contained insect remains. The two Bellbird droppings both contained insect remains but no seeds.

DISCUSSION

Although these are small samples taken in only one month, they complement the data of Gravatt (1970, 1971) for that time, especially for Stitchbirds. Gravatt recorded only 14 feeding observations in autumn and only one observation of nectar feeding (on *Metrosideros fulgens*) in April. Our results support the conclusion of Gravatt (1971) that in autumn fruit is eaten much more frequently by Stitchbirds (50% of feeding observations) than by Tuis (27%) or Bellbirds (10%). The pollen and dropping data indicate that Bellbirds feed more on nectar and insects than do Stitchbirds, as shown also by Gravatt (1971).

Other studies report similar findings. On Hen Island, Merton (1966) observed Bellbirds and Tuis feeding in May; of 96 observations of Bellbirds feeding, 53% were taking insects, 46% nectar, and 1% fruit. In comparison, of 93 observations of Tuis feeding, 34% were taking insects, 65% nectar and 1% fruit. In the Orongorongo Valley near Wellington, insect remains were found in significantly more Bellbird droppings than Tui droppings collected throughout the year (chi-square = 3.92, $p < 0.5$) (B. M. Fitzgerald, unpub. data).

Craig *et al.* (1981) stressed that the proportions of fruit, nectar and invertebrates in the diet of each species of honeyeater vary between seasons and localities, and they caution against broad generalisations. However, they have not shown that the order of preference for fruit, nectar or invertebrates by co-existing species of honeyeater is ever reversed. Our data collected in April support the generalisations by Gravatt (1971) that Stitchbirds are the most frugivorous of the three species, taking fewer invertebrates and less nectar than Bellbirds, and that Bellbirds are the most insectivorous of the three species. Future studies should be designed to show the conditions under which the species depart from this pattern.

ACKNOWLEDGEMENTS

We appreciate the opportunity provided by C. R. Veitch (Wildlife Service) to visit the island and thank M. N. Clout and R. H. Taylor for comments on the manuscript.

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SHORT NOTES

A DISTANT RECOVERY OF A BULLER'S MOLLYMAWK

Between 1961 and 1977 University of Canterbury Expedition members banded 833 adult Buller's Mollymawks *Diomedea bulleri* and 858 of their chicks at the Snares Islands (48°07'S, 166°36'E). In addition, Dr L. E. Richdale banded 159 breeding birds there in 1948 of which at least one was still ashore in the 1976/77 breeding season.

Recoveries away from the island have been few and all from around New Zealand, but M-19006, a chick banded by D. S. & C. J. Horning on 6 August 1972, has recently been reported as recovered at 12°25'S, 105°06'W on 13 October 1979, caught on a fishing vessel's longline. The bird was some 7460 km north-west of its birthplace and about 2000 km south-west of the Galapagos Islands and rather to the east of the Humboldt Current.

That some Buller's Mollymawks migrate to cold waters off western South America has long been known (cf. Murphy, 1936, *Oceanic birds of South America:* 525) but this appears to be the first report of a marked bird of this species outside New Zealand.

The bird's precise date of birth was not recorded but it would have been about 7 years 7 months old when it died. Age at first breeding has not been determined, but similar-sized petrels like *Diomedea immutabilis* are known to lay at about 8 to 9 years old (Fisher, 1975, *Auk* 92: 433-441) and other birds of the 1972 cohort were noted back on the island in June 1981 by C. J. R. Robertson but none was seen to be tending a chick. Thus M-19006 would possibly have returned to The Snares as an advanced pre-breeder in the following January or February, had it survived.

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FALCONS BREEDING IN THE WESTERN KING COUNTRY

Very little is known about the status of the New Zealand Falcon *Falco novaeseelandiae* in the North Island. Much of the data to be obtained from the literature is of scattered, individual sightings giving little indication if breeding is taking place. Fox (1978, *Notornis* 25: 317-331) gathered data from the literature and from local observers to produce national distribution maps for this species, but we consider that his estimate of the breeding range of falcons in the North Island is too limited.

We have seen falcons in the western King Country, north of Marokopa, for two years and our data show that this district still supports a viable breeding population. We have found pairs breeding successfully on Mt Pirongia and at Pirongia South, Te Toi, Taharoa, Marokopa, Waitomo and Ohakura, and unsuccessfully at Moerangi, Te Kauri and Hikurangi. Falcons occur throughout the western King Country in association with blocks of native forest but are uncommon in the north of the district, especially where forest canopies are greatly modified and the birds are likely to be shot. Further south, around Marokopa and Tawarau State Forest, falcons are more numerous with reports of multiple sightings and wandering juveniles relatively common. We have little data as yet from the very large forest area surrounding the Herangi Range between Marokopa and Awakino but the information we do have suggests the presence of a fairly substantial breeding population.

Fox estimated the breeding range of the falcon in the North Island to cover some 24 986 km^2 to which we would add approximately 923 km^2 from the western King Country, and as breeding has been confirmed south of Mokau, at Tapuiwahine, Okahukura, Otunui and Ohura (C. F. J. O'Donnell, pers. comm.), this extensive forest area could also be regarded as part of the falcons' breeding range. We are unsure of the extent of this latter area but suggest that if the western King Country and central Taranaki forest areas were included in Fox's estimate, and falcons are found to breed regularly in other districts such as the Coromandel and Kaimai Ranges, the total area of the North Island breeding range would be over 30 000 km^2.

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NOTES ON THE SHINING CUCKOO (Chrysococcyx lucidus) IN NEW ZEALAND

By B. J. GILL

ABSTRACT

Thirty-one records from Kowhai Bush and the Nest Record Scheme show that Shining Cuckoos laid from mid-October to early January. At Kowhai Bush a cuckoo was seen to "freeze" while it apparently watched a pair of Grey Warblers (its host), and warblers were distressed when a stuffed cuckoo was put near their nest. Dissection of a female cuckoo disclosed an egg-shell (probably a warbler's) in its gizzard. The newly hatched Shining Cuckoo bears natal feathers (trichoptiles) and is thus unusual among Cuculinae. The physical and behavioural development of nestlings is described, and weights and tarsal lengths are given. Fledgling cuckoos were fed by their foster parents for up to 28 days.

INTRODUCTION

The Shining Cuckoo *(Chrysococcyx lucidus)* is a common and widespread summer migrant to New Zealand, where it parasitises the Grey Warbler *(Gerygone igata)*. For three breeding seasons, starting in 1976-77, I studied the cuckoo's brood-parasitic activities by finding nests of the warbler at Kowhai Bush, Kaikoura. The main study-area of 30 ha at the seaward end of Kowhai Bush is described in Gill (1980a). The Grey Warbler's breeding is reported separately (Gill 1982 and in prep.), and many aspects of brood-parasitism are covered elsewhere (Gill, in press). In this paper I report some of the more descriptive parts of the study — in particular the cuckoo's breeding season in each year, several topics involving eggs and laying, and the physical and behavioural development of nestlings.

METHODS

I used a dental mirror 3 cm in diameter mounted obliquely on a handle to view the Grey Warbler's clutch in the enclosed nest and check for the presence of the Shining Cuckoo's egg. Artificial lighting was unnecessary. Nestling cuckoos showed little tendency to fly prematurely and were easily handled and returned to the nest throughout their nestling period. I banded them as soon as their legs were strong enough — at 12-15 days old. Size-B bands are recommended but in some cases size-C coloured bands would have fitted less tightly. When Shining Cuckoos perch, little or no leg is visible, and reading colour-combinations is difficult.

NOTORNIS 29: 215-227 (1982)

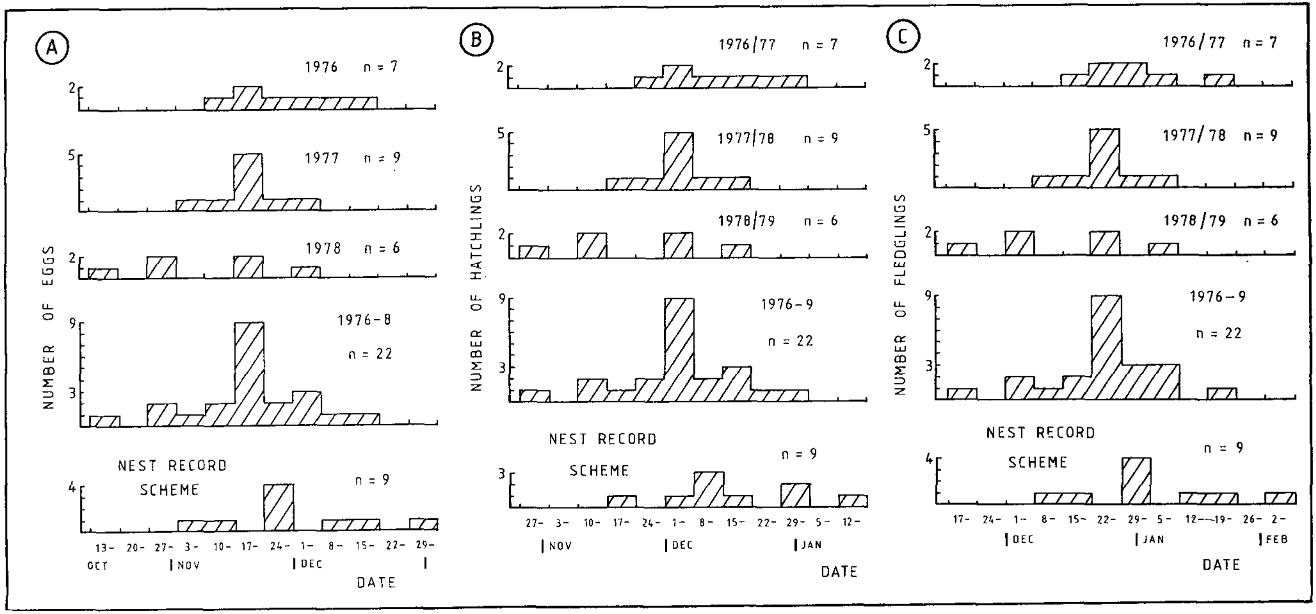

FIGURE 1 — Dates (grouped by week beginning 13-19 October) of (A) laying, (B) hatching and (C) fledging of eggs and nestlings of the Shining Cuckoo at Kowhai Bush (three seasons) and as reported to the OSNZ Nest Record Scheme.

BREEDING SEASON

Figure 1 shows the dates (grouped into weeks) of laying, hatching and fledging of 22 eggs and nestlings of the Shining Cuckoo at Kowhai Bush. Also given are nine records (1923-1967) from the OSNZ Nest Record Scheme. If a record was incomplete — a date of laying, hatching or fledging was not observed or the egg or nestling failed to survive — then I estimated the missing date or dates.

Figure 1A shows that Shining Cuckoos laid from mid-October (earliest egg 14 October 1978 — Kowhai Bush) to early January (latest egg 1 January 1924 — Nest Record Scheme). The modal time of laying was the second half of November. In addition to the records shown, two female cuckoos that I dissected each had an egg in the oviduct ready for laying. One bird died on 28 November 1968 and the other in the second week of December 1975.

Cuckoos apparently laid successively earlier at Kowhai Bush from 1976 to 1978 (Fig. 1A). This agrees with the observation that the host bred earlier in 1977 than in 1976, perhaps because winter and spring were milder in 1977 (Gill, in prep.). The record of laying in mid-October 1978 is perhaps exceptional, but there was another record of early laying that year. On 6 November 1978 I found an abandoned nest at Kowhai Bush containing a dehydrated cuckoo's egg presumably laid in mid-October or earlier. Excepting these two records, the cuckoo parasitised only the warbler's late clutches — initiated on or after 23 October (see Gill 1982). Clutches produced by warblers in mid-October probably follow the loss of an earlier clutch, so it remains unlikely that first clutches are ever parasitised. In Western Australia *Ch. lucidus* may lay as early as in late August (Ford 1963).

Shining Cuckoos hatched (Fig. 1B) from 29 October (Kowhai Bush) to 17 January (Nest Record Scheme), and fledged (Fig. 1C) between 19 November (Kowhai Bush) and 5 February (Nest Record Scheme). The modal times of hatching and fledging were early and late December respectively. There is a record (Class. Summ. Notes 1972) of " flying young being fed Kaitaia, early November 1965." Such a fledgling must have hatched from a very early egg laid in early October.

A summary of the reproductive activities of Shining Cuckoos and their host for the six months during which the latter breeds is as follows (see Cunningham 1955, Gill 1982).

August (late winter): Warblers build first nests and begin laying; a few cuckoos arrive in New Zealand.

September (early spring): Building becomes less frequent, laying reaches a peak and warblers start hatching; cuckoos apparently arrive in greatest numbers.

October (mid-spring): Warblers rarely build and seldom lay, but most of their early broods hatch and fledge; cuckoos lay first eggs.

November (late spring): Warblers re-build, re-lay and continue to hatch and fledge; laying by cuckoos reaches a peak and some cuckoos hatch and fledge.

December (early summer): Building stops; laying by both species tails off; late warbler broods and most cuckoos hatch and fledge.

January (mid-summer): The last nestlings (warbler and cuckoo) fledge.

EGGS

Behaviour associated with laying

Females of many brood-parasitic birds find nests in which to lay by watching the hosts build (Payne 1977). For example, European Cuckoos *(Cuculus canorus)* may remain still for up to several hours at a time watching their hosts (Chance 1922). In November 1976 I saw an adult Shining Cuckoo (sex unknown) suddenly sleek its feathers and stiffen, head in line with body at 45° to the horizontal, as two foraging warblers approached to within a few metres. The cuckoo remained perfectly still but for a slight rotation of its head, which kept the warblers in view. The warblers apparently did not notice the cuckoo. Later I found the warblers' nest 30 m away, and the clutch was parasitised 12 days after the above observation. It suggests that direct and unobtrusive scrutiny of its host may be important to the Shining Cuckoo in locating nests. The barred underparts and iridescent green dorsal colours of the Shining Cuckoo, although gaudy in a museum skin, are remarkably cryptic in the field, and may help the cuckoo to watch its host unobserved.

Many British song-birds respond aggressively if a stuffed European Cuckoo is placed near their nest (Edwards *et al.* 1949). In September 1977 I flushed a female Grey Warbler from a partly incubated clutch and fixed a stuffed male Shining Cuckoo about half a metre behind the nest. When the female returned she moved in circles within a few metres of the cuckoo, twittering constantly. This drew the male, who reacted in a similar but more vigorous way. There was no physical contact with the model. The commotion attracted Silvereyes *(Zosterops lateralis)* and provoked alarm calls from a Blackbird *(Turdus merula)*. I removed the cuckoo after a few minutes. The male began to sing continuously and the pair took 15 minutes to settle down. It remains to be seen whether warblers respond in this way to a stuffed bird of any species placed near their nest.

The way by which Shining Cuckoos lay in the Grey Warbler's enclosed nest is not known, but there seem to be three possibilities.

1. *The cuckoo enters the nest.* This is plausible because Shining Cuckoos tend to be slimmer, and entrances to nests larger, than one imagines. Adult cuckoos weigh 23 g (Gill 1980b), but nests held nestling warblers with a combined weight of up to 30 g, and

single nestling cuckoos weighing up to 25 g. Oliver (1955) gave the account of a person who allegedly saw a Shining Cuckoo laying by forcing itself in through the entrance and out through the opposite wall, the damage being repaired by the warbler. However, of the six nests I examined up to a few hours after the cuckoo laid, none was damaged. I doubt the warbler's capacity to repair nests since I saw no evidence of it, even though weakening of the nest's entrance, attachment or body was common as the nestlings grew.

2. *The cuckoo clings to the outside and inserts its cloaca through the entrance.* This is suggested by the fact that the female European Cuckoo has a protrusible cloaca and hard-shelled eggs (Baker 1942, cited by Lack 1963), which allow direct laying, even from a small height, into difficult nests. However, eggs of the Shining Cuckoo at Kowhai Bush seemed to be about as thin-shelled as the host's.

3. *The cuckoo lays elsewhere and carries its egg to the nest.* Fulton (1910) considered this method " almost certainly " employed by Shining Cuckoos, and Andersen (1926) quoted a manuscript alleging that it was seen often by early Maoris. Several species of cuckoo, including *Ch. lucidus* in Australia (Morris & Catchpole 1978), have been seen carrying eggs of their hosts away from nests, but never carrying their own eggs to nests. I tried fitting a Shining Cuckoo's egg into the bill of a dead adult. The lower edge of the broad maxilla followed the curve of the egg perfectly, and the mandible pressed upwards in such a way as would hold the egg easily in place. Thus, it seems possible that the female Shining Cuckoo could carry her egg to the nest.

A female Shining Cuckoo collected in Christchurch on 6 November 1977 had about a third of an egg-shell in its gizzard. The egg was white with brownish speckles and so was probably a Grey Warbler's, suggesting that eggs removed during parasitism (or at other times) are swallowed. In Australia, Morris & Catchpole (1978) saw *Ch. lucidus* eating an egg of its host, but the shell was discarded. In Northland, Michie (1948) saw on separate occasions a Shining Cuckoo swallowing the contents of a Chaffinch's egg *(Fringilla coelebs)* and a Grey Warbler's egg, then dropping the shell.

Colour, shape and size

Oliver's description (1955), repeated by Falla *et al.* (1970) and traceable to Buller (1888), that eggs of the Shining Cuckoo are " greenish or bluish white to olive brown or dark greenish brown," lacks clarity. The 16 eggs I saw at Kowhai Bush (shells from six collected) were olive-green. On close examination they seemed to have a basal colour of pale grey-green overlaid with a finely-mottled olivaceous pigment. Some eggs were darker than others because this superficial colouring varied in intensity. A few eggs lost patches of the superficial pigment, perhaps after rubbing against eggs of the host.

The olivaceous pigment is said to be water soluble in this species (Serventy & Whittell 1976).

Most Shining Cuckoo eggs were almost elliptical — the narrower end was nearly as blunt as the wider — but the smallest egg in my sample (17.3 x 12.0 mm) was the same shape as a song-bird's egg. Other eggs that I measured were as follows: 20.1 x 13.1 mm, 18.8 x 12.3 mm, 18.6 x 13.1 mm.

NESTLINGS

The newly hatched cuckoo

Shining Cuckoos at hatching (Fig. 2A) had dark grey skin, apart from a dorsal pink area at the base of the neck which sometimes extended on to the back and belly. The head and back were sparsely covered in coarse, white, hair-like natal down-feathers (trichoptiles), and the rictal flanges were white. The bill was pink at its base but otherwise grey, and the buccal lining and tongue were pink. The legs were grey with pale soles and white claws, and there were bristles less than 1 mm long on the caudal and alar tracts. The toes were facultatively zygodactylous.

The natal down of Shining Cuckoos (Fig. 2A-C) was restricted to the occipital, and especially coronal, regions of the head, and to the two dorsolateral areas of the back. There were about 40 long trichoptiles on the head and about 20 on the back, plus many shorter thinner trichoptiles on head and back. The natal down-feathers (neossoptiles) of passerines are arranged in regular rows, whereas the Shining Cuckoo's trichoptiles were more scattered. Figure 3 shows the Grey Warbler's branched fluffy neossoptile and the filamentous trichoptile of the Shining Cuckoo.

Nestlings in several cuculid subfamilies (e.g. Coccyzinae, Centropodinae) have natal feathers (Miller 1924). For example, Shelford (1900) coined the term " trichoptile " for the hair-like feathers up to 4 cm long on nestlings of *Centropus sinensis.* However, it has been supposed that all parasitic cuckoos (Cuculinae) are naked at hatching. Miller (1924) stated that nestlings of *Cuculus* lack natal down, and this was confirmed for the African *Chrysococcyx* by Jensen & Jensen (1969) and Jensen & Vernon (1970). Naked nestlings of the European Cuckoo and of Klaas's Cuckoo *(Chrysococcyx klaas)* are illustrated in Wyllie (1975: plate 48) and in Jensen & Clinning (1974: Fig. 13A) respectively. In Australia, nestlings of Horsfield's Bronze-cuckoos *(Ch. basalis)* and of *Ch. lucidus* are said to be naked at hatching (McGilp 1941, Courtney & Marchant 1971), but nestling Gould's Bronze-cuckoo *(Ch. russatus)* have " four white tufts on the rear of the crown and no other down elsewhere " and nestling Little Bronze-cuckoos *(Ch. malayanus minutillus)* have " pale yellowish plumules on the crown and along the back " (McGill & Goddard 1979).

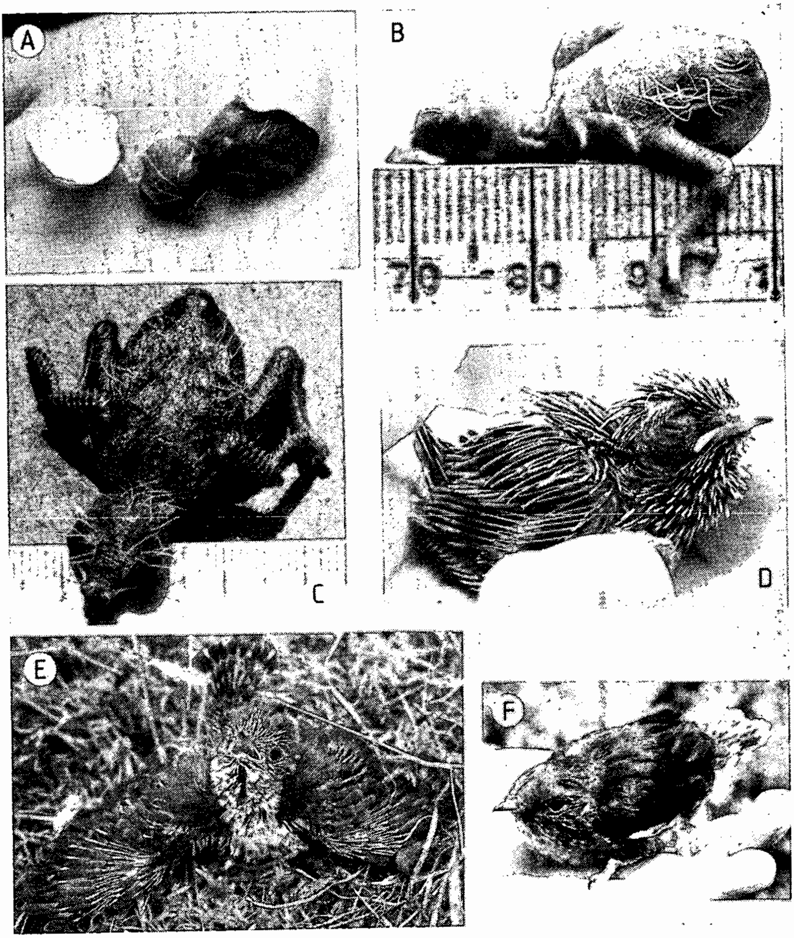

FIGURE 2 — Developmental stages of the nestling Shining Cuckoo (scales in mm): (A) At hatching; (B) 1 day old; (C) 6 days old; (D) c. 14 days old; (E) c. 15 days old, in defensive display; (F) c. 19 days old

Physical development

I described changes with age in the superficial morphology of Shining Cuckoos from regular examination in the field of 16 nestlings. The following description is generalised because the rate of development varied greatly among individuals — compare, for example, the nestling in Fig. 2D with that in Fig. 2E. The names and positions of major feather-tracts in the cuckoo are the same as for song-birds (for the Grey Warbler see Gill, in prep.), except that song-birds have a median spinal pteryla, whereas the Shining Cuckoo has paired spinal

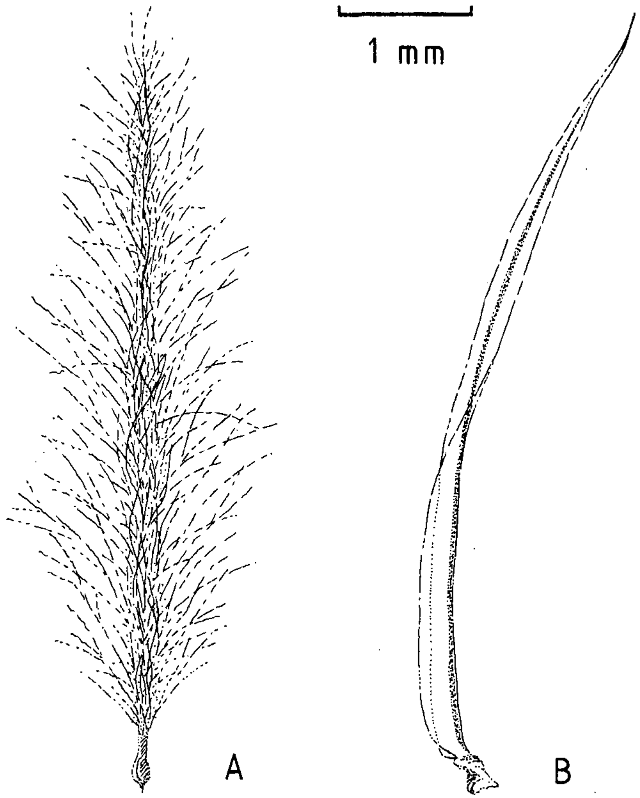

FIGURE 3 — (A) Neossoptile from a nestling Grey Warbler. (B) Trichoptile from a nestling Shining Cuckoo

pterylae separated by a median dorsal apterium and united posteriorly. Day 0 was the day of hatching. The nestling period was 19-22 days.

Day 1-5 (Fig. 2B): The skin darkened to deep grey or black, especially dorsally; claws turned grey. The bill darkened, especially dorsally and terminally; the tongue developed a grey tip. Eyes partly opened, revealing dark brown irides; rictal flanges turned pale yellow in most cases.

Day 6-9 (Fig. 2C): The skin became dull orange where ventral pterylae were forming. Pin feathers (or at least the bristles terminal to them) were visible on all tracts and reached up to about 7 mm on the alar. Pin feathers of the pectoral and crural pterylae were bright orange-yellow; all others were dark grey or black, except those of the sterno-abdominal and femoral pterylae, which were mixed. By day 9 at the earliest, the tips of many pin feathers had admitted air and turned pale. The legs became blue-grey with pale yellow soles. Eyes opened fully.

Day 10-14 (Fig. 2D): Humeral and alar feathers were often first to erupt from their sheaths, on day 10 at the earliest. By day 14 most feathers were erupting in all pterylae and nearly all natal down had been shed. Dorsal plumage was iridescent brownish-green; feathers of the breast and belly were yellowish. Most of the bill was dark grey; rictal flanges, which did not change beyond pale yellow, were regressing. The edges of the buccal lining were sometimes yellowish.

Day 15-19+ (Fig. 2E,F): The first iridescent green bar on the otherwise yellow ventral feathers was visible from about day 15. Sheaths became less conspicuous externally as the plumage developed, and the ventral apterium was occluded before fledging. As with most altricial birds, rectrices did not develop fully in the nestling. The egg tooth was shed at 15-17 days.

The physical development of Shining Cuckoos is similar to that described for *Chrysococcyx klaas* (Jensen & Clinning 1974) and for the Didric Cuckoo (*Ch. caprius;* Jensen & Vernon 1970). Apart from lacking natal down, nestlings of these species appear to differ from *lucidus* only in minor details such as coloration.

Behavioural development

Soon after hatching, Shining Cuckoos gripped the nest, and from an early age they struggled against handling by flexing the wings and legs, and by clenching and unclenching the toes. Young nestlings held the wings out stiffly from the body, but once the cuckoo was clothed in pin feathers (the " porcupine " stage; Fig. 2D) the wings flopped limply to the side, and the head flopped forward when the nestling was placed on a flat surface.

Nestlings first cheeped soon after hatching, and the cheeping of larger nestlings, audible 10-20 m away, reached a crescendo whenever the foster-parents arrived with food. The begging call was similar to that of young warblers, and mimicry may be involved, as apparently occurs in some Australian *Chrysococcyx* (Courtney 1967).

From day 7, cuckoos screeched loudly and rhythmically *(eee-eee-eee-eee)* on removal from the nest and if provoked during handling. After day 11-14, they responded to visual stimuli and gave a defensive display in or out the nest (Fig. 2E). The cuckoo would lift its head high, gape widely or incline the bill downwards, and raise the crown and throat feathers. It would lunge and snap at passing objects and rotate the head almost a full circle to follow the source of annoyance. If placed on the ground the cuckoo spread the wings, bringing them forward. Jensen & Clinning (1974) reported a similar display in *Ch. klaas.* Older nestling Shining Cuckoos often responded to handling by discharging from the cloaca a dark brown, sticky (but not foul-smelling) fluid. Jensen & Clinning considered this to be defensive in *Ch. klaas* since the fluid was nauseating. Not until a few days before fledging could Shining Cuckoos perch and support their own weight.

Growth

Once daily, between 1000 h and 1500 h, I weighed nestling Shining Cuckoos and measured their right tarsus (diagonally from the notch at the tibiotarsal joint to the bend of the folded foot). The mean values for three years' data pooled are graphed as a function of age by Gill (in press), and the data are given in Table 1 for their value in ageing. Day 0 was that on which daily visits first revealed the nestling.

FLEDGLINGS

Newly fledged Shining Cuckoos had a dark grey bill (black in adults) with the base pink ventrally and blue-grey legs (black in adults). The dorsal plumage lacked the deep copper sheen of adults, and the bill and tail were shorter. Fledglings had pale yellowish underparts (white in adults). The iridescent green ventral barring was slightly less pronounced than in adults but was essentially the same. The sides and flanks were strongly barred, the belly was unbarred, and the breast was irregularly barred (appearing almost longitudinally striped from a short distance). Friedmann (1968) and Marchant (1972) were not entirely correct in stating that the young of Indo-Australian *Chrysococcyx* are not barred below.

Newly fledged Shining Cuckoos, which were weak fliers, behaved secretively and perched silently and immobile for long periods. Later, however, when flying well, cuckoos cheeped loudly, begged vigorously by fluttering the wings, and followed their foster-parents, cheeping in flight. They were aggressive towards the warblers and often pecked at them immediately after the delivery of food.

I saw cuckoos being fed for up to 28 days after fledging, but they may be fed for longer. Cuckoos caught prey from about their

16th day free of the nest. For the first 3-4 days both foster-parents cared for the fledgling, but thereafter the cuckoo was nearly always the male's responsibility. Fledglings of *Chrysococcyx klaas* are fed for at least 25 days (Jensen & Clinning 1974); those of *Ch. caprius* for up to 38 days (Reed 1968).

A juvenile Shining Cuckoo collected in Christchurch on 12 February 1979 had a layer of subcutaneous fat several millimetres thick on the lower abdomen and other depositis along the gizzard and intestine. An adult taken in Greymouth on 8 February 1973 also had massive deposits of abdominal fat. These observations indicate preparation for migration of both adults and juveniles during late summer.

IDENTIFYING THE SEXES

According to Mayr (1932), females of *Ch. lucidus lucidus* differ from males in coloration of the crown, hind-neck, ventral bars and fourth rectrix. Oliver (1955) and Falla *et al.* (1970) repeated Mayr's account. However, I saw no obvious sexual dimorphism in the plumage of 19 dead adults from New Zealand. The average weight

TABLE 1 — Weights (g) and tarsal lengths (mm) of nestling Shining Cuckoos. Age in days.

	Weight				Tarsus			
Age	Mean	n	SD	Range	Mean	n	SD	Range
0	1.60	7	0.22	1.2-1.9	7.26	7	0.43	6.6-7.7
1	2.24	7	0.29	1.7-2.6	8.30	7	0.35	7.6-8.6
2	3.09	7	0.43	2.4-3.7	9.49	7	0.49	8.8-10.3
3	4.38	6	0.66	3.1-4.9	10.54	7	0.55	9.8-11.2
4	5.25	4	1.84	3.3-7.1	11.55	4	0.93	10.4-12.4
5	6.58	6	1.51	4.5-7.7	12.52	6	0.96	11.4-13.9
6	7.82	6	1.82	5.2-9.2	13.23	6	1.09	11.8-14.5
7	9.62	6	1.75	7.3-11.3	14.08	6	1.00	12.7-15.6
8	11.80	3	2.46	9.0-13.6	15.50	3	0.89	14.5-16.2
9	12.78	4	1.90	10.8-14.5	15.55	4	0.58	15.0-16.3
10	15.40	5	2.45	12.4-17.4	16.50	5	0.90	15.1-17.4
11	17.28	5	2.04	14.9-18.9	17.78	4	0.79	16.7-18.6
12	18.46	5	1.89	15.9-20.1	18.18	5	0.74	17.4-19.0
13	19.78	4	1.47	17.9-21.0	18.38	4	0.87	17.7-19.6
14	21.00	4	0.72	20.3-22.0	19.10	4	0.61	18.5-19.8
15	21.58	4	1.08	20.6-23.0	19.63	4	0.28	19.3-19.9
16	22.15	4	0.37	21.8-22.6	20.18	4	0.22	19.9-20.4
17	21.97	3	1.07	21.3-23.2	20.93	3	0.32	20.7-21.3
18	21.73	3	1.32	20.3-22.9	21.23	3	0.40	20.8-21.6

and measurements of males and females in this sample did not differ significantly (Gill 1980b) and I was unable to sex them except by dissection. I therefore agree with MacDonald (1973) who stated that the sexes are alike in *Ch. lucidus.* Which of the sexes calls is not known.

COMMUNAL DISPLAY INDUCED BY TAPES

Watson & Bull (1950) and Fitzgerald (1960) reported a communal display of uncertain social meaning, in which up to 10 Shining Cuckoos gather at a site, calling and flying from perch to perch. Twice in December 1976 while luring cuckoos by playing a tape recording of their calls (in an unsuccessful attempt to net the birds), I induced what seemed to be a communal display. Soon after I set the tape to play, three or four cuckoos appeared and remained for up to an hour, flying about and perching in the canopy above the tape recorder. They called repeatedly, giving the terminal down-slurred part of the call, and flicking out their wings partly or fully.

ACKNOWLEDGEMENTS

I thank the University Grants Committee for a Postgraduate Scholarship; the Zoology Department, University of Canterbury, for institutional support, especially use of the Edward Percival Field Station, Kaikoura; the Marlborough Catchment Board for permission to work at Kowhai Bush; and the OSNZ for access to cards in the Nest Record Scheme (the last cuckoo card examined was number 11764).

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SHORT NOTES

FIJI'S SEDENTARY STARLINGS

Hill (1952) was the first to report the arrival of the Starling *(Sturnus vulgaris)* in Fiji. In 1951 he found it numerous on the island of Ono-i-lau (28° 48'S, 178° 45'W), *the isolated southernmost* island of the Fiji archipelago. Although not seen by Hill at the time, it was also resident on three offshore islands of Ono-i-lau (Parham 1955) and on Vatoa I., 130 km NNE of Ono-i-lau (Manson-Bahr 1953). Hill (1952) was told by the local inhabitants that the Starlings had arrived about 20 years previously following a hurricane, but some villagers told Carrick & Walker (1953) that the Starlings had arrived since 1948.

Mayr (1945) made no mention of the presence of Starlings in Fiji, apparently overlooking six skins in the collection of the Whitney South Sea Expedition. These had been collected by Jose Correia, the expedition's assistant collector at the time, when he visited Vatoa I., 17-19 June 1925, en route from Suva, Fiji, to Tongatapu, Tonga. The expedition's principal collector, Rollo H. Beck, missed this leg of the expedition.

In his journal, Correia (17-18 June 1925) identified the Starling (*Esturino* in his native Portuguese) and recognised it as a species not previously collected in Fiji. Apparently it was uncommon on Vatoa, only one flock being seen and it was very shy. Local villagers told him that the Starlings had arrived only about 6 months previously. On his subsequent visit to Ono-i-lau (20-24 June 1925), Correia did not mention seeing Starlings and did not collect any. Therefore, the

Starlings may have arrived first at Vatoa and colonised Ono-i-lau at a later date. It has probably also colonised Tongatapu, Tonga, 375 km east of Ono-i-lau, from one of these sources since it was not collected there by the Whitney South Sea Expedition (27 June-8 July 1925); it was first recorded from Tongatapu in the early 1970s (Carlson 1974, Dhondt 1976).

The origin of the Starlings that colonised Vatoa is not known. The nearest resident population was that on Raoul I., Kermadec Islands (1200 km south of Vatoa), descendants of a spontaneous colonisation from New Zealand before 1910 (Iredale 1910). The Starling has proved itself to be the most wide-ranging of New Zealand's exotic avifauna, having colonised more, distant offshore islands than any other species (Williams 1953).

No tropical cyclones were recorded in Fiji during 1924 or 1925, although five were recorded in 1923 (Gabites 1978), and so the Starling's arrival on Vatoa as a result of a hurricane seems unlikely. Since the distance between the New Zealand mainland and Raoul I. is similar to that between Raoul I. and Vatoa I., a natural colonisation is credible, especially in view of the likely assistance from the South-east Tradewinds which blow for much of the year. That the first Starlings apparently passed over the southernmost island group of Ono-i-lau is puzzling and supports an alternative theory that they may have been ship-assisted colonists (see Boyer 1955); they may also have arrived in Vatoa after one of the 1923 cyclones, rather earlier than the Vatoa villagers told Correia.

In view of the Starling's proven ability to colonise New Zealand's offshore islands and its probable arrival in Fiji, it is surprising that it has not spread northwards through the Fiji Lau group from Vatoa. The interisland distances are small, always shorter than 100 km, which is less than the distance between Vatoa and Ono-i-lau.

The Starling has been a very successful colonist in temperate regions but unsuccessful in the tropics (see Long 1981). This is clearly demonstrated in Australia, where it is well established in coastal areas of eastern Australia, including many offshore islands, up to about the Tropic of Capricorn (23°S). There are occasional records from many localities further north, including Port Moresby in Papua New Guinea (Pizzey 1980), which indicate a highly dispersive population. The inability of the Starling to establish itself in these tropical areas demonstrates the existence of an important physiological or ecological constraint. There appear to be no naturalised populations anywhere in the world within 18° of the Equator. The population on Jamaica, at 18 °N, is almost at the same latitude north of the Equator as Viti Levu, Fiji's largest island, is south of it, and so the Starling's inability to spread through the Fiji Group is all the more surprising and should not, perhaps, be taken for granted. Similarly it will be interesting to see if the Starling is able to establish itself in Hawaii, 20°N, now that it has just arrived there for the first time (Elliot 1980). Starlings were resident in the New Hebrides (Vila — 17° 45′S) at one time (Cain & Galbraith 1957) but have apparently died out, since they were not recorded by Medway & Marshall (1975) or Diamond & Marshall (1976).

The problem of thermal adaptation and the absence of significant seasonal change in photoperiod in the low tropics are the obvious factors which might affect Starling biology and prevent this temperate species from colonising the tropics. Johnson & Cowan (1975) have shown that the Starling is a relatively heat-tolerant species despite its temperate origins; however, tolerance to temperature extremes does not necessarily imply any ecological adaptation or breeding ability. The importance of photoperiod as a *Zeitgeber* of both gonad and moult cycles in the Starling has been demonstrated frequently (see Murton & Westwood 1977). For example, Gwinner (1977) showed that gonad and moult cycles could be synchronised by photoperiod cycles shorter than 1 year, even with a period of only 2.4 months (five cycles per year). However, Starlings will also undergo regular gonadal cycles in constant photoperiods of between 11 and 13 hours of light (Gwinner 1973), and the period of such gonadal activity is lengthened compared to typical temperate breeding cycles.

In view of their responses to artificially manipulated photoperiods, it seems likely that Starlings should be able to entrain a breeding season to the low-amplitude photoperiodic changes at tropical latitudes. Such gonadal responses have been demonstrated in the Rufous-collared Sparrow *(Zonotrichia capensis costaricensis)* at 10°N (Epple *et al.* 1972). In Fiji, at 20°S, there is a 2 h 27 min difference in daylength between the shortest and longest days. In the laboratory, food cues have been demonstrated to be important in determining whether Starlings respond to photoperiodic stimulation with gonadal growth (Westwood & Dobson 1981), and so it is possible that low latitudes do not adequately satisfy both light and food requirements at the same time to allow breeding.

Alternatively, it may be that the absence of suitable photoperiodic cues affects the initiation of the moult, which could in turn disrupt the annual cycle by affecting the breeding season, since these two events are apparently mutually incompatible in the Starling. Hill (1952) saw indications of the Starling's breeding in the second week of September on Ono-i-lau, and Parham (1955) recorded breeding in October. Of the Starlings collected by Correia on Vatoa in mid-June, two males and one female had enlarged gonads. These observations agree with the normal breeding season of most passerines in Fiji, which is from August/September to February/March (Watling 1982).

Whichever climatic or physiological factors might be affecting the Starling in the low tropics, it is very hard to imagine how they can operate and be limiting over very small distances. Fulaga is only 85 km north of Vatoa, and yet in 60 years the Starling has not managed to colonise it or any other of the 300 or so islands of Fiji. Within

30 years of its introduction to New Zealand the Starling had started to colonise New Zealand's offshore islands (Williams 1953) and after 60 years it had reached Norfolk Island (700 km), the Kermadecs (1100 km), and probably on to Vatoa (1200 km).

Whatever are the constraints on the spread of the Starling in Fiji and the tropics in general, and feeding ecology is obviously likely, they certainly merit a detailed study.

ACKNOWLEDGEMENTS

Fergus Clunie, Dr S. Dobson and Dr C. Feare provided helpful criticism on drafts of this note. Mary LeCroy was most helpful during my recent visit to the American Museum of Natural History, New York.

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NOTES ON SOME WADERS AT VATUWAQA, SUVA, FIJI

Between December 1979 and November 1981 I visited Vatuwaqa beach near Suva at least twice in each month except March 1980 to note the species of wader present, their plumage state, to count their numbers at or close to low tide and, where possible, to obtain information on their attachment to a particular area. The length of beach watched was about 2 km and included both banks of the Vatuwaqa River mouth, which has deposited a silt which carries a large population of invertebrates attractive to wading birds.

Study on feeding flats at low tide does not yield the high counts which may be obtained when concentrations of resting birds are observed at high tide (Smart 1971, *Notes on the occurrence of waders in Fiji,* Notornis 18: 267-279), but does, even without banding, allow repeat observations on individual birds with clearly recognisable characteristics.

LEAST GOLDEN PLOVER *(Pluvialis fulva)*

Present throughout the year and only on 26 June 1980 was none seen. Otherwise the numbers were 1-6 from late April to early August and 3-18 during the rest of the year. In 1981 prenuptial moult was first seen on 7 March. (In March 1980, I saw Golden Plover in prenuptial moult on Rarotonga from 17 to 20 March and on Nuie on 20 and 21 March.) During late March and early April most birds were in prenuptial moult. However, all but one of the birds which overwintered in Fiji remained in non-breeding plumage. The exception was in full breeding plumage between late June and early August 1981 and then in post-nuptial moult on 22 August.

BANDED DOTTEREL *(Charadrius bicinctus)*

One in June 1980, the only sighting in 51 visits.

MONGOLIAN DOTTEREL *(Charadrius mongolus)*

Single birds 14 June 1980 and 15 August 1981. Smart (1971) saw small dotterels, probably of this species, in all months on the Rewa sandbank a few miles away.

BLACK-TAILED GODWIT *(Limosa limosa)*

Black-tailed Godwits have not previously been recorded from Fiji. I saw one first on 13 October 1980 feeding with a group of Bar-tailed Godwit. The note made on that occasion was " Does not appear speckled at rest and is rather darker than bar-tailed. White rump, black bar on tail, prominent white wing bar, rather longer legs clearly visible behind tail in flight." From that date this bird was seen on eight of nine visits up to 23 March 1981. It then disappeared, having presumably migrated north. From the prominence of the white wing bar, I consider the bird was an Asiatic Black-tailed Godwit *(L. l. melanuroides)*.

On 12 September 1981 an exactly similar black-tailed godwit appeared on the same beach and was seen on five of nine visits between then and my last visit on 14 November.

The plumage of this bird was indistinguishable by field observation from that of the Auckland Island specimen in the collection of the National Museum, Wellington.

BAR-TAILED GODWIT *(Limosa lapponica)*

During the summer months these were the most numerous birds on the beach and a few remained all winter. The numbers in the summer of 1980/81 varied between 14 and 53, but in 1981 had not exceeded 25 on any visit up to my last on 14 November. In the winter months numbers seen varied between none and five. In 1980, 25 were present on 20 July, perhaps early arrivals from the north. In 1981 no increase in numbers was detected until 15 August.

One bird with a recently broken leg was first seen on 14 June 1980. This bird, with the broken distal section slowly retracting, was seen on nearly all visits until 25 January 1981 when, coincident with a fall in the number of godwits present it disappeared.

It was notable that only a few godwits were clearly in prenuptial moult before moving north, unlike the Golden Plovers and tattlers. None of the godwits which overwintered in Fiji showed any breeding plumage.

WANDERING TATTLER *(Tringa incana)*

This species was seen on most visits at all times of year, although it was not detected on four successive visits in the winter of 1981. The numbers were never large and the highest count was seven. This species was less attracted by the muddy fan at the river mouth than others and appeared to be more evenly spread on all beaches around Suva. These low-tide counts contrast with several counts of over 200 in the Suva Point area recorded by Smart (1971).

In 1980 the earliest seen in prenuptial moult was on Nuie Island on 20 March. In 1981 individuals in prenuptial moult were detected from 7 March to 3 May. None of the overwintering birds showed breeding plumage.

SIBERIAN TATTLER *(Tringa brevipes)*

Field separation of tattler species is notoriously difficult and only on one occasion was a Siberian Tattler confidently identified. On this occasion the prominent white eyestripe was clearly different from the wanderers and the under tail-coverts were clearly whiter. This species was recorded by Smart both from the same area and from the Rewa sandbank.

TURNSTONE *(Arenaria interpres)*

Turnstones were present throughout the year with winter counts between zero and two and summer counts between one and 14.

Prenuptial moult was seen in a few birds between 22 March and 19 April. The overwintering birds were in non-breeding plumage.

RED-NECKED STINT *(Calidris ruficollis)*

This species was only once seen; a solitary bird on 19 July 1981. Single stints were recorded three times by Smart from the Rewa sandbank.

DISCUSSION

Two species recorded by Smart in small numbers at Suva Point were not seen, the Far-eastern Curlew *(Numenius madagascariensis)* and the Whimbrel *(Numenius phaeopus)*.

Such evidence as could be obtained without marking the birds indicated that those birds which settled in Fiji for a substantial period continued to feed in the same limited area for most of their stay. It is also tempting to suggest that the solitary Black-tailed Godwit which was so loyal to the Vatuwaqa beach was the same individual in both years.

A large proportion of Least Golden Plovers and tattlers was in prenuptial moult or near to full breeding plumage in the autumn in Fiji. By contrast, only a low percentage of Bar-tailed Godwits and Turnstones showed easily recognisable prenuptial moult at any time.

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SEABIRD RECORDS FROM TONGA — FURTHER NOTES FROM THE LITERATURE

Whitney South Sea Expedition

In a previous paper on Tongan seabirds (Jenkins 1980), I noted that I had not seen the journals of the Whitney South Sea Expedition. Through the good graces of Mary LeCroy, I now have photocopies of those parts of the journals that refer to Tonga. They are Rollo Beck's daily journal (Whitney vol. F: 144-170), his summary of Tongan birds (Whitney vol. F: 188-200), and Jose Correia's daily journal (Whitney vol. O: 7-18). They refer to visits to various islands, apparently all made during daytime, between 1 July and 26 August 1926.

For convenience, I have grouped records of the more frequently reported birds in Table 1. These records further emphasise the importance of 'Ata, Hunga Tonga, Hunga Ha'apai, and Fonualei as seabird breeding islands.

The journals correct some of my claims as to first records and first breeding records for Tonga, as follows.

Wandering Albatross *(Diomedea exulans):* One was seen on the evening of 13 July 1925 when the *France* was standing off 'Ata. " Its plumage was brown, with the head of a lighter colour." This is almost certainly the first record for Tonga.

Short-tailed Shearwater *(Puffinus tenuirostris):* Of his visit to Hunga Tonga Beck recorded " Shearwater burrows were everywhere in the soft ground and we sank in to our knees every few steps. One downy young dried specimen nearly ready to fly was picked up. It was probably *P. tenuirostris* as E. W. Gifford in November saw lots of that species ? fifty miles north of here in 1920." If the birds seen by Gifford were indeed *tenuirostris,* and we now know that both it and *griseus* can occur in these waters in November, it is the first record for Tonga. Beck's unoccupied burrows and dried chick corpse found on Hunga Tonga were almost certainly those of *Puffinus pacificus.*

Wedge-tailed Shearwater *(Puffinus pacificus):* Unoccupied burrows found on four islands (see Table 1) probably all belonged to

TABLE 1 — Seabirds seen on or near Tongan Islands during the Whitney South Sea Expedition

Island	Herald Petrel	Audubon's Shearwater	Burrows	Red-tailed Tropicbird	White-tailed Tropicbird	Brown Booby	Blue-faced Booby	Red-footed Booby	Greater Frigatebird	Lesser Frigatebird	Crested Tern	Sooty Tern	Black-naped Tern	White Tern	Common Noddy	Black Noddy
Tongatapu						s		s			s		s			
'Eua	s	s			a	s		s				s				
'Ata				b	b	b	b	b		s						
Kelefesia (Nomuka Gp.)			x		a											
Hunga Tonga	b		x	b		b		b	a?b			b				
Hunga Ha'apai	b		x	b		b		b				b				
Off Tofua		s						s				s				
Ha'apai Group																
Fotuha'a											s					
Lauhoko													a			
Mo'unga'one											s					
Fotumanga						a		b	a	a					s	s
Kotu Group																
Tokulu												b	a			
Putaputa											a		a			
O'au											a					
Maninita (Va'vau Gp.)								b			a					
Late					a	b										
Toku														a	a	a
Fonualei			x	b	b	b		b				b			b	
Niuafo'ou					a									a	a	
Niutoputapu											s			a	s	
Tafahi					a			s				s		b		

s = offshore a = ashore b = breeding x = unoccupied burrows *pacificus.* One of these islands was Kelefesia, where Gifford had collected Wedge-tails in 1921. Gifford wrote " The birds were obtained for me by natives . . . they reported the birds nesting in burrows about a yard long " (Davidson 1931). I have already suggested the other three islands as Wedge-tail breeding islands, based on sea observations (Jenkins 1979).

Tropicbirds and boobies: Beck was the first to record the breeding of the Red-tailed Tropicbird, and he recorded breeding on four islands, contrary to my suggestion (Jenkins 1980) that the only probable breeding ground was at 'Ata. He was also the first to record the breeding of the three species of booby that occur in Tonga.

Sooty Tern *(Sterna fuscata):* Beck recorded their breeding on four islands, with the largest colony on Fonualei, of which he said " I counted one hundred young Sooty Terns walking and scrambling before me in one depression. Over fifty thousand terns were present, without doubt, on the island. One colony is half a mile long by a hundred yards wide, and a couple of smaller ones were seen nearer the smoking crater."

Brenchley's voyage in HMS *Curacao*

The *Curacao* visited Tonga and many other Pacific islands in 1865, and later Brenchley presented 135 bird specimens, collected during the voyage, to the British Museum (Sharpe 1906). I previously suggested that there might be more *Curacao* birds at Maidstone Museum (Jenkins 1980). However, E. G. Philip, Keeper of Natural History at Maidstone, noted (pers. comm.) " I have checked through the records of the Museum here and cannot find any reference to the birds collected by J. L. Brenchley on his cruise in HMS *Curacao.* This is a bit strange as most of the other collections made on the cruise are housed here . . . . I should point out that we did have a rather serious fire at this Museum in 1977 when quite a few documents and some specimens were lost so that I cannot be 100% sure that some bird specimens never came here, but I am sure that there is no record of them being housed here now, nor are there any bird specimens collected in the cruise housed here."

When the *Curacao* returned to Sydney after her Pacific Islands voyage the material collected was exhibited. Mr Philip has kindly sent me a photocopy of that part of the catalogue of the Exhibition (Anon 1865) which dealt with the bird specimens. It records 218 bird specimens numbered from 426 - 643. Unfortunately they are listed by genera only and no dates of collection are given. The last four are seabirds, but none can be said to be from Tonga. The entries are as follows:—

640	*Sula*	young male	caught at sea
641	*Sterna*	female	M'bau, Fiji Group
642	*Tachypetes*	female	shot at sea 19° 15'S 161° 40'E (north-east of New Caledonia). Over this entry is " aquila — frigatebird " handwritten by Brenchley (E. G. Philip, pers. comm.)
643	*Phalacrocorax*	female	caught at sea

Only one seabird was amongst those presented to the British Museum, of which Dr I. C. J. Galbraith (pers. comm.) said " . . . fortunately that one is clearly Wiseman's number 641 . . . . though number 641 does not appear on the specimen labels nor in the register, our number 1870.3.31.70 was entered as *Sterna poliocera* from M'bau. It is a female Crested Tern *Thalasseus bergii* collected in August 1865." Dr Galbraith also notes " It is possible that we have one or more of the other three, received through some third party; but there is no way of tracing this through our registers . . . ."

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FIORDLAND CRESTED PENGUIN

The delivery of a road-killed bird to the Taranaki Museum towards the end of 1981 produced a most interesting record for the Taranaki Region. The resident District Nurse at Mokau, Margaret Fairhall, on 15 October 1981 noticed the dead bird lying on SH3, south of the Mohakatino River. Realising it was unusual, she sent it to the Taranaki Museum, where it was readily identified as a Fiordland Crested Penguin *(Eudyptes pachyrhynchus)*. The area of state highway in question travels parallel and very close to the coastline, which is in general rugged and steep. The location of the specimen prompted me to inquire further, and I found that the owners of a holiday property in the area, Mr & Mrs L. Miller of Inglewood, had been aware of the bird's presence for some time. Apparently the penguin had been a familiar sight in the area for about 2 years and had become quite tame, responding to calls and readily approaching the holiday cottage. Fearing for the bird's safety, the Millers did not tell others of its presence and were saddened at its death. Some excellent photographs are evidence of its existence.

It is the first record of a Fiordland Crested Penguin in Taranaki to my knowledge. A penguin, later identified as an Erect-crested Penguin *(E. sclateri)*, was photographed by Mr G. Munro at the end of the Lower Timaru Road, south of New Plymouth, during early February 1966.

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INDIAN MYNAS IN EASTERN SOUTH ISLAND

On the morning of 17 January 1982, I saw an Indian Myna *(Acridotheres tristis)* above the Clifton Hill cliffs south of Shag Rock at Sumner (43°33′S, 172°44′E). The weather was fine and the observation distance was 5-15 m. The Myna was flying south, steadily gaining height with a laboured flight pattern. The distinctive mode of flight, body plumage and striking white wing flashes left no doubt about identification. The bird was seen from below, and the light enhanced the wing flashes in a way I have seen also on the wings of Cape Pigeons *(Daption capense)*.

Indian Mynas have been reported only sporadically in the South Island. In 1956 two were seen near Nelson (Falla *et al.* 1979). Bull *et al.* (1978) recorded Mynas on the central east coast in only three of the 2016 national grid squares (10 000-yard squares) that make up the South Island survey region. There have, however, been several Myna sightings in Canterbury in 1981-1982. Since October 1981, J. Baggstrom, Ranger, Christchurch Botanic Gardens (pers. comm.), has received three unsubstantiated reports in summer of Mynas from New Brighton (c. 43°31′S, 172°44′E). In December 1981, S. Moore (pers. comm.) had a report from Ashley (c. 43°16′S, 172°36′E). On 29 January 1982, H. Niven (pers. comm.) saw a Myna at Bromley (c. 43°32′S, 172°42′E). On 3 February 1982, H. McAndrew (pers. comm.) saw two Mynas on the main road near Dunsandel (c. 43°40′S, 172°12′E). In Marlborough, R. Small (pers. comm.) saw four Mynas in May 1981 in Puriri Bay on the western shore of Arapawa Island (c. 41°11′S, 174°19′E) in Queen Charlotte Sound.

These several sightings in the last 12-18 months suggest that some Mynas may be breeding in some eastern districts of the South Island. However, the possibility that the birds were escaped captive birds cannot be dismissed. One Canterbury aviarist knows of a number of aviaries in which Mynas are held and cited one instance in Christchurch where the birds have been liberated with the intention of establishing a wild population. These birds have apparently survived during the summer but none has been seen in Christchurch in winter. Mynas are well established in the North Island north of 40°S (Kinsky *et al.* 1970). More southern latitudes may be too cold for them to become established.

I should like to thank Brent Cowie and Gordon Williams for helping me with this note.

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REVIEWS

Hawks in focus: A Study of Australia's Birds of Prey, by Jack and Lindsay Cupper. 1981. Jaclin Enterprises, Mildura, Australia. pp. 208.

This book depicts, in a series of over 300 excellent colour photographs, all of Australia's diurnal birds of prey. Most remarkable, however, is the fact that Jack and Lindsay Cupper (father and son team) have obtained these photographs in the seven years between 1974 and 1981.

Birds of prey are among the most photogenic of birds, but are perhaps also some of the most difficult to work with because of their cautious behaviour, especially near the nest site. The authors have clearly used plenty of effort, patience and skill to assemble this portfolio.

Most photographs have been taken with a 6" x 7" format and the quality shows; the use of substantial tower hides was necessary for gaining access to many of the raptor nests.

The text consists largely of accounts of their activities in pursuit of birds of prey throughout Australia. Mixed with these accounts are interesting and valuable observations of raptor behaviour seldom to be found in field guides or handbooks. Some of their important observations, for example, notes on the interbreeding of Grey and Brown Goshawks *(Accipiter novaehollandiae* X *A. fasciatus),* are presented in separate chapters — fully illustrated, of course.

Each of the 24 species is covered well, and at the end of each species chapter are summaries dealing with alternative names, dimensions, distribution (with map), voice, prey, and details of nests and eggs.

John Fennel

Aves Brasileiras, by Johan Dalgas Frisch. 1981. Vol. I, 351 pp. with an addendum *Birds of Brazil, Identification Guide in the English Language,* 15 pp. Dalgas-Ecoltec-Ecologia Tecnica e Comercio Ltda, Sao Paulo, Brazil.

Hearing the word "Brazil" any young bird lover or naturalist will turn his mind to this amazing country, which makes up more than half of the South American continent, and even more so to the Amazon valley and its unique vegetation and fantastic animal life. Johan Dalgas Frisch's book provides an adequate picture of the avifauna of Brazil.

Before I briefly discuss the book, its origin may be of some interest. Svend Frisch, Johan's father, a Danish-born engineer, spent a large part of his life drawing Brazilian birds. Early in this work Johan was hunting birds with his slingshot. Soon Svend persuaded his son to collect only birds that his father could use for his ambitious project of drawing all of Brazil's more than 2000 species. It wasn't long before the boy became an observer and student of birds, eventually taking over his father's work and publishing it in the present form.

The death of Svend Frisch in 1969 prevented the illustration of species such as humming birds and terns, which are not included in Vol. I. Volume II will deal with various aspects of ornithology, such as migration patterns, bird feeding habits, the adaptation of Brazilian birds to European agriculture, and their ecology. At this stage Johan Dalgas Frisch is the premier ornithologist and conservationist of Brazil.

The *Aves Brasileiras* begins with a preface by Amador Aguiar, President of the Association for the Preservation of Nature. This is followed by an identification guide based on the classic work of R. M. de Schauensee (1966). The vernacular nomenclature presented even greater difficulties. Some of these names are in Portuguese but many others derive from Tupi, an Indian language. A further part of the text is devoted to the distribution of the various bird species, showing where each species is found in Brazil proper or on the boundaries of the neighbouring countries. Another chapter is devoted to the characteristics of the various bird groups.

Very important is the arrangement of the beautiful bird illustrations in colour by Svend Frisch. We find the bird illustrations on one page and on the page opposite the scientific and vernacular names and also their general Brazilian distribution.

The final chapter of this handsome book is devoted to field ornithology: choosing binoculars and their use in the field, bird photography and recording bird songs. An index of Portuguese vernacular bird names makes finding a particular bird species and its illustration easy.

The *Addendum* in English is important as it allows the study of *Aves Brasileiras* to those who have no knowledge of the Portuguese language.

Kazimierz Wodzicki

The Phylogeny and Relationships of the Ratite Birds as Indicated by DNA-DNA Hybridization by Charles G. Sibley and Jon E. Ahlquist. In: Evolution Today, G. G. E. Scudder & J. L. Reveal (eds). Proceedings of the Second International Congress of Systematic and Evolutionary Biology, pp. 301-335. 1981.

This paper begins with a useful general introduction, which reviews the various ideas that have been held, over the last century or so, on the relationships of the ratites — beginning with Huxley (1867), who believed that the family was monophyletic in origin and then Furbringer (1886) who considered it to be diphyletic. The ensuing controversy, which began by using comparative morphology, especially of the palate, has continued to the present day, using such disciplines as behaviour, genetics and biochemistry on the way.

Sibley and Ahlquist in their paper use the technique of DNA-DNA hybridisation for their study. The rationale, technique and modes of analysis are fully and clearly explained, and the authors discuss the molecular evolution of DNA and calculate the rate at which it has occurred. They conclude that " the average rate of nucleotide substitution is the same in all lineages of birds." If this view is correct, DNA hybridisation values should be proportional to the absolute time that has elapsed since the various lineages have diverged.

The authors' experimental results are then tied in with the accepted history of Gondwanaland; and Cracraft's (1974) " character analysis of primitive derived sequences " of morphological characters (the cladistic approach) are compared with the results obtained from the hybridisation experiments.

Finally, Sibley and Ahlquist offer their classification of the ratites and tinamous. " The Neotropical tinamous (Tinamidae) are the nearest relatives to the ratites and the entire assemblage is a monophyletic taxon. . . . . The results indicate that the tinamous branched first from the ancestral stem, probably in the Lower or Middle Cretaceous. In the late Cretaceous (about 80 million years ago), when the southern continents drifted apart, two branching events gave rise to three lineages, one leading to the modern ostriches, a second to the rheas and the third to the Australasian ratites. The latter subdivided in the Eocene when the New Zealand and Australo-Papuan forms became fully isolated."

The whole paper is very stimulating, but it remains to be seen what the relevant experts think of the required archipelagic connection between north-east Australia and north-west New Zealand, possibly via New Caledonia, which is supposed to have persisted into the Eocene with a density of islands such as to permit crossings by strong swimmers and weak fliers. Such a connection would leave unsolved the problem of the non-arrival of marsupials.

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Printed by TE RAU PRESS LTD., Peel Street, Gisborne