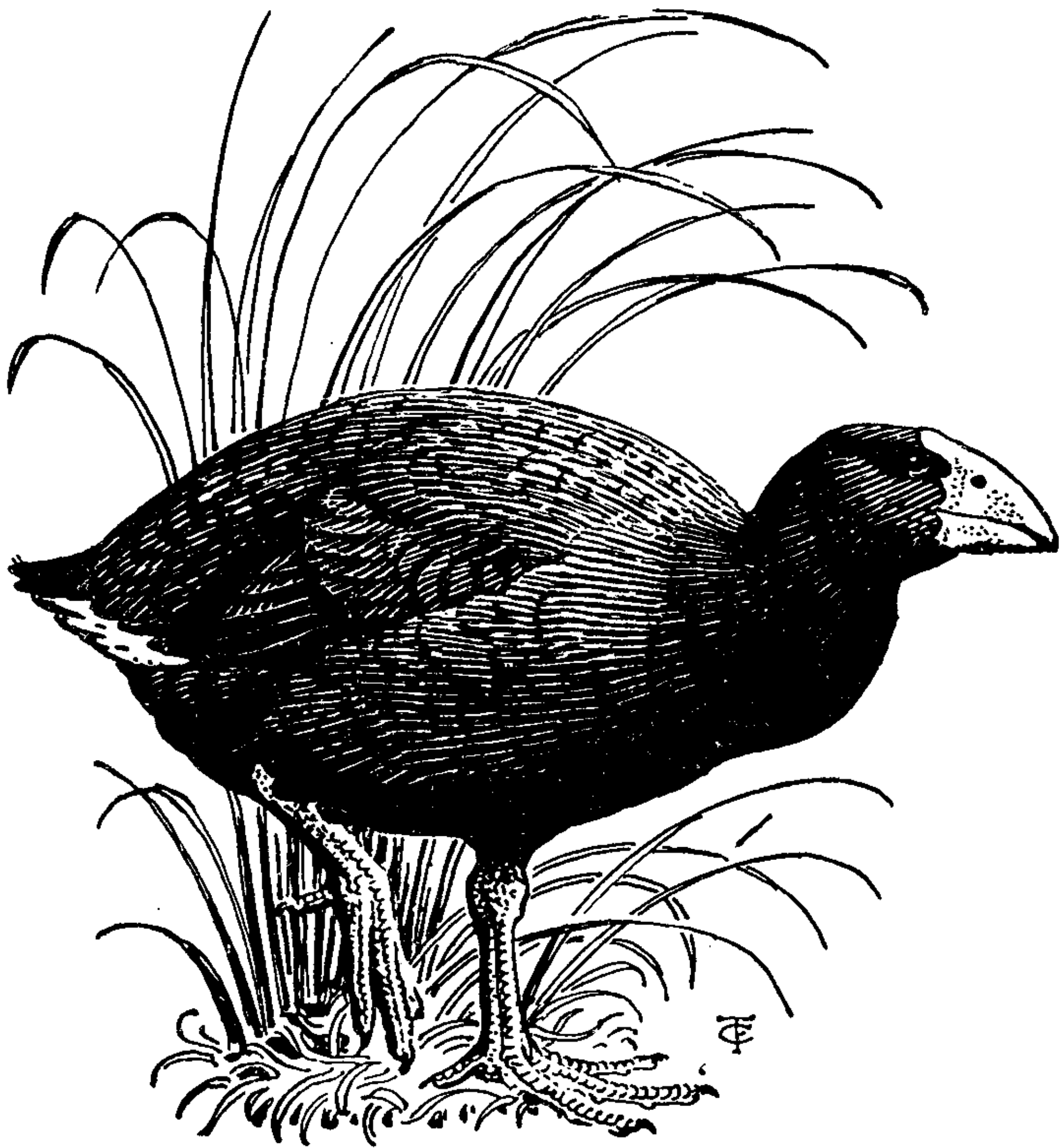


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BEHAVIOUR OF THE RED-FOOTED CORMORANT (*Phalacrocorax gaimardi*)

By DOUGLAS SIEGEL-CAUSEY

ABSTRACT

The pair bonding, recognition, defence, and courtship displays of the Red-footed Cormorant are described for the first time. Similarity in displays reinforces van Tets' contention that this species is a member of the *Stictocarbo* group. Its closest relatives seem to be the spotted shags of New Zealand waters and the European Shag. The Atlantic population of the Red-footed Cormorant is small and isolated, and it may differ from the much larger population along the Pacific coast by various behavioural and ecological features.

INTRODUCTION

One of the least known cormorants of the world is the Red-footed Cormorant (*Phalacrocorax gaimardi*), which breeds along the Pacific coastlines of Peru and Chile from near the equator to about 45°S (see Murphy 1936, Koepcke & Koepcke 1953, Johnson 1965, and Jehl & Rumboll 1976). A small, isolated population on the Atlantic coast is restricted to a small area of the Patagonian coastline (Doello-Jurado 1917, Zapata 1967) near Puerto Deseado, Santa Cruz Province, Argentina (40°S, 80°W). The largest colony in Argentina is located on the cliffs of Isla Elena (200 pairs) near the mouth of Ria Deseado, with an equal number distributed in four other locations 5-10 km farther upriver. About 70 km north of Puerto Deseado, a small colony of about 50 pairs breeds at Cabo Blanco; about 20 km south of Puerto Deseado, a small group of about 30 pairs breeds on Roca Olorosa in Bahia Oso Marino.

This population apparently does not migrate far in the post-breeding season, and extralimital transients are rare. Adults and juveniles seem to keep close to shore, and do not move more than about 300 km to the north and south (Jehl & Rumboll 1976). Although individuals have been seen

occasionally in the Straits of Magellan (Ogilvie-Grant 1898, Murphy 1936), no intervening colonies have been found in Tierra del Fuego, prompting many researchers to confer subspecific status on the Atlantic (*P. gaimardi ciniger*) and Pacific (*P. g. gaimardi*) populations. Humphrey & Bridge (1970) gave differences between the populations in culmen length, plumage, and bill colour, but because of small samples and other problems, it is difficult to tell if these population differences are real.

As part of a larger study of the biogeographic variation of this species throughout southern South America, I observed breeding behaviours in the Atlantic population in the late austral spring of 1985. These data help to show its behavioural affinities and phylogenetic relationships with the other members of the family.

METHODS

I observed courtship behaviour, pair bonding, and other related activities of Red-footed Cormorants in a colony of about 200 pairs on Isla Elena in Ria Deseado near Puerto Deseado, Argentina, during late January and February 1985. (See Zapata 1967 for a description of the colonies and de la Pena 1980 for descriptions of nests and nest sites.) Observation periods ranged from 1 h to 5 h; the total amount of time spent observing behaviour in the colony was equivalent to about 5000 bird-hours. When I began, breeding was still underway, but pairs were still forming and nests were still being initiated throughout the observation period. I observed courtship sequences of different lengths, about half ending in mounting. As I was unable to follow the progress of pairs or nests past the end of February, the courtship behaviour I observed may not represent the full range that may be associated with pairs that mate earlier in the season.

I observed courting pairs through 7x50 binoculars or a 45x telescope; I recorded behavioural acts in shorthand and on 35 mm slide film. I sexed birds by relative body size and behaviour, but I was confident in identification only by the position of individuals during mountings, and by observing certain behavioural displays traced to males or females. Behavioural terminology follows van Tets (1965), except where noted.

BEHAVIOUR

Locomotion

Adult Red-footed Cormorants moved rarely on land. Flat tops of rocks and islets were favoured resting spots (see also Coker 1919). On islets in the mouth of Ria Deseado, small flocks of juveniles and adults sometimes stood motionless on the sandy beaches. When approached on their resting areas by other cormorants (King and Imperial Blue-eyed Shags, *P. albiventer* and *P. atriceps*; Olivaceous and Magellanic Cormorants, *P. olivaceus* and *P. magellanicus*), adults would always take off and fly rather than shuffle two or three steps to the side; juveniles however seemed more likely to move away than fly.

While on the nest, adults moved around the rim by shuffling, never lifting the base of the foot higher than the intertarsal joint. Red-footed Cormorants use a very modified form of Stepping to move around the nest

rim when changing incubation bouts. The bird initiating the change brings its head down on its breast with its neck held erect, and it steps around the nest rim by deliberately lifting its feet above the intertarsal joint. Stepping is used by other cormorants as an appeasement display when moving through the colony and near neighbours (pers. obs.).

Wing-spreading

I did not see this behaviour used by any adults or juveniles.

Nest-building

Red-footed Cormorants build their nests on sheer rock walls beneath overhanging rock ledges without any ground approach (see Fig. 43 in Koepcke 1953). For example, the small colony on Roca Olorosa in Bahia Oso Marino was 20 m above the level of the sea on the nearly vertical basaltic cliff faces. Unlike in the neighbouring Magellanic Cormorant colonies on Isla Chata, the birds could approach these nests only by air: once out of the nest, Red-footed Cormorant juveniles had no way to return except to fly.

Take-off

This display is considered to encompass three stages: Look, Crouch, Leap (van Tets 1965). When leaving the nest, a Red-footed Cormorant moves to the rim and Looks by holding its neck motionless over its shoulder with its body held upright, gular depressed by the hyoid, and its bill pointed away from the cliff (see Fig. 1a). This is very similar to the Twisting and Pointing display described by van Tets (1965) for the Pelagic (*P. pelagicus*) and Red-faced Cormorants (*P. urile*). The bird does a distinct Crouch, often repeatedly, by dropping its breast and raising its abdomen; the gular pouch is depressed by the hyoid and the bill is kept closed. The Leap is always horizontal and away from the nest, never up into the air. As soon as it leaves the nest, the bird utters a distinctive clear, warbling whistle which rises, then quickly falls in pitch. Coker (1919) likened this call to sparrow chirps, and Johnson (1965) described it as high-pitched and squealing. With only minor exceptions in calls and positions, these displays are quite similar to those reported for the European Shag, *P. aristotelis* (Snow 1963), and the Pelagic and Red-faced Cormorants (van Tets 1965, Dick pers. comm., Siegel-Causey, pers. obs.).

Landing

When landing at the nest, a Red-footed Cormorant flies up from below with its neck and head held 45°-60° from the horizontal and its bill wide open. As it approaches the cliff face, it brings its feet up in front of its body. Within about 30 m of the cliff, it gives a call similar to the Take-off call (Kink-throating, van Tets pers. comm.) but stops calling abruptly once on the ground. Immediately after landing, it extends its neck over the nest rim (or over the incubating bird), its neck feathers erected and the gular depressed by the hyoid (Post-landing posture of van Tets 1965). This pose is held motionless for a few seconds. I heard no post-landing vocalisations. The bird already on the nest would almost always lift its breast from the ground, drop its bill to the nest (Nest-indicating), and Nest-worry. Both adults would then Neck-twine and Allopreen (see Fig. 2). These post-landing behaviours resemble those used by the European Shag (Snow 1963) and other species of cormorants and shags (van Tets, pers. comm.).

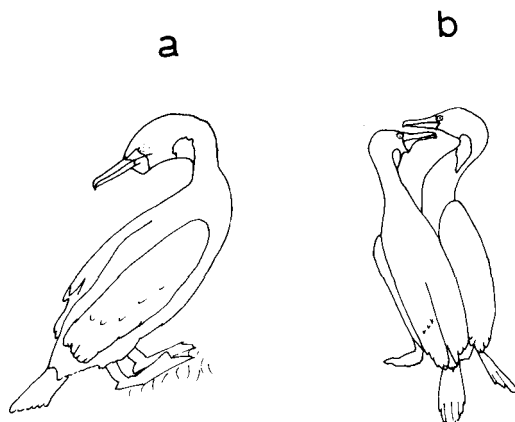


FIGURE 1 — Communication behaviour of the Red-footed Cormorant. (a) The Look phase of the Take-off display. (b) Throat-clicking during courtship. Note that the male on the left is Kink-throating. Figures are redrawn from photographs.

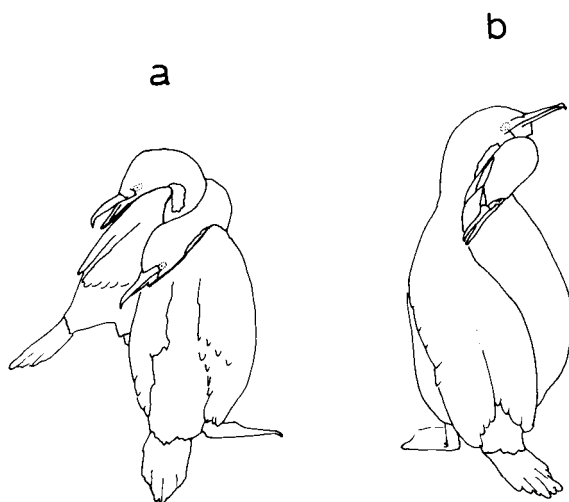


FIGURE 2 — Pairing displays of the Red-footed Cormorant. (a) Neck-twining and (b) Allopreening. Figures are redrawn from photographs that were part of a sequence observed between the same pair of birds.

Hop

The Hop, which is distinctive to gannets, boobies, darters, shags and cormorants, appears to be a symbolic, abbreviated flight (van Tets 1965) in that it comprises elements of the Take-off and Landing displays. For Red-footed Cormorants, the Hop display is an adjunct to the development of the pair bond. Males and females perform the display similarly. First, the head is pointed downwards with the neck stiffly arched towards the feet, the bill closed and the gular depressed by the hyoid, and the wings are slightly opened near the body. The bird makes a short jump upwards by making a sharp push with its feet. The feet leave the ground unevenly, often only one foot clearing the nest or ground. After the Hop, the bird does a Post-landing display, often very quickly.

At the beginning of the season, both sexes use the Hop frequently after landing and before take-off, before allopreening bouts, before and after mounting, to initiate nest relief, and in general, as a form of "punctuation" between other courtship displays. Later in the season, it seems to be used mainly before leaving the nest and at incubation changeovers.

Threat

Perhaps because the breeding season was well established, I saw little aggression among the Red-footed Cormorants. The calm of the colony was seldom broken by squabbling neighbours or by parents defending their nests, very similar to that observed in a Pelagic Cormorant colony (Siegel-Causey & Hunt 1981).

The usual threat display I observed consisted of very vague, lateral quivers of the head with the neck unextended; it was terminated by Nest-indicating. This display was used mostly as a primary threat, only rarely leading into other forms. The much rarer Thrust, presumably a higher-intensity threat, was used only in conjunction with the first display. If the defender was not already sitting down on the nest, it would drop its breast down to the nest rim and thrust its open bill weakly at the offender. As in the first display, Thrusting was followed by Nest-indicating. This cycle would often be repeated many times, but two or three repetitions were usually enough to drive away errant Red-footed Cormorants.

These threat displays resemble those described for the European Shag (Snow 1963) and other species of cormorants (van Tets, pers. comm.) but differ by their very low intensity. A derived form of the Thrust display, in which a weak Thrust and nest touch were combined into a single action, was seen directed by nesting adults at loafing juveniles and encroaching neighbours. It rarely was repeated and seemed to be used more in the context of site ownership and less as an agonistic display. I did not see Snaking used, although this display of waving the extended head laterally with opened bill at the invader is commonly used by other cormorants in defence (Siegel-Causey 1978). I also heard no vocalisations used with any agonistic display.

Male advertising

The displays used only by males during courtship were Darting and Throwback. In Darting, the male starts with his body semi-erect and wings closed. From this position he draws his head horizontally back and forth along the midline with small stiff movements, occasionally making a faint clicking noise in rhythm with the forward movement.

At the most forward position, he opens his bill slightly and displays the bright red gape. Darting was often repeated many times, but occasionally was interrupted by looking around to the side. This is similar to that observed in the Pelagic and Red-faced Cormorants (Dick, pers. comm.; Siegel-Causey, pers. obs.).

The male followed Darting with the Throwback, usually as the female approached. When both were at the nest, the male would Throwback after about four to five Dartings. In Throwback, the male stretches his neck along his back, points his slightly opened beak back towards the tail and rhythmically Kink-throats. The Throwback position is usually held for 3-5 seconds with the wings held tightly to the body. No calls are made. Occasionally, Throwbacks were combined with a single flip of the wings, similar to Wing-flapping of the European Shag (Snow 1963), Pelagic and Red-faced Cormorants (Snow 1963, Dick pers. comm., Siegel-Causey pers. obs.), in that the tips of the folded wings were moved sharply away from the body and brought immediately back. Although I often observed this display, I was unable to discern any pattern of its use by Red-footed Cormorants.

Recognition and pairing displays

Male Red-footed Cormorants use a distinctive display to greet incoming females to the nest and to indicate nest relief. The neck is laid along the back, as in the Throwback display, and the bill is slightly opened, pointed back towards the tail, and then rolled quickly from side to side a few times. See Fig. 3. A single click is uttered on each roll. Except for the position of the neck, this behaviour appears similar to Gaping in the European Shag (Snow 1963). Both sexes of the European Shag use Gaping for recognition, but I observed only the male Red-footed Cormorant do it.

Throat-clicking is characteristic of Red-footed Cormorants returning to the nest, especially when bringing nest material, and often after copulation. The standing bird holds its body and neck semi-erect and its head horizontally over the back and neck of the sitting bird; its beak is closed, and its wings and plumage are close to the body (Fig. 1b). Kink-throating is done in conjunction with the emission of rhythmic clicks. After a few seconds of clicking, the bird slowly relaxes. Throat-clicking is often alternated with mutual Nest-worrying (van Tets 1965), which is a display where both partners make lateral quivering movements with their bills on or near the nest. Nest-worrying seemed to be used by Red-footed Cormorants in many contexts, for both sexes used this movement in greeting, as part of other recognition and courtship displays, and even between threat displays.

The most distinctive pair-bonding behaviour of the Red-footed Cormorant is Allopreening. It is initiated by either sex, generally by means of a behaviour similar to Bill-waving described for Blue-eyed shags (Siegel-Causey, in press). The initiator opens its beak about 45° and waves it near the face of the other bird horizontally so that it passes around the second bird's unmoving closed beak. Both then Neck-twine and gently nibble each other's long white neck patches. After 10-15 s, Allopreening stops, but usually it is repeated without Throat-clicking or Bill-waving. Repeated bouts last up to 4 minutes without either bird changing position or behaviour.

Although Bowing is a common behaviour in the European Shag and Pelagic Cormorant, I seldom saw it and could see little pattern in its use. All of these recognition displays appear similar in form to those of the European Shag (Snow 1963) and the Pelagic and Red-faced Cormorants (Dick pers. comm., Siegel-Causey pers. obs.).

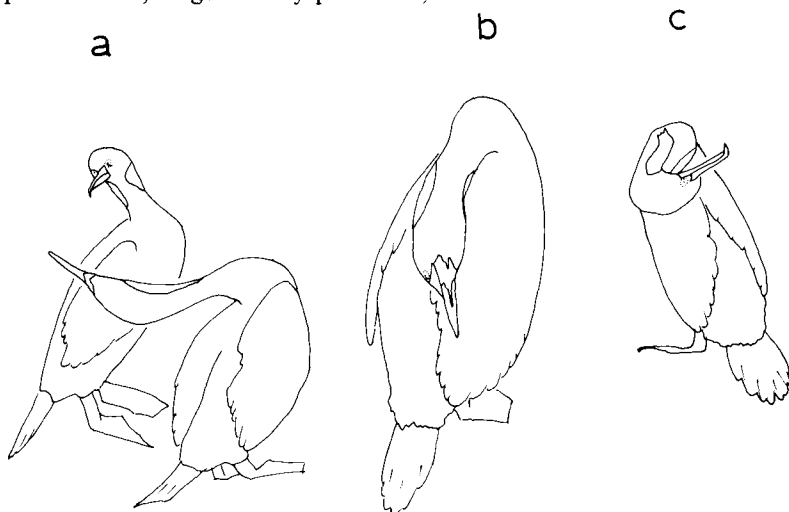


FIGURE 3 — The Gaping display of the Red-footed Cormorant. (a) Beginning, (b) rolling, and (c) ending phases of the display. Figures redrawn from photographs.

Courtship

Males invite prospective females to approach by Darting and Throwbacks, rarely by Wing-flipping. The female responds by sidling closer to the male and Hopping. The male then Throwbacks only, the female responding by Hopping and Throat-clicking. Intensive bouts of Allopreening follow, the male occasionally doing Throwbacks, rarely Wing-flipping. Mounting is usually preceded and followed by the male Throat-clicking and the female Nest-worrying. Although reverse mountings have been reported in cormorants (see Bernstein & Maxson 1982), I have not seen it in the Red-footed Cormorant. The cycle of Allopreening, Throat-clicking, and Mounting persists over a few days, gradually being replaced by nest building and pair-bond displays. In its barest outlines, this sequence of courtship behaviours matches that described for the European Shag (Snow 1963).

DISCUSSION

Murphy (1936) summarised the evidence to that date on the affinities of the Red-footed Cormorant, and identified the spotted shags (*P. punctatus* and *P. featherstoni*) as its closest relatives, apparently on the grounds of general similarity and proximity. At the same time, von Boetticher (1935), struck by the fact that only the Red-footed Cormorant and the Great Cormorant

(*P. carbo*) have 14 tail feathers, introduced a new subgenus *Poikilocarbo* for the Red-footed Cormorant and retained the latter species in the subgenus *Phalacrocorax*. As little other than the number of tail feathers was presented for justification, and such monotypic groupings do not help in assessing relationship, this work was ignored by systematicists.

In van Tets' (1974) reorganisation of the Phalacrocoracidae, the Red-footed Cormorant is referred on behavioural evidence to the subgenus *Stictocarbo* along with the spotted shags and the Magellanic, Pelagic, and Red-faced Cormorants. Only partial ethograms of the spotted shags are available for comparison (van Tets, pers. comm.), but other evidence from skeletal morphology (Siegel-Causey, pers. obs.) indicates that they and the European Shag are the closest relatives of the Red-footed Cormorant. I expect that when the behaviours of the spotted shags are better known, the similarities between the spotted shags and Red-footed Cormorant will be closer than those observed between it and the European Shag.

Whether Atlantic and Pacific populations of Red-footed Cormorants differ in behaviour is also not known. Although not very well described, the nest-site selection and nest-building behaviours, certain vocalisations, and the courtship display of Bill-waving appear similar (Doello-Jurado 1917, Coker 1919, Murphy 1936, Koepcke & Koepcke 1953, Johnson 1965, Zapata 1967). The foods eaten, the size of the feeding and resting flocks, the distances of winter dispersion, and the strength of the ties to a particular colony or nest site appear to be quite divergent between Atlantic and Pacific populations (Coker 1919, Bullock 1935, Murphy 1936, Olrog 1948, Johnson 1965, Markham 1971, Jehl & Rumboll 1976). The Red-footed Cormorants of the Atlantic coast are apparently more sedentary and more social than those of the Pacific coast. How far these differences are due to genetic divergence or to environmental differences between coastlines is not known.

The species of the *Stictocarbo* group so far studied are, by their behaviour, clearly more closely related to one another than to other cormorants. Among these cormorants, there appears to be two distinct behavioural groups: the Magellanic, Pelagic, and Red-faced Cormorants; and the European Shag, Red-footed Cormorant and, provisionally, the spotted shags.

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SHORT NOTE

Notes on the feeding habits of the New Zealand Dotterel

Buller wrote in 1873 (*A History of the Birds of New Zealand*) that the New Zealand Dotterel (*Charadrius obscurus*) feeds mainly on small crustacea, mollusca and sandhoppers. In 1888 (second edition) he added insects to this list. Some interesting feeding habits and many specific items of prey have been recorded since then, though most works just quote Buller.

Hutton & Drummond (1923, *Animals of New Zealand*, 4th ed.) specified craneflies and grasshoppers as being important food items. In 1963 McKenzie & Sibson (*Notornis* 10: 350) recorded the taking of a cricket and a moth. New Zealand Dotterels have been seen feeding in rock pools and in grassland, tossing aside pieces of dry cowdung, by Edgar (*Notornis*, 16: 86) and worms are mentioned as part of their diet by Power (1971, *Waders in New Zealand*). Raking soft sand to flush sandhoppers was described by Jones (*Notornis* 22: 324), who also witnessed foot-trembling by New Zealand Dotterels (*Notornis* 31: 208). Heather watched New Zealand Dotterels on Great Barrier Island feeding on the little black mussel (*Xenostrobus pulex*)

pulling them off the rocks and swallowing them whole (*Notornis* 27: 164-166). Two different methods of catching fish have been recorded by Latham (*Notornis* 26: 36) and Habraken (*Notornis* 27: 159). Vigorous foot-paddling in shallow water to bring tiny aquatic creatures to the surface has been observed by Searle (*Notornis* 31: 208).

On 19 June 1982 I watched a pair of New Zealand Dotterels feeding along the fresh tideline just to the north-west of the Tarawera River mouth. They were feeding primarily on small, moribund specimens of the common rock crab (*Hemigrapsus edwardsi*), as they washed in. These were small enough, 20-30 mm across, to be eaten whole without any preparatory bashing.

When I visited the Rangitaiki River mouth on 12 June 1983 the beach was covered with the remains of a recent large wash-up of live horse mussels (*Atrina zelandica*). The Southern Black-backed Gulls (*Larus dominicanus*) had done a thorough job of breaking open the shells and eating the contents. There were, however, scraps of flesh clinging to many of the shells and it was on these that I watched a cock New Zealand Dotterel feeding, sometimes exerting considerable effort to free a piece. His mate, on the other hand, did not show the slightest interest in the shells during the half hour that I watched.

P. C. M. LATHAM, *c/o Papamoa Beach P.O., via Te Puke*

On several occasions I have observed New Zealand Dotterels catching small crabs on mudflats. A dotterel would stand still watching an area of mud and, on sighting a crab, would run forward and pounce on it. On 12 December 1985, while having lunch in the car beside Pakiri River estuary, Northland, I watched half a dozen New Zealand Dotterels feeding. One bird caught a crab and then dismembered it. It seized the crab by one limb, shook it vigorously until the limb came off, and swallowed the limb. It then pounced on the crab before it could scuttle away. It removed all the limbs in this way, leaving the body, which it swallowed whole.

RICHARD PARRISH, *Wildlife Service, Nelson*

This topic seems suitable for a co-operative or local study – New Zealand Dotterel foods and feeding methods. Have we similar *New Zealand* information on our distinguished rarer visitors? For example, Hugh Robertson, Jim Hamilton and Barrie Heather, at Porangahau estuary on 22 June 1986, watched a Mongolian Dotterel catching and dismembering crabs. It would race forward in a hunched flat-back posture, grab a small crab from the water, take it to 'dry' mud and beat it repeatedly until it could be swallowed. This can hardly be new; but we need systematic study rather than such casual anecdotes. – Ed.

THE BREEDING AND FLOCKING BEHAVIOUR OF YELLOWHEADS AT ARTHUR'S PASS NATIONAL PARK

By A. F. READ

ABSTRACT

Yellowheads (*Mohoua ochrocephala*) were observed between November 1983 and May 1984 in the Hawdon River Valley, Arthur's Pass National Park. Of 11 breeding pairs, at least three had a third adult associated with them. Three pairs were watched in detail, and two nests were found, both in holes in live beech trees. The maximum breeding range was 7 ha. Young fledged in late December, and so laying had occurred in early November and hatching in late November-early December. There was no indication of double broods or renesting. Family groups of adults and juveniles remained in their breeding ranges for up to 2.5 days after fledging and then ranged throughout the forest. Parental care continued for about 55 days. From mid-January family groups began to come together for several hours and flocks of up to 25 Yellowheads were seen. In April and May flocks of 6-12 Yellowheads were seen, the birds apparently remaining together all day. Yellowheads were often in mixed species flocks.

INTRODUCTION

The Yellowhead (*Mohoua ochrocephala* Gmelin 1789) is an insectivorous South Island forest passerine which, together with the Whitehead (*M. albicilla*), forms a well-differentiated endemic genus of obscure affinity (Fleming 1962, Keast 1977, Falla *et al.* 1979). The Yellowhead's distribution, unlike that of the Whitehead in the North Island, appears to have been contracting since the 1880s, and in recent years its patchy distribution has become still further reduced (Child 1981, Gaze 1985). While studying the abundance and habitat use of Yellowheads in Arthur's Pass National Park during 1983-84 (Read 1984), I took the opportunity to observe breeding and flocking behaviour.

Only two studies have dealt in any detail with the behaviour of the Yellowhead: those of Guthrie-Smith (1936) in the Pukikirunga Range of Abel Tasman National Park and of Soper (1960, 1963) in the Eglinton Valley, Fiordland National Park. Both these studies concentrated on breeding behaviour, particularly nest building, mating and incubation, and made little mention of post-breeding behaviour. All other information on Yellowhead behaviour has come from anecdotal records by early naturalists (for example, Potts 1869, Reischek 1885, Smith 1888). Current knowledge of the Yellowhead has been summarised by Robertson (1985).

My aims in this paper are firstly to describe the breeding cycle of Yellowheads at Arthur's Pass, which is now the northernmost locality where Yellowheads are present in sustainable numbers (Gaze 1985), and secondly to provide information on their post-fledging behaviour.

METHODS

Study area

The Hawdon River Valley (42°58'S, 171°45'E) lies to the east of the main divide in Arthur's Pass National Park. Although steep and gorged in its upper reaches, the Hawdon River is braided below its junction with the East Hawdon Stream and meanders across a wide flood plain down to 600 m a.s.l. The stable areas of river flats are grassed, and the lower terraces and main slopes are covered by mixed forest of red beech (*Nothofagus fusca*) and mountain beech (*N. solandri* var. *cliffortioides*), rising to a sharp timberline at 1200-1300 m a.s.l. The history, landforms, vegetation and fauna of the area are described in detail by Read (1984). About 500 ha of forest were searched for Yellowheads during the study (Read & O'Donnell, in press), in particular the forests on the west of the braided section of the river.

Observations

I kept notes of breeding and flocking behaviour seen during the study, which lasted from November 1983 to May 1984, and located breeding pairs during a distribution survey from 21 November to 4 December 1983. If a breeding pair was seen consistently with a third bird I considered the trio to be 'co-operatively breeding' (Emlen 1984). To estimate the maximum area of each breeding range, I assumed that the ranges were circular and took as the radius the longest distance I saw adults away from their nest.

Three pairs were watched in detail, and the nests of two of these were watched for 5 hours in mid-December to see how often the parents fed the nestlings. I inferred their breeding cycles from observed fledging dates and from the incubation and fledging periods (18 and 21 days respectively) determined by Soper (1963).

Groups of Yellowheads were followed for long periods after nesting, and general notes of flock size, parental care and other species associated with the flocks were kept.

The Yellowheads were not banded and so I could not recognise them individually. Until late December I could tell the sex of nesting adults because one bird of each breeding pair or trio always had a brighter yellow head and less dark colouring on the back of its head. This bird I assumed to be male, after Guthrie-Smith (1936) and Soper (1960). However, I could not use this difference after December, possibly because of the post-nuptial moult (Read 1984). Cunningham & Holdaway (1986), after a study of museum specimens, discussed the difficulty of sexing Yellowheads.

Terminology

Home range: The area around the nest in which adult Yellowheads foraged during incubation and brooding. Because the density of breeding pairs was low in the Hawdon Valley (1 pair/45.5 ha, Read & O'Donnell, in press) and I did not see breeding Yellowheads interacting with other Yellowheads, I could not tell whether home ranges were actively defended and so qualified as territories.

Itinerant non-breeders: Birds seen at a locality only once and therefore assumed to be mobile and not breeding.

RESULTS

Eleven breeding pairs were found during the distribution survey (Read & O'Donnell, in press). Three broods fledged between 17 and 23 December, and so laying had occurred between 8 and 15 November and hatching between 29 November and 6 December. Another pair was feeding nestlings on 24 December and presumably had laid after 15 November. Figure 1 shows the inferred breeding cycles of the first three pairs and summarises the behaviour of Yellowheads in the study area after young had fledged.

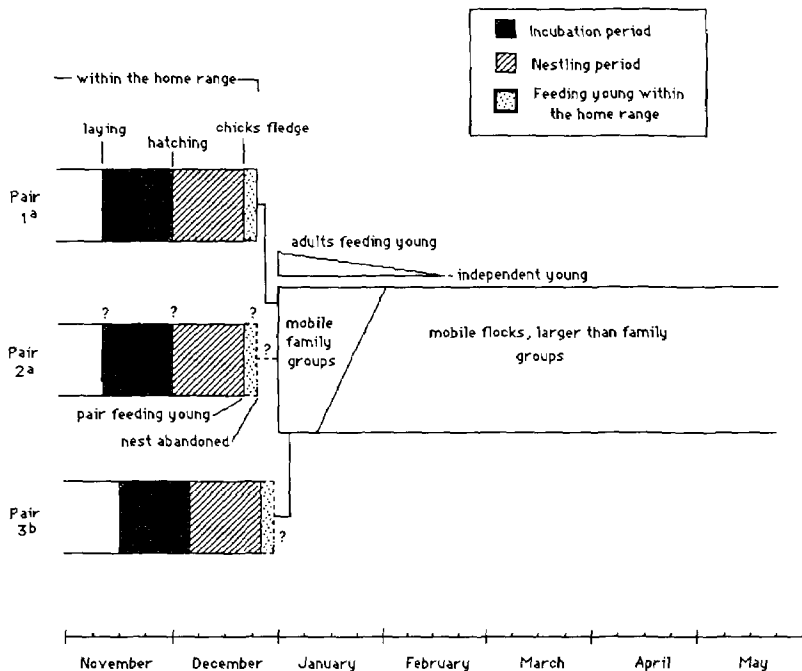


FIGURE 1 — The breeding cycle of the three pairs watched most intensively, and a summary of how Yellowheads behaved after abandoning their home ranges. Dates of laying and hatching were calculated back from known dates of fledging, using the incubation and fledging periods given by Guthrie-Smith (1936) and Soper (1963). a = nests found; b = no nest found but very weak fledglings being fed on the ground; ? = date cannot be inferred.

Behaviour during nesting

Both nests found were in holes in live trees, one 12 m up a red beech, the other 15 m up a mountain beech. Both trees were partly hollow, and the entrance holes of both nests were worn smooth. The only nest visible was a neat, cup-shaped arrangement of moss and grasses.

Of the eleven home ranges found, at least three contained a third bird (Table 1). Two of these birds were females, but the sex of the third was not known. Only one of the three pairs watched closely had an associate (a female), but because the birds were not banded I could not tell whether both females were incubating.

I could not determine clutch and brood sizes, but family groups with two and four juveniles were seen after fledging (Table 1).

TABLE 1 — Size of Yellowhead groups seen. Only groups which could be properly counted are included

| | Group Size | Number |
|--|---------------------------------|--------|
| Nesting (late Nov - mid-Dec) | Single pairs | 8 |
| | 1 pair + 1 helper | 3 |
| | Itinerant non-breeders | 6 |
| After fledging but still within home range | 1 pair + 2 fledglings | 3 |
| | 1 pair + 1 adult + 2 fledglings | 1 |
| December, outside home range | 1 pair | 1 |
| | 1 pair + 2 fledglings | 3 |
| | Itinerant non-breeders | 2 |
| Early January | 2 adults | 1 |
| | 2 adults + 2 juveniles | 7 |
| | 3 adults + 2 juveniles | 2 |
| | 2 adults + 4 juveniles | 1 |
| Mid-January to mid-February | 3 adults | 1 |
| | 2 adults + 2 juveniles | 4 |
| | 3 adults + 3 juveniles | 2 |
| | 2 adults + 4 juveniles | 1 |
| | Flocks: 5-10 birds | 2 |
| | 11-15 birds | 1 |
| | 16-20 birds | 1 |
| March to May | >20 birds | 2 |
| | | |
| March to May | Flocks: 5-10 birds | 4 |
| | 11-15 birds | 1 |

At the two nests watched in mid-December, both adults were feeding nestlings c.16 days old. The adults foraged up to 150 m from the nest, although usually much less. Thus, the maximum area of the breeding home ranges was 7 ha. During 5 hours of observation males fed the nestlings every 11.5 min on average (range 8-18 min), and females fed them every 14 min (range 8-22 min). Both parents usually flew to the hole within 2 minutes of each other. On several occasions the adults fed the nestlings from the edge of the hole without going in.

Post-fledging behaviour within home range

At first, the fledglings in two home ranges could fly only a few metres and so the adults had to forage in the same areas as they had when nesting. These fledglings were very conspicuous, begging for food and making feeble attempts to forage and fly. Both parents fed the young, and one group of fledglings was also fed by a helper. Individual fledglings in both groups were

fed on average every 23 min (range 2-64 min; 9.5 hours of observation). This was slightly less often than the young were fed in the nest, possibly because the fledged young were also partly foraging for themselves.

For their first few hours after leaving the nest the fledglings were within 1 metre of the ground, perched in the undergrowth or among windfall, and often directly on the ground. As the juveniles gained strength they were gradually able to fly higher, and slowly progressed higher in the forest. One family group remained in the same area for 2.5 days. I could not revisit the other family for 10 days, by which time they had left their breeding range.

Although the young fledglings were usually hidden in the undergrowth, they seemed easy for predators to catch. While approaching one fledgling I scared a feral cat (*Felis catus*) only a metre from the young bird, and later saw the cat twice more.

Behaviour after dispersing from home range

The Yellowhead families abandoned their home ranges in late December, and during the rest of the study I saw no Yellowheads in any of the breeding home ranges. There was no indication of renesting or double brooding; all the Yellowheads were travelling widely and none were seen regularly at any locality.

Family groups of two or three adults and two to four juveniles ranged through the forest (Table 1). I followed several groups for six hours or more, and after mid-January these often travelled 1.0-1.5 km.

In late December and early January the juveniles perched in the canopy, often out of sight from the ground. They would remain in the same tree for 10-20 minutes and occasionally for as long as an hour while the adults foraged nearby. Both adults fed the young, returning with food every 2-6 minutes (20 hours of observation). Eventually the adults would move to another tree and call, the juveniles would fly into the new tree, and the pattern would be repeated. By mid-January the young began to follow the adults, begging noisily, and so they spent less time in individual trees. Only once were adults seen to move well away from their juveniles, when eight Yellowheads mobbed a roosting Morepork (*Ninox novaeseelandiae*) about 100 m from the juveniles.

The juveniles' foraging attempts became more frequent as they grew older. In late December and January they spent less than 20% of the time foraging, but this had increased to about 65% by February. The rest of the time was spent calling, preening and roosting (Read 1984). As the juveniles began to forage more intensively they ranged vertically through the forest, often coming down to the lower understorey or the ground to feed. They were still being fed by adults, although only once every half hour. After mid-February no adults were seen feeding young. Thus, parental care continued for about 55 days, although this was difficult to determine exactly because no juveniles were colour banded.

Juveniles gave adult-type calls in February, but I could still distinguish them from adults by their more laboured flight, begging calls and mottled colouring, and by the greater time spent preening and roosting. They were also more inquisitive, often perching within 1 m of observers.

Flocking

From mid-January family groups began coming together for short periods, and I saw flocks of up to 25 Yellowheads (Table 1). These flocks were very noisy, calling and singing. Within these flocks I saw Yellowheads chase each other only twice, and in general they made only vocal contact. The amount of calling by each bird was related to the number of Yellowheads in the flock: individuals called more often in large flocks than in family groups. Whenever two or more family groups were together, their greater noise apparently attracted other Yellowheads and larger flocks would form. After several hours the flocks would break into family-sized groups again. In April and May I saw flocks of 6 to 12 Yellowheads that stayed together all day.

The flock noise was much less in autumn, and by May I could often locate flocks only by the noise of debris hitting the forest floor after being dislodged by foraging birds.

Many other species associated with the Yellowhead flocks, and especially with the larger flocks: parakeets (*Cyanoramphus* spp.), Fantails (*Rhipidura fuliginosa*), Yellow-breasted Tits (*Petroica macrocephala*), Riflemen (*Acanthisitta chloris*), Brown Creepers (*Finschia novaeseelandiae*), Grey Warblers (*Gerygone igata*), Silvereyes (*Zosterops lateralis*), and Bellbirds (*Anthornis melanura*) (Read & McClelland 1984). The Yellowheads led these mixed species flocks and determined where they went. Parakeets were often seen following Yellowheads, even during the nesting period. They often fed at the exact site a foraging Yellowhead had just left which suggests some sort of feeding association, although the frequency of this behaviour was not quantified. When recordings of Yellowhead calls were played they often attracted parakeets.

The Yellowheads were, in general, not aggressive towards other species. Throughout the study only nine interspecific behavioural interactions were noted: a stoat (*Mustela erminea*), a roosting Morepork and a Long-tailed Cuckoo (*Eudynamis taitensis*) were mobbed, and two Yellow-breasted Tits, a Chaffinch (*Fringilla coelebs*), a Rifleman and a Fantail were chased when they came within 0.5 m of a foraging Yellowhead or a roosting juvenile.

DISCUSSION

Both Guthrie-Smith (1936) in Abel Tasman National Park and Soper (1963) in Fiordland National Park found that breeding occurred during November and December, as I did in the Hawdon Valley. However, in Nelson Lakes National Park, Moncrieff (1925) observed Yellowheads feeding fledglings on 22 November, which means the eggs would have been laid in mid-October. G. Elliott (pers. comm.) found Yellowheads incubating in mid-October in the Eglinton Valley, Fiordland National Park. These differences suggest that the timing of breeding can vary. Moncrieff (1957) stated that Yellowhead breeding begins in October, but she gave no further details.

Breeding in the Hawdon River Valley during my study apparently finished earlier (late December) than it does elsewhere or than it has done

in other years. Moncrieff (1957) said that breeding continued until February, and in the Eglington Valley in 1985 breeding did not finish until mid-February (G. Elliott, pers. comm.). There are two records of Yellowheads feeding chicks in the Arthur's Pass region after December: one in the Waimakiriri catchment in early March (OSNZ Nest Record Scheme) and one in early February 1986 in the Hawdon River Valley itself (P. Reese, pers. comm.). The lack of renesting by Yellowheads in the Hawdon River Valley in 1983-84 probably accounts for the shorter breeding season. Yet Yellowheads are apparently fully capable of raising two broods in Fiordland National Park (G. Elliott, 1986).

Why, then, did the Yellowheads in the Hawdon River Valley have a shorter, later breeding season and why did they not attempt a second brood? Perrins (1970) suggested that the date of laying is determined by the time at which the female is able to find enough food to form eggs, and there is now experimental evidence for this from at least ten studies (Davies & Lundberg 1985 and references therein). Food availability has also been demonstrated to affect the number of clutches laid (Davies & Lundberg 1985). Thus the single broods and shorter breeding season, as well as the low density of Yellowheads, could be due to a shortage of food in the Hawdon Valley during my study.

Associate adults were at two of the five nests Soper (1963) studied, but with such small samples in both this and Soper's study it is not yet possible to draw any conclusions as to the frequency of co-operative breeding in Yellowheads. Furthermore, it is still unclear whether the third bird is purely a nest helper (Emlen 1984), or whether Yellowheads are polygamous (Soper 1963 p.34, Robertson 1985 p.277) with several birds contributing physically and genetically to the young in one nest. Certainly, though, a third Yellowhead may contribute to the raising of young even when the density of breeding pairs is very low and there is no obvious shortage of suitable breeding habitat or non-breeding adults (Read & O'Donnell, in press).

In view of the vulnerable conservation status of Yellowheads, the feeding of young on or close to the ground during the first few hours out of the nest must be cause for concern. Further study is needed to see whether my results are typical. Being hole nesters, Yellowheads are unlikely to abandon their nest prematurely. If fledglings do spend their first few hours after leaving the nest near the ground, they may be at risk from mammalian predators, particularly when predator densities are high, for example after a beech seeding year (King 1983).

Further study: As Yellowheads have vanished to the north and west of Arthur's Pass National Park and their present range is continuing to contract (Gaze 1985), the fate of the Hawdon Valley birds is important for the future of the species. If behaviour during the 1983-84 summer was typical, my study raises several problems. How often do fledglings spend their first few hours close to the ground? How often do Yellowheads have a shortened breeding season and not attempt second broods?

The Yellowhead may also be a good species to use for answering theoretical questions on mixed-species flocks and co-operative breeding: for

example, what role do Yellowheads play in these flocks and why are adult trios present at nests when there is no apparent shortage of breeding habitat or of unmated birds?

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BREEDING ECOLOGY AND CONSERVATION OF THE BLACK PETREL (*Procellaria parkinsoni*)

By M. J. IMBER

ABSTRACT

The breeding of the Black Petrel on Little Barrier Island was studied during 1971-75 in 22 study burrows and then reviewed at about 2-yearly intervals. Predation by feral cats affected the population most, causing the number of breeding and non-breeding birds associated with study burrows to decline from 39 in 1971-72 to 14 in 1976-77. Cats were eliminated between 1977 and 1980. By 1982-83 further attrition due to poor recruitment had stopped.

The breeding season of the Black Petrel is from October to July. Eggs are laid from about 10 November to about 20 January but mainly in early December. Prelaying activities are brief, but other phases of the breeding cycle are not. Incubation shifts and the nestling period may be long because of limitations of the food supply.

The major breeding place is Great Barrier Island. Surveys there during chick-rearing in 1977 and 1978 revealed very little predation and relatively high breeding success. The cause of this is discussed.

INTRODUCTION

The Black Petrel (*Procellaria parkinsoni*), or Parkinson's Petrel, which breeds only in New Zealand, is the smallest and most northerly breeding of its genus. It formerly bred on the North Island and northern South Island, in at least four widespread places reported in European times (Dieffenbach 1843, Reischek 1886, Buller 1905, Oliver 1955). It was a highly valued muttonbird of Maoris, some of whom called it Taiko. Their lore suggests other former breeding places, some far inland. The only authentic report of breeding on the main islands this century was in Taranaki (Medway 1960), some distance from where Dieffenbach first reported it, and where a few might still breed (D. G. Medway, pers. comm.).

At sea during the breeding season it ranges far to the north and east of the North Island (Murphy 1936, Imber 1976, T. G. Lovegrove pers. comm.) and also west into the Tasman Sea, reaching Australia (D. W. Eades, pers. comm.; Fig. 1). It migrates to the eastern tropical Pacific after the breeding season (Loomis 1918, Murphy 1936, Jehl 1974, Pitman & Unitt 1981, J. Farrand pers. comm.).

HISTORICAL NOTES

Dieffenbach (1843) made the first observations recorded of Black Petrels. In December 1839, guided by a local Maori, he was making a first attempt to climb Mount Taranaki (Egmont), North Island. "On the 8th we several times crossed the Mangorake. Its banks are steep, and from one of them Tangutu dug out a titi: this bird, a *Procellaria*, or mutton-bird as it is

commonly called, has many peculiarities. In the month of December it comes from the sea to the mountains inland, especially to the fore-hills of Mount Egmont. Here the female, which is at that time very fat, but afterwards becomes thin and emaciated, lays one egg, which is remarkably large for the size of the bird. Instead of building a nest, she deposits and covers over her egg in a deep channel under the roots of trees, or at the sides of a cliff, and never leaves the place until the egg is hatched. The natives believe that during this period the female takes no food, and have accordingly named it "the bird of one feeding" This locality, then heavily forested, is upstream of the present Egmont Village, at about 300 m. It is now dairy-farming country.



FIGURE 1 — Black Petrel seen 35 km east of Sydney, Australia, on 26 November 1983. Many adults are on their prelaying exodus at this time of year and could travel far from their colony.

Photograph: D. W. Eades

Hutton (1870) discovered Black Petrels breeding above 460 m on Little Barrier Island ($36^{\circ}12'S$, $175^{\circ}05'E$) in December 1867. Reischek (1886) observed some of their breeding habits there between 1882 and 1885, and he discovered them breeding west of Auckland in the Waitakere Ranges ($37^{\circ}S$, $174^{\circ}30'E$) above 300 m in December 1884. Although he was wrong about the roles of the sexes in incubation, his observations are the most detailed previously recorded. Unlike Hutton, he discovered how they went to sea: "They are expert climbers; I saw them, by the aid of their sharp claws, their bill, and wings, climbing up trees out of the perpendicular, from whence they flew away". He found eggs from 28 November, but his finding a chick

"about the end of December" implies that earlier layings occur, and young chicks as late as April indicate a long laying period. Black Petrels were then abundant on Little Barrier, but ominous signs were the remains of many killed, Reischek thought by pigs and dogs, and the few young that remained by late April.

By Act of Parliament in 1894, Little Barrier (2817 ha, 722 m high) was purchased by the Crown to become New Zealand's first nature reserve. The first curator, arriving in 1897, killed one dog and several pigs during his first year (Mueller 1897) but feral cats persisted, though destruction of them had high priority. Drummond (1907) reported that cats were the only predator remaining. A notable effort was that of L. Hardgrave, who killed 360 cats and c.6000 Polynesian rats, or kiore (*Rattus exulans*), during his 11 years' residence up to 1944 (Hamilton 1961).

From 1945 to 1954 there was an increase in studies of the fauna of Little Barrier. In December 1946 Sibson (1947) made observations on the calls and behaviour of Black Petrels. Both he and Parkin (*in* Turbott 1947) reported corpses, possibly cat-killed, on The Thumb. On 25 and 28 June 1947, J. W. St Paul found recent headless remains of eight fledglings cat-eaten on the Thumb-Summit track and on Tirikakawa Ridge (McKenzie 1948). From 30 December 1947 to 2 January 1948, a party observed incubating birds near the Summit and took a few measurements of eggs and wings (Sibson 1949). In November 1948, more remains were found on the high tracks (McKenzie 1950). During November-December 1949, five corpses were found, four on Thumb track (Dawson 1950). In May 1954, Edwards (1954) found four decomposed headless corpses, which he misidentified as Grey-faced Petrels (*Pterodroma macroptera gouldi*), on Thumb and Summit tracks.

Between 1963 and 1971, Lois G. Bishop (later Wagener) and Sylvia M. Reed, accompanied by other Auckland members of OSNZ, made occasional studies of Black Petrels along the Thumb-Summit ridge and banded 12. However, their efforts were greatly handicapped by the growing scarceness of these petrels.

In 1968-69 the Wildlife Service tried to rid Little Barrier of cats. Feline enteritis virus was introduced and greatly reduced cat numbers (G. P. Adams, Internal Affairs Dept. files). Trapping killed another 130 cats, but the operation foundered for lack of staff and money.

My study began in 1971 as part of a Wildlife Service survey of potentially endangered birds in New Zealand. Studies of the status of the Black Petrel and Cook's Petrel (*Pterodroma cookii*) had high priority and could be done concurrently.

METHODS

The main study area extended from near the junction of Thumb and Summit tracks to beyond the Summit (Fig. 2 & 3), except for an isolated burrow by the Summit track at 490 m, which I checked only when passing from or back to the base hut at intervals of 2-5 days.



FIGURE 2 — Little Barrier Island: view from the summit towards The Thumb (W-SW). The study area extends from the foreground to the left distance. Camp was on the knoll at left.

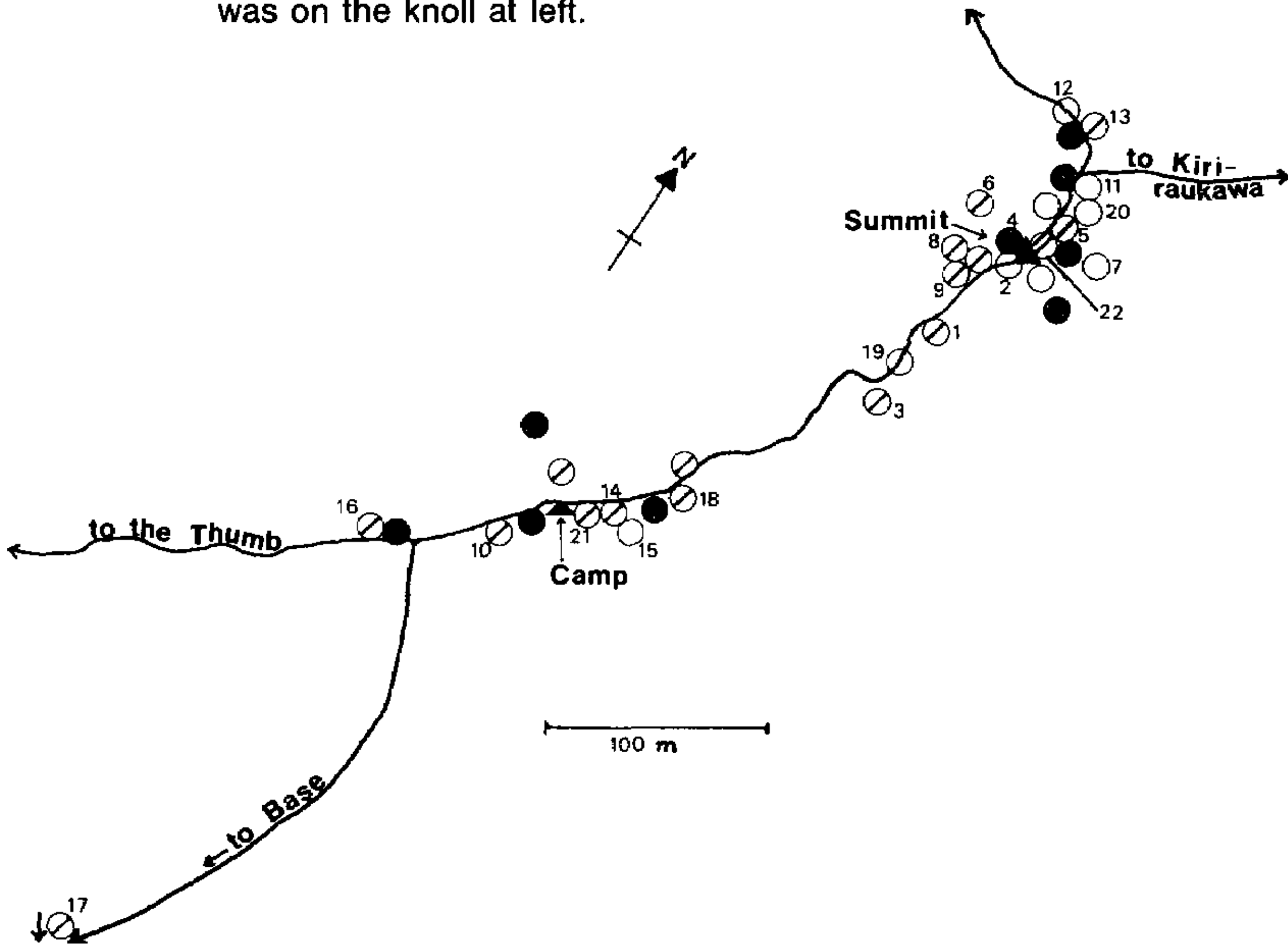


FIGURE 3 — Plan of the study area on Little Barrier Island. Study burrows are numbered. Black circles: burrows disused throughout 1971-1983. Crossed circles: burrows in use in 1971 but becoming disused by 1983. Open circles: burrows in use throughout 1971-1983 (but two possibly disused briefly). Not all disused burrows are shown.

In the main study area I regularly examined 22 burrows through observation holes opening into the nest chambers and sealed with rock slabs. These 22 were about half of the Black Petrel burrows still recognisable in that area, but many of those not studied were disused. I assessed breeding success in the non-study burrows of the main area by external signs or by probing with a stick late in the breeding season.

Study periods were as follows. 1971-72: 2-12 Nov, 22 Feb-9 Mar, 4-18 May. 1972-73: 30 Nov-16 Dec, 16-25 Feb, 13-24 May. 1973-74: 31 Oct-11 Nov, 15-22 Dec, 4-17 Feb, 11-21 May. 1974-75: 18-27 Mar, 2 May. 1976-77: 26-31 Mar. 1978-79: 17-23 Mar. 1981-82: 1-3 Apr. 1982-83: 16 Jan. No visits were made in 1975-76, 1977-78, 1979-80 and 1980-81.

Beyond the main study area my assistants and I explored the main ridge westwards to and including The Thumb and eastwards to Kiriraukawa in May each year of 1972-74, and in March and partly in May 1975. During this survey we looked for corpses, banded and weighed fledglings, and noted whether burrows were used or disused. By means of this survey, we could compare events in the main study area to see that we were not disturbing the petrels unduly or affecting the intensity of cat predation.

I aged the corpses (adult or fledgling) by means of the skull and primary tips. Cats ate most fledgling skulls, discarding the bill, but they could not crush adult skulls. A skull could usually be aged by its bill plates: ivory tinged grey in fledglings and pale greenish-yellow in adults. The tips of the outer primaries were sharp-pointed and black in fledglings but more rounded, often slightly notched, and faded in adults.

During visits between October and March of 1971-74 we spent more time daily on 50 study burrows of Cook's Petrel, but on other visits we worked mainly on Black Petrels. We inspected study burrows in daytime. Occasional night work was done between the Summit and The Thumb to observe behaviour and band petrels. We banded all birds caught, and we colour-banded adults (green-male, black-female) in study burrows if one of a pair was sexed by cloacal inspection soon after laying. We routinely screened study burrow entrances with twigs or leaves.

Dimensions of eggs and all weights are given as range, mean and standard deviation.

The breeding population on Great Barrier Island was surveyed from 15 to 21 March 1977 and from 30 March to 14 April 1978. The same methods were used as in the extended survey on Little Barrier.

RESULTS

Calls

Although Reischek (1886) stated that Black Petrels make a call similar to that of Black Swans (*Cygnus atratus*) as they fly over their colonies, he seems to have been mistaken. Apparently he heard these calls in the Waitakere Ranges, where Black Swans often fly at night between Manukau and Kaipara Harbours (M. J. Williams, pers. comm.) and may have already been doing so in 1884. Sibson (1947, 1949) noted that these petrels are silent as they fly over Little Barrier, and I agree.

As noted by Sibson (1947), the main call is a staccato, rapid *clack, clack, clack* given from just inside the mouth of the burrow or from the ground outside. Although Sibson heard the call "from several directions" in one night in 1946, I heard it only four times in over 60 nights in the study area from November to March. On Great Barrier we heard this call every night in March, but in 1978 we did not hear it after the early morning of 3 April. This call seems to advertise that the calling bird owns a burrow or other nest site and wants a mate. Although males seem more successful than females in replacing lost mates (Table 1, but sample small and not statistically significant), I do not know whether only the males make the advertising call.

TABLE 1 — Remating success of sexed Black Petrels that lost mates on Little Barrier Island, 1972-1975

| Sex | N widowed or divorced | N new mates attracted | N abandoning their burrow |
|--------|--------------------------|--------------------------|------------------------------|
| Female | 5 | 1 | 4 |
| Male | 6 | 3 | 3 |

A subdued variation of this call is sometimes duetted when the pair meets in the burrow, perhaps as part of a greeting ceremony. I have heard this call in the courtship period and during the changeover of a pair incubating an infertile egg beyond the normal period.

Chicks, when older than about 2-3 weeks, utter a honk or snort which has a startling effect, even when one expects it. Amplified in the nest chamber, it suggests a larger animal, thereby perhaps repelling an intruder.

Nest site

On Little Barrier all nests were in burrows 1-3 m long in the peaty soil of the ridge tops, or under tree bases, or in banks. Through generations of use they were often very spacious. I saw no new burrows dug. Although nests were as often below the level of the entrance as above it, all nest chambers remained dry, except for two after several days of torrential rain. Nests were not raised, but White-chinned Petrels (*Procellaria aequinoctialis*) do so only in wet places (Imber 1983).

On Great Barrier a greater range of nest sites was in use. As well as burrows, nests were in and under hollow logs and in cavities under banks and among tree roots. The most exposed nests had no live chicks, however.

It was evident on Great Barrier that the breeding population was closely linked to virgin forest. During 1920-1935, large areas of kauri (*Agathis australis*) forest were logged and the remaining brush was burned adjacent to the high central ridges where Black Petrels now breed. The fires destroyed the peat, old logs and bases of mature trees — all actual or potential nesting habitat for these petrels. However, rather than having a relict fire-induced distribution, the breeding population may actually have increased this century on Great Barrier and spread within unmodified forest, where I saw evidence of apparently new burrows being dug.

Other occupants of burrows

A Sooty Shearwater (*Puffinus griseus*) was found once in a disused study burrow. One burrow in the survey area was also used by Brown Kiwis (*Apteryx australis*) but apparently mainly when not in use by petrels. In the winter of 1973 a first-year cat died in a study burrow.

After several years of disuse, fallen leaves and root growth begin to fill the burrows. Then Cook's Petrels may take them over, sometimes extending them and filling the surplus space with their diggings. On The Thumb in 1945, P. C. Bull (pers. comm.) found only Black Petrel burrows. Now Cook's Petrel burrows, some obviously having belonged to the larger species, outnumber them there.

Return to the colonies

Turbott (1947, 1961) reported Black Petrels absent between 1 and 10 October 1945. During a faunal survey of Little Barrier beginning on 24 September 1975, the first sign was a fresh cat-kill on 10 October (D. Sutherland, pers. comm.). At my earliest inspection date, 1 November, many had already reoccupied their burrows. Late breeders may not return until December, however.

Courtship and the prelaying exodus

Courtship activity was studied on 1-11 November 1971 and 1973. In burrows where an egg was subsequently laid, no bird was present on 59 of 68 burrow-days, the male was there on 6, and the pair on 3. Some birds also visited at night but did not stay till next day. Males spending a day or two alone at the nest were sometimes joined by their mate next day. One male, whose mate did not return, spent 31 October-4 November and 8-9 November in his burrow and, after 12 November-14 December when I was absent, was apparently visiting almost nightly between 15 and 22 December. His burrow was not used in following years.

Apparently it is mainly the males that effect the mating rendezvous by frequent visits to or attendance at the burrow. Females seem to make only occasional visits at night, rarely staying by day, until they meet their mate again, but then spend at least a day with him at the nest, when presumably they copulate.

The prelaying exodus of female and male follows immediately. During early December 1972, I observed 10 burrows over 123 burrow-days within 24 days to laying. When the pair had gone there were no visits, even at night, until the female arrived to lay or the male to incubate. Although no prelaying exodus was timed directly, I calculated some by using hatching dates and the incubation period to estimate laying dates. Thus, three females were absent for about 22, 23 and 23 days and another four were absent for at least 21, 22, 23 and 24 days. So the exodus may average 23 days for females but 24 days for males (see the section on incubation below).

Because laying extends over such a prolonged period, the exodus does not occur *en masse*, as in some shearwaters.

Laying

Females laid within 12 hours of their arrival. The distribution of laying dates for 15 females in 1972 and 8 in 1973 (Fig. 4) shows two peaks in 1972,

but the late peak seems to have been unusual, judging by observations of chick development on Little Barrier in early 1972 and on Great Barrier in 1977 and 1978. Although 20 November to 25 December seems the main laying period, the full period is much longer. For example, one chick which I found on Great Barrier on 2 April would probably have departed by 15 April; calculation backwards indicates that the egg would have been laid about 10 November. There are several records of fledglings departing in July (Bell 1976; T. A. Caithness, pers. comm.), and a fledgling in full plumage was still on Little Barrier on 21 July (T. G. Lovegrove, pers. comm.). This chick would have come from an egg laid in late January. These dates confirm Reischek's (1886) indication of an extended laying period.

Dimensions (mm) of nine eggs, seven measured in this study and two by Sibson (1949), were length 65.8-72.0, 69.3, 2.17 and width 46.8-54.2, 50.5, 2.10. The weights (g) of nine eggs the day after laying were 88.7-108.5, 98.8, 7.47. Five females within 12 hours after laying weighed 714-791 g, 747, 29.8. The ratio of their egg to body weight was 0.13. In White-chinned Petrels this ratio was 0.13 for three females (Imber 1983).

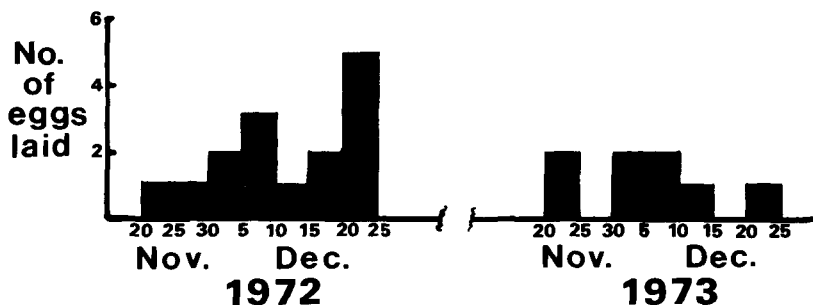


FIGURE 4 — Distribution of laying dates in study burrows on Little Barrier Island in 1972 and 1973

Incubation and hatching

The start of incubation was observed 10 times. Males took the first main shift. Four males returned first and awaited the female (for up to 3 days), both of one pair arrived on the same night, but five females had to start incubation (for 1,2,3,4 and 13 days). Thus, the prelaying exodus of males averaged one day longer than that of females, and the first incubation shift by females (including nil shifts) averaged 2.3 days. Two pairs were present during the day after laying, but I did not see this happen at any other time during incubation or chick-rearing.

Because few pairs were under observation and because the laying period and main incubation shifts were long, I did not time any complete shifts. I used weight changes during incubation (below) to calculate lengths of main shifts. The longer incomplete shifts noted were: first main shift (males) 17, 14, 11, 10 and 4 of 8 days; second main shift (females) 8 and 7 days; third main shift (males) 9 days. Females took the final incubation shift, including

hatching, in seven out of eight pairs. This shift lasted 3 days (one complete shift) and at least 2-4 days (six probably incomplete shifts). Eggs pipped 2-4 days before hatching.

The only incubation period I timed was 56.5 days. By comparison, those of two White-chinned Petrel eggs were 57 and 58 days (Mougin 1971).

I saw egg neglect only once. A male, weighing 55 g less than the lightest male beginning to incubate, arrived 3 days before the female laid but did not stay till she laid. She incubated for only 3 days, despite being the heaviest female weighed at laying. Her departure was probably caused by a brief visit by the male the fourth night. Five days later the male was again present but not incubating, and he left next night. Observations ceased next day. The male may have been too immature to incubate, although old enough to mate. The following year this pair hatched their egg.

The fertility rate of 66 eggs, by candling with sunlight, was 92.4%. Infertile eggs were incubated well beyond normal hatching time, at least an extra 15 and 17 days in the two cases measured. They were then usually expelled from the nest.

I found little evidence of eggs being eaten by kiore. Because incubation is normally attentive, these rats would have had few chances to take unprotected eggs. Further, the size and thickness of the shell of these eggs could have impeded kiore.

Weight changes during incubation

To incubate for long periods, birds put on considerable weight (Table 2). From the weight change through incubation and the rate of weight loss in males (Table 2), the length of shifts can be calculated. Males would have incubated for an average of 17-18 days in their first shift. Females would have incubated for about 16 days in their main shift, if their rate of weight loss was similar to that of the males, but I did not collect enough female weights for analysis.

The weight loss in five incubating males, as a percentage of initial weight, was 1.13% per day. One male was weighed during incubation in successive years. From 893 g on day 2 of his first shift in 1972 he lost 9.5 g/day over the following 13 days. From 972 g on day 2 of his first shift in 1973 he lost 12.0 g/day over 6 days. Perhaps weight loss is greater when the initial weight is heavier. Because of defecation, weight also declines more quickly at the start of a shift.

Chick-rearing

I observed eight chicks for a total of 56 chick-days during their first 10 days of life. Mothers were present 15 times, fathers 21 times, and the chick was alone 20 times. Thus, chicks were attended on 65% of these early days. There was no set pattern to parental attendance, but chicks were rarely alone during the first 2-3 days; usually mothers were present then and fathers afterwards. One mother, however, returned after only 4 days. Even those chicks which were alone by day during their first 10 days were being fed on 50% of nights. Thus there was much activity of breeders coming and going at that time (mainly February).

TABLE 2 — Weights (g) of female and male Black Petrels during courtship and at the beginning and end of their incubation shifts, and rate of weight loss during incubation in males

| | Females | | | | Males | | | |
|-------------------------------------|---------|---------|------|------|-------|----------|------|------|
| | N | Range | Mean | ± SD | N | Range | Mean | ± SD |
| Courtship | 8 | 587-791 | 682 | 57.4 | 9 | 620-855 | 723 | 77.1 |
| Beginning of main incubation shift* | 3 | 830-852 | 841 | 11.0 | 6 | 818-989 | 883 | 63.2 |
| End of main incubation shift* | 1 | - | <690 | - | 5 | 631-756 | 709 | 48.0 |
| Incubation weight loss | | | | | | | | |
| Interval (days) | - | - | - | - | 5 | 6-13 | 7.8 | - |
| Weight loss (g/day) | - | - | - | - | 5 | 8.7-12.0 | 9.9 | - |

*First shift of males

At about 1 month of age, chicks were being fed on 38% of nights (10 chicks studied over 82 chick-nights), which is about three feeds every eight nights. Parents still occasionally stayed with their chick by day. The mean weight of 12 feeds was 120.6 g (range 89-167 g, SD 22.34), making allowance for the weight loss of 28.8 g/day determined from four chicks not fed over 14 chick-days. Already chicks could take a great deal of food: one chick that was fed by its father one night, by both parents next night and by its mother on the third night increased from 385 g to 810 g.

Chicks attained maximum weights in April and May. Between 1 and 14 April 1978 on Great Barrier, 59% of 63 chicks weighed more than 1000 g. Between 4 and 17 May in 1972 and 1973 on Little Barrier, 26 chicks had an average weight of 947 g (range 725-1278 g).

Departure of chicks

Departures extended from mid-April to late July, but were rare in April and July. The mean fledgling period of six chicks was 107.3 days (range 96-122 d, SD 8.43). Departures tended to be at a peak around 20 May. Many chicks still weighed 900-1000 g when fully feathered but did not leave the island until their weight had declined. The estimated weight at departure of three chicks was 725, 752 and 794 g (average 757 g), which is above the average adult weight during courtship (704 g). No chick suspected as having flown still bore down when last seen.

Chicks received substantial meals to within 12 days of departure, and so I am not sure that there is a desertion period. One chick received 168 g of food 12 days before leaving; another, 96 g 8 days before leaving. It was difficult to detect parental visits in the last week because chicks may have taken little or no food, and their emergences made screening of burrows unhelpful. At this stage chicks were losing weight at 15.6-19.0 g/day. One chick was visited by a parent when I considered its departure overdue, but it had not been weighed.

Nocturnal observations and signs at the burrow mouth (down, defecations, regularly disturbed screens) showed that many chicks were emerging 10 nights before they would leave the island. On the surface they exercised their wings, searched for take-off points (a tree, bluff or high point providing a clear horizontal flight path), or merely sat and rested. I saw a chick climb a leaning, fern-clad tree until level with an opening in the canopy about 25 m away. It flapped vigorously, rising off the trunk, rested and looked about, then flapped again, repeating this for 15 minutes. Then it flew towards the opening but crashed into a branch. I searched the crash site but found nothing. Then I went to its burrow 30 m away and found that it had already returned there. It left later that night. Fledglings lacked adults' knowledge of good take-off points. For example, many breeders from *one group of burrows used one stunted tree for take-off in certain winds, involving a walk of at least 50 m for some of them.*

This long period spent preparing to leave made chicks very vulnerable to predation by cats. One fully feathered but heavy chick found outside its burrow on 4 May had not left on 12 May and was killed by a cat within the next three nights.

Breeding success

Predation by cats (Fig. 5) was the main cause of breeding failure (Tables 3, 4). The 1971/72 breeding season was initially very successful with 81% of eggs in the study burrows resulting in fledglings. Only 1% of adults and 6.7% of nestlings were killed by cats, but cats killed about 67% of fledglings once they began emerging. The reduction of cat numbers in 1968/69 probably did much for this relatively successful breeding season.

The 1972/73 breeding season was much less successful. The peak of laying in the study burrows was about two weeks later than in the previous year. Fewer eggs hatched (82.4% against 93.8%) and more chicks died (21.4% against 6.7%), but again cats were the main cause of failure. More chicks were killed on the nest (28.6% against 6.7%), and probably all of those emerging were killed. By 24 May 1973 no chicks had left the study area and only three were still alive: two had just begun emerging and the third was downy and seriously underfed. Cats were killing all emerging chicks at that time, and so these three probably did not survive. The number of adults killed by cats also increased (Table 4). That cats were numerous on Little Barrier at that time is shown not only by the damage done to the Black Petrels but also by the 72 cats killed by E. and B. Wisnesky in the preceding (1972) winter.

In the 1973/74 season, six breeders of the previous season did not return to their burrows. Most had probably divorced their mates because at least three had had their chick killed on the nest in the previous season. Predation of chicks both on the nest and on the surface continued at such high levels that less than 5% of pairs had their chick leave the island. Predation of adults, mainly late in the breeding season, was also still increasing.

In 1974/75 at least 28% of the study adults were killed by cats. Unlike previous seasons this predation occurred throughout the breeding season. In addition, cats killed all of the few chicks reared, mainly at emergence. The extended survey revealed the same everywhere (Table 4).

I did not visit Little Barrier during the 1975/76 breeding season. The cats had left so few breeding pairs intact that I had little to study, and the main purpose of the investigation (to report on conservation of Black Petrels) had already been achieved (Imber 1975). Observations by D. Smith, D. Sutherland and C. R. Veitch (pers. comm.) show that predation of adults and, later, chicks continued throughout the 1975/76 breeding season.

My survey of study burrows in March 1977 showed that only six pairs were present, compared with 18 pairs in 1971/72 and 1972/73. These remaining pairs may have reared up to four chicks that season, and one certainly fledged successfully because it later returned to breed. I found no sign of cat predation in the study area, but the extended survey showed that at least two chicks had been killed on the nest. From the very few petrel remains I saw then, it appeared that cat numbers had fallen greatly over the preceding two years. However, the restricted trapping and poisoning of cats in 1975 and 1976 probably was not the only cause of this. A second epidemic of feline enteritis may have occurred when cat numbers peaked in 1975.

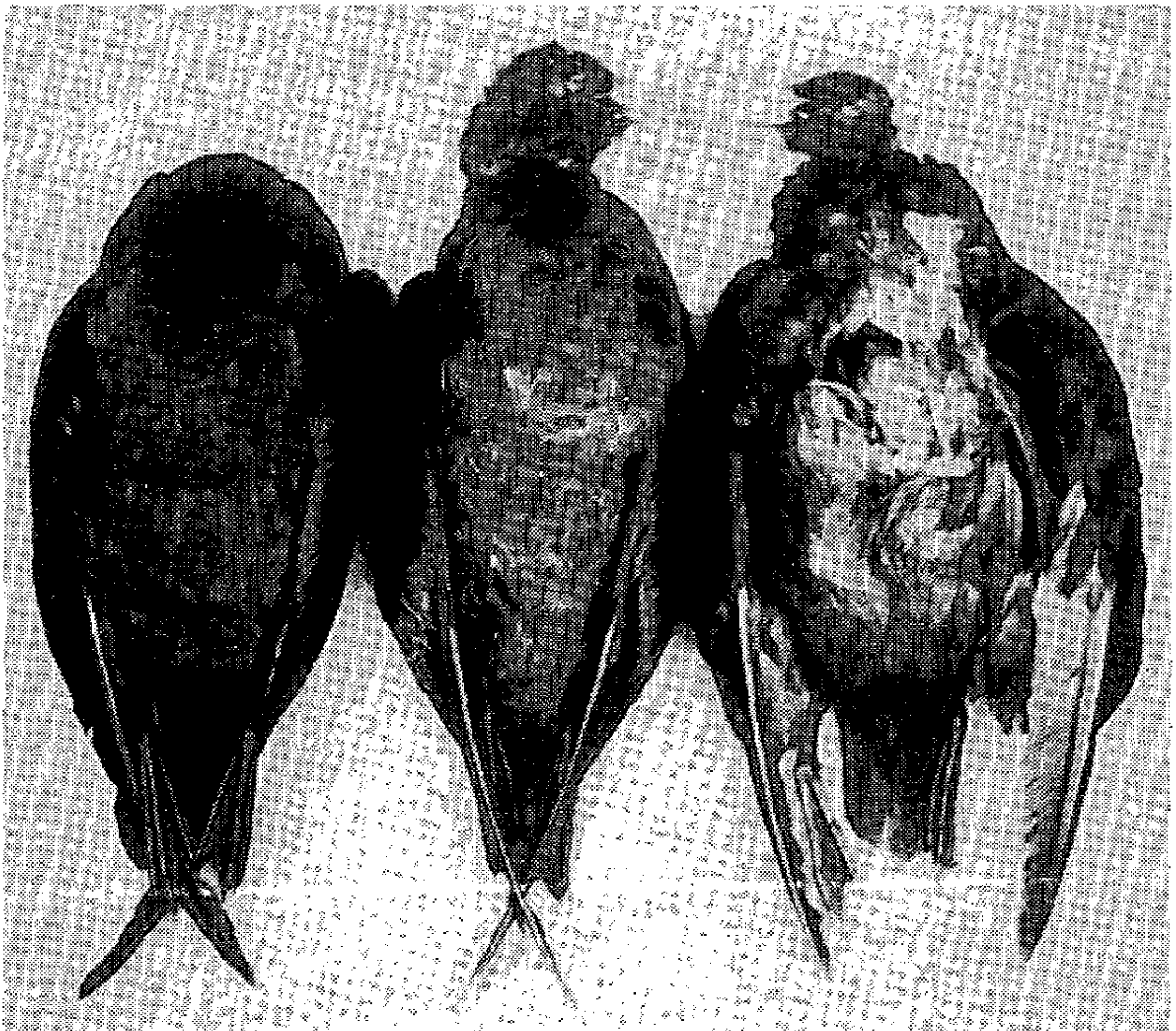


FIGURE 5 — Cat-killed Black Petrels, Little Barrier Island, May 1972. Left: fledgling beheaded by cat, only neck and skull eaten, as often occurred that year when the ratio of fledglings to cats was relatively high. Centre: Adult female (now a skin in the National Museum) showing russet belly because of worn plumage. She had been attacked by a cat and escaped but died just inside her burrow, her skull punctured by one of the cat's canine teeth. Right: fledgling partly eaten by cat, skull intact.

TABLE 3 — Breeding success and status of the 22 study burrows of Black Petrels on Little Barrier Island, 1971-1983

| | 1971/2 | 1972/3 | 1973/4 | 1974/5 | 1976/7 | 1978/9 | 1981/2 | 1982/3 |
|---|--------|--------|--------|--------|--------|--------|--------|--------|
| Burrows in use | 21 | 21 | 19 | 15 | 8 | 7 | 7 | 7 |
| Birds using these burrows | 39 | 39 | 33 | 25 | 14 | 13 | 12 | 12 |
| Adult deaths at sea or divorces | 1 | 6 | 1 | 1 | ? | ? | ? | ? |
| Adults known killed by cats | 0 | 1 | 2 | 7 | 0 | 0 | 0 | 0 |
| Eggs laid | 16 | 17 | 10 | 7 | 5 | 6 | 4 | 4-5 |
| Eggs hatched | 15 | 14 | 9 | 5 | 5 | 6 | 2 | 3? |
| Chicks killed on nest by cats | 1 | 4(+) | 3 | 1? | 0 | 0 | 0 | 0 |
| Chicks killed on surface by cats | 7-8 | 5-7 | 4 | 3 | 0? | 0 | 0 | 0 |
| Chicks departing | 5-6 | 0-2 | 1 | 0 | 4? | 5 | 2 | ? |
| Minimum % of adults + chicks cat-killed | 16.7 | 22.6 | 21.4 | 35.7 | ? | 0 | 0 | 0 |

TABLE 4 — Results of surveys of Black Petrel burrows on Little Barrier Island from west of The Thumb to Kiriraukawa in May 1972-1974 and March and May 1975 (includes the study burrows)

| | 1972 | 1973 | 1974 | 1975 |
|--------------------------|-------|------|------|-------|
| Burrows inspected | 107 | 81 | 111 | 117 |
| Burrows in use | 98 | * | 85 | <90 |
| Chicks killed by cats | 40-50 | 24+ | 34+ | c. 27 |
| Adults killed by cats | 2 | 6 | 10 | 37+ |
| Chicks probably departed | c. 22 | 0-5 | 1-2 | 0 |

*Not recorded

A full-scale campaign to eradicate the cats began in 1977 (Veitch 1980, 1983). In 1978/79 six pairs still occupied the study burrows. Their numbers, although low, were stable from 1977 to 1979 as the campaign against cats took effect, and also as a likely result of the eradication efforts in 1968/69. That campaign led to breeding successes in 1972 (Table 4) and probably also in 1970 and 1971. Allowing 6-7 years for the chicks to return to breed, some of those chicks should have entered the breeding population during the 1975/76 to 1978/79 seasons, thus checking the decline. In March 1979 I saw corpses of Cook's Petrels only, but a few Black Petrel fledglings were killed later by cats (Veitch, pers. comm.). At that time at least 40 cats were still on Little Barrier, but these were killed in 1979 and 1980 (Veitch 1983).

The study population reached its nadir in 1980/81 when only six burrows were used by 11 adults. The numbers breeding had declined because of the few chicks surviving the 1972/73 to 1975/76 breeding seasons. In 1981/82 and 1982/83 it seemed that the population was stable.

Breeding frequency

Established pairs laid an egg every year unless the pair bond was disrupted by death or divorce. Rearing a chick to fledging, however, seemed to hinder most pairs from doing the same in the following year, except for the earliest breeders. Presumably, the later a pair is involved in chick-feeding, which can be as late as mid-winter, the harder it is for them to return early enough or in satisfactory condition for the next season. For example, the pair in burrow 14 reared a fledgling in 1971/72 (egg laid 5 December) and in 1972/73 (egg laid 21 December), but in 1973/74 (egg laid 21 December) the chick was seriously underweight at 86 days old, when cats killed it and its mother. Of 10 pairs that reared fledglings in 1971/72 and bred again in 1972/73 without interference by cats, only five again reared fledglings. Among the five pairs that failed, one had an infertile egg, two failed before or near hatching, the chick of one pair died, and one pair reared a very light, late chick (691 g at 93 days and still very downy). Eggs of the five repeatedly successful pairs were laid between about 20 November and 5 December in 1971/72, except for one female that laid about 25 December in both years.

One female consistently laid earliest in the study burrows (usually by 25 November), and this pair reared a fledgling in every year studied except one (infertile egg) from 1971/72 to 1978/79.

Return of young birds and age at first breeding

The only chick recaptured on Little Barrier was reared in 1976/77 and was incubating a piped egg on 16 January 1983 about 20 m from its natal burrow. A chick banded on Great Barrier on 14 March 1972 by R. M. Lockley was recaptured there on 17 March 1977 while it was 'clacking' near the entrance to a short burrow, quite late in the period of activity for non-breeders. In April 1978 its burrow had a fresh nest but no chick. Thus, some chicks return at 5 years and some breed at 6 years.

On Little Barrier the shortened life expectancy until recently of breeding adults and their pair-bonds, and the small prebreeding part of the population, may have caused a heavy demand for any returning young birds to mate with surviving breeders. Therefore, breeding may begin when birds are younger than they might be in a self-regulating, undepressed population.

Longevity and pair-bond stability

On 20 March 1975 I found an adult killed by a cat near the Summit. The bird had been banded near there in January 1963 when it was probably at least 5 years old, making it at least 17 years old at death. A male bred in a study burrow throughout the seasons 1971/72 to 1982/83 and so was still alive at over 17 years. In 1983 he was the only breeder definitely known to be still in my study burrows out of the 33 banded in 1971/72 and 1972/73; three others, including his mate, may also have survived.

Cats destroyed pair-bonds not only by killing the adults but also by killing nestlings, which apparently precipitated divorces. *The female left* in all three cases of probable divorce where I knew the sex of the remaining partner. Table 5 shows the subsequent effect of breeding success on pair-bonds. Failed breeders were significantly more likely to separate, even when I had allowed for a yearly average natural mortality of adults of 6% (but this was only 2.6% in 1971/72).

TABLE 5 — The effect of breeding success on stability of pair-bonds of Black Petrels on Little Barrier Island from 1972 to 1974

| | Chick reared to fledging | No chick reared |
|----------------------------|-----------------------------|--------------------|
| Pair together next season | 16 | 6 |
| Pair* divorced next season | 0 | 3 |

*Allowance made for probable death of some mates

$$\text{Chi}^2 = 6.061, p < 0.05$$

A number of breeders disappeared from the study burrows after losing mates by death or divorce. None of these bereaved birds was found in another study burrow or among the few adults caught in non-study burrows. Only

one was among the later corpses. The fate of these birds can only be guessed at, but perhaps some moved to Great Barrier, 30 km away.

Great Barrier Island survey

Breeding of Black Petrels on Great Barrier was not reported until 1964 (Bell & Brathwaite 1964). Until our 1977/78 surveys (Fig. 6), breeding was known only on and near Hirakimata, the summit of the island (Bartle 1967, Reed 1972, Bell 1976). Breeding colonies extend disjointedly from Cooper's Castle in the north (pers. obs.) to Te Ahumata in the south (C. R. Veitch, pers. comm.). Recently an adult, perhaps killed by a dog, has been found near Tryphena, 6 km further south (I. MacFadden, pers. comm.). I found the main breeding areas to be on Hirakimata (Mt Hobson) and the higher ridges radiating from it, around the western end of the ridge separating the north and south forks of the Kaiarara Stream, and on the shoulders of The Hog's Back (Fig. 6).

The surveys showed high breeding success on Great Barrier (Table 6). Black Petrels were using more varied nest sites and shorter burrows than on Little Barrier, where fewer than 50% of nestlings could be reached from the entrance compared with 60% on Great Barrier. This correlates with the very few deaths caused by cats (Table 6). Other evidence of cat predation was the scattered corpses of eight Cook's Petrels. Despite careful searches for burrows around all of these kills, I found only three in the north Kaiarara Valley. Elsewhere, corpses were apparently of prospecting birds landing at random, and so I concluded that very few Cook's Petrels breed on Great Barrier.

I trapped ship rats (*Rattus rattus*) and kiore from near sea level to the summit. Dogs had apparently dug open at least two burrows, although I found no evidence that petrels had been killed. Wild pigs' rooting was seen near one group of burrows. Mustelids are not known on Great Barrier. It is illegal to introduce them, but further liberations of noxious animals will always be a potential threat to petrels on this 300 km² island, with nearly 1000 inhabitants and many visitors.

The number of Black Petrels

The Black Petrel is known to breed only on Little Barrier and Great Barrier Islands. Little Barrier has 50-100 breeding pairs (Fig. 7). On Great Barrier we found about 175 burrows probably used by breeding pairs but, in such places as The Hog's Back, our survey was merely a transect of the breeding area. I estimate that Great Barrier has 500-1000 breeding pairs.

There are few non-breeders from Little Barrier, but from Great Barrier, with its high productivity and with young birds not breeding for at least 6 years, there may be nearly 2000 non-breeders. The total would then be 3000-4000 birds.

DISCUSSION

Comparison with breeding biology of White-chinned Petrels

Mougin (1970, 1971, 1975) studied White-chinned Petrels breeding on the Crozet Islands. In those aspects of Mougin's and my study that are comparable, I noted two major differences. Firstly, many more prospecting

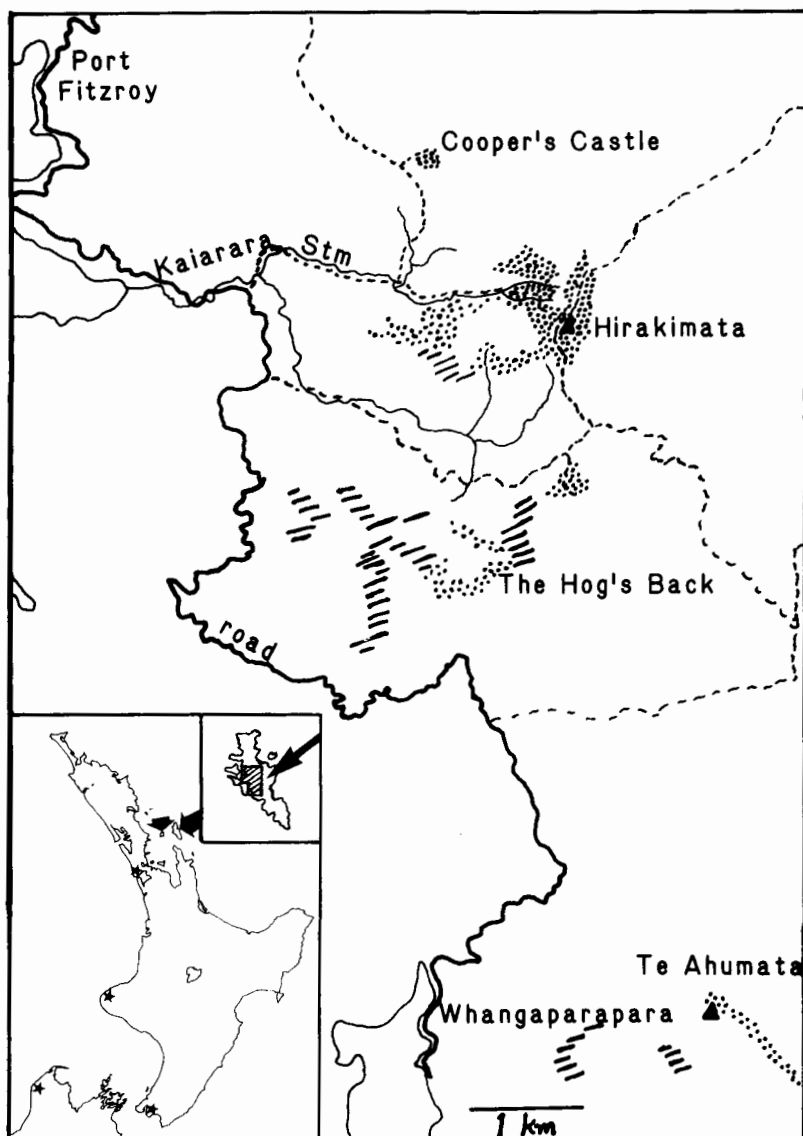


FIGURE 6 — Distribution of Black Petrels on Great Barrier Island in 1977-78. Solid line: unsealed road. Dashed line: walking tracks. Dotted areas: known or inferred distribution of breeding Black Petrels. Cross-hatching: additional, unexplored areas (virgin forest) that may hold burrows. Inset: northern New Zealand showing existing breeding places of Black Petrels (arrows) and former breeding sites (stars).

TABLE 6 — Breeding success two-thirds of the way through chick-rearing in Black Petrel burrows surveyed on Great Barrier Island in 1977 and 1978

| | 1977 | | 1978* | |
|--|------|----|-------|----|
| | N | % | N | % |
| Burrows inspected | 83 | | 188 | |
| Chicks banded | 22 | | 64 | |
| Chicks out of reach | 18 | | 40 | |
| Empty, used burrows | 39 | | 69 | |
| Burrows probably not suitable for breeding | 4 | | 15 | |
| Breeding success at that stage† | | 50 | | 60 |
| Predated adults | 1 | | 0 | |
| Predated chicks | 0 | | 1 | |
| Eggs apparently eaten by rats | 2 | | 5 | |

*Includes most of the 1977 burrows studied

†Chicks per burrows probably having a breeding pair

birds visited Mougin's study burrows than visited mine. More than two birds visited 25% of his burrows in one breeding season and 45% in the next, whereas in my two seasons of most intensive observations (1972/73, 1973/74) more than two visited only one (3%) of my burrows. Even though Mougin made more burrow inspections (almost daily), the difference is likely to be significant. It reflects the healthy balance of breeders and non-breeders on the Crozets, contrasting with the few non-breeders on Little Barrier.

Secondly, the breeding habits of Black Petrels show the effects of having to travel further for food and having to feed in less productive seas. Apart from some scavenging at ships (J. M. Moreland, pers. comm.), they feed at the edge of, or beyond, the continental shelf (Imber 1976). The shortest distance to the shelf edge from Little Barrier is 60 km north-eastwards, but in some other directions it is much greater because the North Island is in the way. At the Crozet Islands petrels can reach deep water within about 50 km in most directions, and those subantarctic waters are more productive than the subtropical seas well north of the subtropical convergence in which Black Petrels feed (Imber 1976). Notable differences in breeding habits are in the incubation routine and the duration of chick-rearing. Thus White-chinned Petrels incubated through seven shifts averaging 1.8, 11.0, 10.0, 10.3, 8.8, 7.8 and 7.7 days to complete their 57-58 day incubation period, whereas Black Petrels had only five consecutive shifts of 2.3, c.18, c.16, c.16 and c.4 days to hatching. White-chinned Petrels reared their 1000 g fledglings in 96 days (range 91-105 days) compared with Black Petrels' 757 g fledglings reared in 107 days (range 96-122 days).

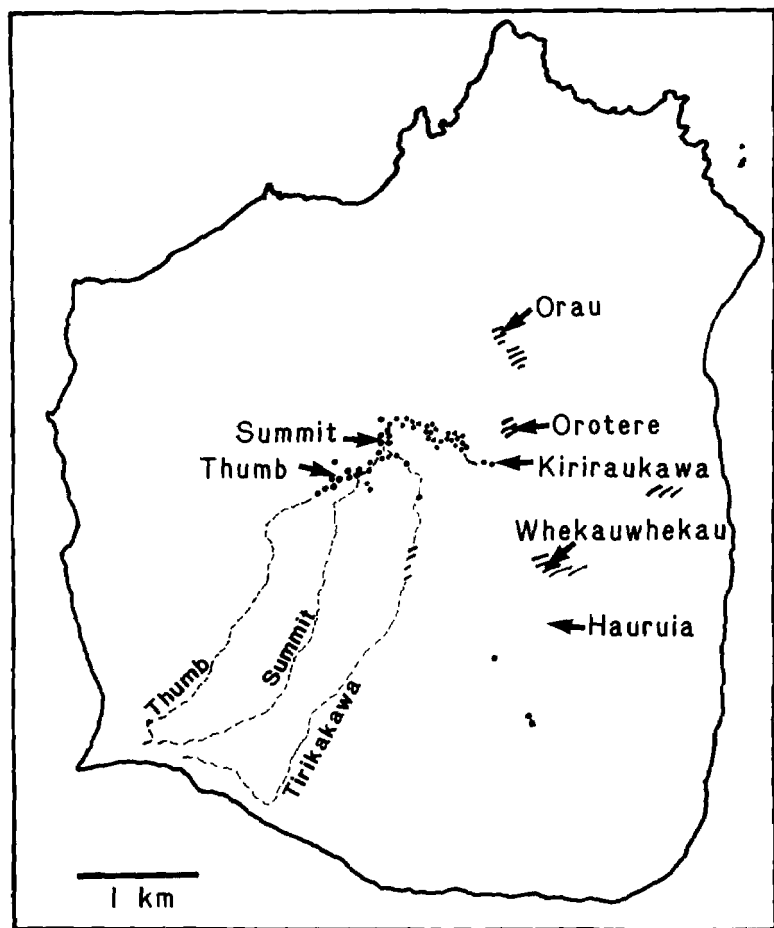


FIGURE 7 — Distribution of Black Petrels on Little Barrier Island around 1982. Dashed lines: walking tracks. Dots: active burrows in areas surveyed by the author. Cross-hatched areas: petrels present (known or reported to author) but actual number and distribution of active burrows not determined. Main peaks are arrowed.

Apparently Black Petrels economise on trips to and from the feeding grounds by feeding and incubating in longer shifts, presumably gaining relatively more weight before incubating than White-chinned Petrels do. Also, Black Petrels may visit chicks less often, bringing larger but more digested meals, possibly containing more stomach oil but less protein. The slower growth of chicks may be the result.

However, there may be an additional cause of the longer fledgling period. The limited data indicate that Black Petrel chicks depart in better condition than those of White-chinned Petrels (Mougin's chicks being lighter than the 1270 g adults). This difference may be related to the trans-Pacific migration of Black Petrels. Perhaps their chicks need adequate fat reserves to supplement poor feeding while they cross the central South Pacific, which is a region of low marine productivity (Shuntov 1972).

Feral cat predation

On Little Barrier cats preyed mainly on Cook's Petrels from October to March (Marshall 1961, Watson 1961), and predation increased in March when chicks leave (C. R. Veitch, pers. comm.; pers. obs.). At other seasons the cats ate kiore, land birds and insects (Marshall 1961, Watson 1961); at higher altitudes they attacked Black Petrels and, along the coastal cliff-tops, Grey-faced Petrels (Sibson 1947, McKenzie 1948).

The evidence shows that it is mainly the very large population of Cook's Petrels on Little Barrier that has been indirectly responsible for the plight of the other petrels. Without these easily caught small petrels (c.200 g), such a large number of cats could not have been sustained. By comparison, cats have a negligible effect on Black Petrels on Great Barrier, where Cook's Petrels are few. Cats fared well on Little Barrier on the very reliable summer supply of petrel food. The abundance of rats and Cook's Petrel fledglings through autumn would have continued to sustain them. But from late April to September, with Cook's Petrels unavailable, they became hungry and began regularly attacking the larger petrels. Coincidentally Black Petrel fledglings began emerging. Grey-faced Petrels suffered most because they breed from March to December and are particularly active on land in winter: they may no longer breed on Little Barrier but they have many other colonies. The decline of Black Petrels was more protracted because, except during periods of highest numbers of cats, mainly fledglings were killed. However, the loss of this colony would have been unfortunate because the Great Barrier colony cannot be protected easily.

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SHORT NOTE

Australian Brown Quail in Tongariro National Park

While assisting Dr Ian Atkinson (Botany Division, DSIR) on a vegetation survey of Tongariro National Park in the summer periods 1962-3 and 1963-4, I covered on foot most of the non-forested country on the slopes of Mounts Tongariro and Ngauruhoe but recorded Brown Quail only once.

On 14 January 1964 we flushed an Australian Brown Quail (*Synoicus ypsilophorus*) from its nest (Fig. 1). The nine eggs, which I photographed but did not measure, were white with mid-brown speckles. This nest was approximately at grid ref. 3065 3835 (NZMS 1, Map N 112), altitude 1000 m, on the lower north-west slopes of the volcanic cinder cone, Pukeonake. The vegetation of the locality was mapped as being red-tussock land (*Chionochloa rubra*) (Atkinson 1982), but it contained also scattered mosses, and herbs and low shrubs such as *Celmisia gracilentia*, *Stackhousia minima* and *Coprosma cheesemanii*.

I thought no more of this record until I read the account of the OSNZ 1982 summer field study based at Erua (Innes *et al.* 1982). Brown Quail were not seen during that study, and J. G. Innes (pers. comm.) knows of no records from Tongariro National Park and its environs. T. A. Caithness (pers. comm.), while studying California Quail (*Lophortyx californica*) from a base at Turangi in the late 1950s, did not see Brown Quail in the district.

In Bull *et al.* (1985), the nearest record of Brown Quail to Tongariro National Park is from the 10 000 yard map square 32/40 at Tokaanu. The most recent record from that square was on 2 February 1979 by C. A. and M. A. Fleming, on the shore of Lake Taupo at the Tokaanu wharf. There are OSNZ records of Brown Quail from several other 10 000 yard squares to the north and west of Tokaanu.

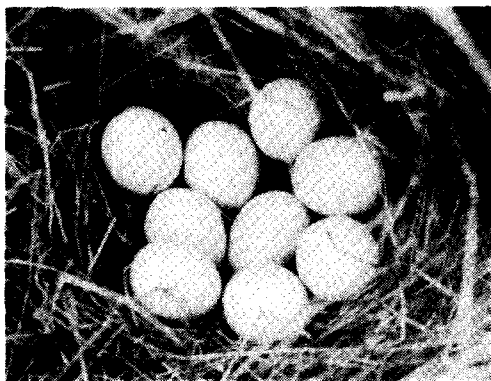


FIGURE 1 — Nest of Brown Quail, Tongariro National Park

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A COLONY OF THE LITTLE SHAG AND THE PIED SHAG IN WHICH THE PLUMAGE FORMS OF THE LITTLE SHAG FREELY INTERBREED

By MICHAEL J. TAYLOR

ABSTRACT

During 1977-1985 a colony of 80-120 Little Shags (*Phalacrocorax melanoleucos brevirostris*) was studied at Hobson Bay, Auckland City. The breeding season of Little Shags was from August to March or April. Pied Shags (*Phalacrocorax varius*), which joined the colony during the study period and have tended to displace the smaller species, have nested throughout the year. For both species highest numbers of nesting pairs were present in spring (October-November). Little Shags of the pied form constituted one-third of the colony and interbred freely with birds of the white-throated and smudgy plumages. Fledglings have either the pied or totally black plumage and both can occur within the same brood. Aspects of behaviour are described and a detailed account of the colony is given.

INTRODUCTION

Many New Zealand ornithologists have shown an interest in the plumage variations of the Little Shag (*Phalacrocorax melanoleucos brevirostris*) and their records are to be found in the Classified Summarised Notes published annually in *Notornis*. Most observers have adopted a simple division into two categories, 'white-throated' and 'pied' birds, although the numbers of smudgy adults and fully black immatures have sometimes been noted in addition. Among the fuller records are those of Poppelwell, who found a proportion of 16.6% pied birds on Otago Harbour over a 9-year period (Poppelwell 1972), and of Moisley, who repeatedly counted roosting birds at Clevedon, south-west Auckland, during April 1960, finding 25 pied birds in tallies of 75-117, averaging 100 (Moisley 1960). In the Far North of New Zealand proportions above 50% have been cited, an example being c. 120 pied and c. 40 white-throated for Parengarenga Harbour, 3-6/4/53 (Prickett 1954). Four reports, totalling 323 birds, show 194 (60%) to be of the pied form. Records for the rest of the North Island yield a proportion of pied birds of 15% (179 out of 1190 in a total of 26 reports spanning 40 years). For the South Island the proportion is 8% (25 out of 293 in 9 reported counts). These published data therefore indicate that the dark form of the Little Shag is in a higher proportion in the south of the country than in the north.

The New Zealand Checklist (1970) treats the Little Shag as a dimorphic subspecies with some intermediate variants. The pied form is regarded as identical with the Little Pied Cormorant of Australia (Falla *et al.* 1979). The fact that the name White-throated Shag has been widely used arises naturally from this being the most abundant form in New Zealand.

This study began as a contribution to the survey of shag nesting colonies initiated by OSNZ c. 1976. Ready access to the colony encouraged me to pursue the observations in greater detail with two particular objectives: to measure how successfully shags nest within the bounds of a large city and to investigate the various plumages of Little Shags at a breeding colony. I also took note of behaviour during nesting, and my findings generally agree with those of recent work in coastal Manawatu (Matthews & Fordham 1986).

METHODS

The colony under investigation is situated on a tidal arm of Hobson Bay, Auckland City, 100 m west of Orakei Bridge, in two adjacent mature pohutukawa trees, with a sheltered, northerly aspect. The trees are c. 15 m high. Little Shags have nested at this site since 1972, when 13 nests were recorded on 16 October (S. M. Reed 1973; P. Smith, pers. comm.), and the colony may have existed for some years before that. My own observations began in 1977.

Pied Shags (*P. varius*) joined the colony in the 1978-79 breeding season, probably because of the decline of the Pied Shag colony 1 km further inland in Orakei Creek, adjacent to Lucerne Road. The Orakei Creek colony, in a single dilapidated macrocarpa tree, still holds a few nests (in 1986) and is frequently the roost of a flock of Little Black Shags (*P. sulcirostris*) between May and August each year. The Orakei Creek colony is not used for nesting by Little Shags, perhaps owing to the open situation of the nest sites which it provides.

The nests of Little Shags in the Hobson Bay colony are built at heights of 5-15 m, usually but not always over water at high tide, and are often well hidden among the foliage. Nests are sometimes no more than 1 m apart, but neighbours tolerate one another, although sitting birds sometimes gape threateningly towards an intruder. The Pied Shags sharing the colony choose more open nest sites and contribute to the opening up of the tree by removing small branches. This activity rather than the guano seemed to be the factor which eventually damaged the tree because parts of the tree used only by Little Shags have remained healthy, as have adjacent pohutukawa trees used all year by Pied Shags for roosting but not for nesting. The nests of the two species do not differ much in size, being about 0.5 m across. Little Shags make more use of leafy material than Pied Shags, which use thicker twigs and sometimes include pieces of wire and plastic tape in their nests.

As the nests are quite high and supported by thin branches, I did not try to reach them. Instead, I observed them at eye level or from below from the steep bank on which the trees are growing. Although the clutch size is given as 3 or 4 (Falla *et al.* 1979), only on a few occasions did I see three small chicks in the nest, never four, and the number raised was usually one or two. I visited the colony for about 1 hour every 3-5 days throughout the 1977-78 and 1978-79 breeding seasons, then at intervals of 2-4 weeks during later seasons.

Great care was taken not to disturb the colony. Early in the season (August) the birds sometimes took flight, but later inspections could be made

without their leaving nests. Before nest building began, pairs would perch side by side at their chosen site, enabling me to record individual plumage patterns. After the first three years, the growth of shrubs blocked my view of some nest sites, and so I concentrated my later investigation on following the size of the colony.

During the two seasons of intensive study, I mapped the individual nests by making sketches from several vantage points and cross-checking between these points. On every inspection I recorded the activity at each nest and noted any extra pairs or lone birds in the colony. I recorded the plumage type of each bird that I could see clearly and the number and condition of chicks large enough to be seen alongside the attending adult or while being fed. I noted such adult behaviour as courtship displays and greeting calls. The level of activity and various calls and other reactions of the chicks were also noted. Tape recordings of the calls of adults and chicks have been deposited with the British Library of Wildlife Sounds.

RESULTS AND DISCUSSION

Behaviour in the colony

The display, nest building and chick-feeding behaviour of Little Shags I observed was similar to that described elsewhere (Harley 1946, Goodwin 1956, Vestjens *et al.* 1985, Matthews & Fordham 1986). Incubation was shared but I did not establish whether one sex took a greater share. The birds greeted each other at the nest but left silently.

Three distinct calls were recognised. One, a greeting call *uh-uh-uh-uh* . . . in a series dying away, is used by birds of either sex when arriving to change over during incubation or to feed chicks and is met by a similar response from the mate. Another, *oo-oo-oo*, a rhythmical sound, accompanies the display movement of repeatedly swinging the head downwards in a vigorous bow, performed by the male bird when seeking to attract a mate. This usually takes place at a chosen nest site or on a partly completed nest, and it is sometimes the prelude to copulation. A different call, *ow-aah*, is given by the male during bouncing or squatting movements performed on the partly build nest. I observed the squatting display much less often than bowing, but have watched sequences in which a bird squatted several times before changing to a series of bows. The ensuing exchange includes the bird pulling and shaking the tail of its mate. Harley (1946) referred to the calls given during display as "cooing", and Matthews & Fordham (1986) described them as having one or two syllables (*uh-aah*). I maintain that the call while bowing has two or three syllables, but we are obviously seeking to describe similar sounds and behaviour. In a busy colony, chicks are likely to be squeaking continuously, and the greeting calls can be distinguished from this background and can be traced to the bird which is bowing or squatting. Thus, one can interpret what is going on in a colony just by listening carefully.

Breeding seasons of Little Shags and Pied Shags

Little Shags are absent from Hobson Bay colony between March and July when a few birds return to roost in the vicinity. Pairs are established

and start nest building or refurbishing the few remaining nest remnants in August, or occasionally in late July. Numbers then increase rapidly to a maximum in October or the first half of November. For the eight years 1977-1984 shown in Figure 1, the range of these maximum October/November counts was 27-60 breeding pairs, the average being 43 pairs. However these figures underestimate the size of the colony because other birds joined the colony later to begin nesting in December or January. Averaged over the eight seasons from 1977 to 1985, the highest counts of occupied nests in each month are as follows: August (14), September (30), October (43), November (39), December (27), January (17), February (12), March (4).

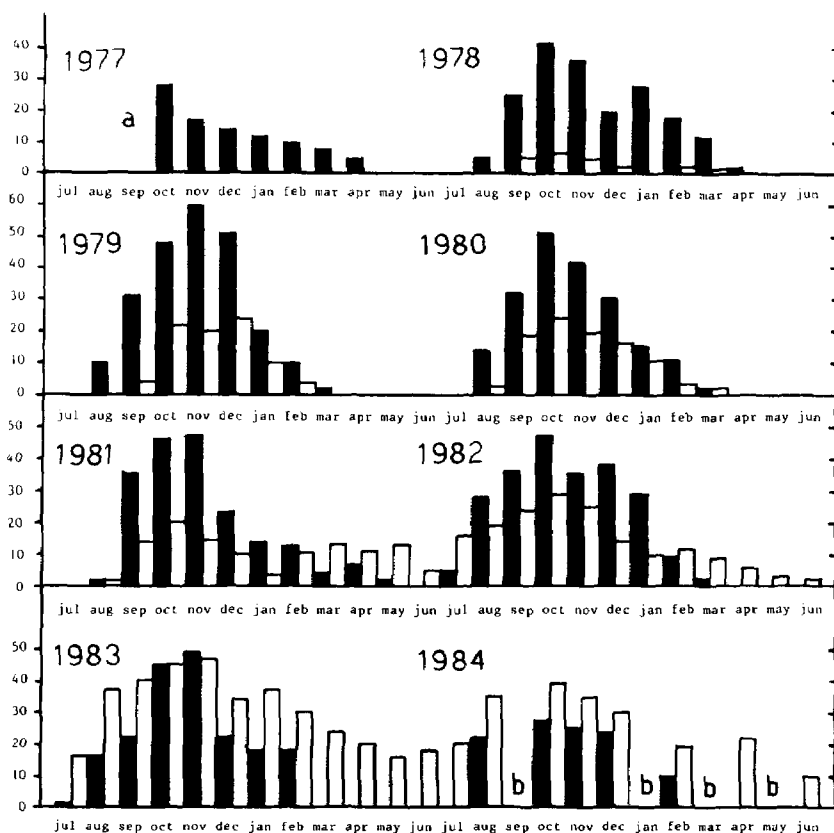


FIGURE 1 — Counts of nesting pairs of Little Shags (solid histogram) and Pied Shags (open histogram) at Hobson Bay in each month for eight years.

(a) Observations began in October 1977 when nesting was already under way.

(b) No counts were taken in September 1984 or in January, March and May 1985.

As Figure 1 shows, the numbers of breeding Little Shags increased during the first three years of the study 1977-1979, but then decreased, partly at least because of sites lost by damage to the nesting trees by Pied Shags. Pied Shags first attempted to nest in this colony in 1978, when nine pairs built nests, although only one succeeded in raising young. Pied Shag numbers increased in the following years until they exceeded the number of Little Shags. More than 40 pairs were present in the spring of 1983, and in October 1984 37 pairs of Pied Shags and 27 pairs of Little Shags were nesting.

The arrival of Pied Shags has allowed the seasonal behaviour of the two species to be compared. As Figure 1 shows, the nesting of Pied Shags has a spring maximum at about the same time (October/November) as that of the Little Shags. A difference is that, from 1981 to 1985, the Pied Shags kept nesting throughout the year. Year-round breeding has been recorded before for this species at colonies in the Auckland region (Millener 1973) and elsewhere in New Zealand (Lalas 1979). The present figures, although confirming the spring maximum, do not show the secondary peak of activity in autumn which has been found elsewhere.

In most seasons, new nests of Little Shags were still being started in January, and so the rearing of young extended into March or April. At the end of the 1981-82 season three late nests were present on 9 May, one with two chicks and the others with sitting adults, perhaps on infertile clutches. No Little Shags were present at the next inspection on 29 May, although nine Pied Shag nests remained, each with one or two young. Instances of prolonged incubation by Little Shags have been reported previously (Taylor 1979).

During the 1978-79 season I recorded the outcome of all the nesting attempts by pairs of Little Shags in the following categories:

| | | |
|--|----|-------|
| Failed to complete the nest | 12 | (13%) |
| Nest lost owing to storm damage | 14 | (16%) |
| Nest deserted during incubation | 20 | (22%) |
| Birds displaced at an early stage by another pair | 6 | (7%) |
| All chicks died in the nest | 6 | (7%) |
| One or two chicks raised to fledging | 32 | (35%) |

The total of 90 nesting attempts exaggerates the size of the colony as it includes the second attempts of at least ten pairs after loss of their first nest. Usually I could not tell what caused birds to desert their nest, but human disturbance did not appear to be an important factor. A dip in numbers for December 1978 was the result of nest losses in a severe storm and was followed by intensive rebuilding.

In summary, the nesting season of Little Shags at Hobson Bay typically extends over eight months of the year. After a spring maximum, nesting is prolonged by some birds rebuilding after losing their nests and also by the arrival of late nesters. In New South Wales a later season, extending from October to May, with a peak of egg-laying in January has been found for this species (Miller 1980).

My observations of Little Shags, using plumage patterns to recognise individuals, indicate that most birds find a mate and begin nesting soon after joining the colony and that they leave the colony when their young have fledged. I saw no immature and few unattached adult Little Shags. In contrast, Pied Shags, both adults and immature birds, use the site as a roost at all times of the year.

Plumage forms of the Little Shag

In describing the various adult plumages, I found the following classification to be practicable. I have used the term form (or morph) rather than phase so as not to imply that changes may occur with age once the bird is out of its immature plumage. This aspect requires further study.

White-throated form: White plumage apparent only on face, sides of head and throat, sometimes extending on to the neck, Figure 2, A and B.

Pied form: White over the whole of the breast and belly as well as face, neck and sides of head, Figure 2, C. Compared with the white-throated form, pied birds tend to have more white plumage on the head, often extending upwards to leave only a narrow black strip on the crown.

Smudgy form: The white of the head and neck extends on to the upper part of the breast and is accompanied by a white patch or patches on the breast and underparts, Figure 2, D. Early in the study, I had hoped that the various patterns of smudgy birds would enable me to identify individuals away from the nest. In practice, this method proved unreliable, but I did use simple sketches of the extent of black and white areas on birds to help me recognise individuals at or near their nests.

- Notes:** 1. If a pied bird had a few dark feathers on the breast or a mainly dark bird had a few white feathers, I ignored them in assigning such birds to the pied and white-throated categories respectively.
2. A few birds had a persistent rufous staining on their white feathers, usually on the neck and upper breast. This has been noticed before in the plumage of this species (Harley 1946, McKenzie 1965, Edgar 1972). Australian work attributes it to ferric staining (Keast & D'Ombrian 1949). The birds probably acquire the stain while feeding, much of which they do by swimming close to the bottom in shallow water to catch food such as small eels and freshwater crayfish (Potts 1977, Miller 1979). The feeding involves a series of dives during which the birds submerge for 9-20 seconds with intervening rests of 5-10 seconds (Stonehouse 1967).

Using this classification, the 84 birds (42 pairs) which comprised the colony on 10 October 1978 consisted of 46 white-throated birds (55%), 27 pied (32%) and 11 smudgy (13%). Similar proportions (white-throated 51%, pied 32%, smudgy 17%) were scored for pairs formed over the entire 1978-79 nesting season at Hobson Bay. See Table 1.

The plumages of breeding pairs of Little Shags and their offspring

Throughout the study period mating took place among the different plumage forms and analysis shows this to be random (Dowding & Taylor, this issue). This result is contrary to the hypothesis that, in mixed colonies,

birds of similar plumage tend to pair. This hypothesis was formerly used to support subspecific status for the White-throated Shag (Oliver 1955).

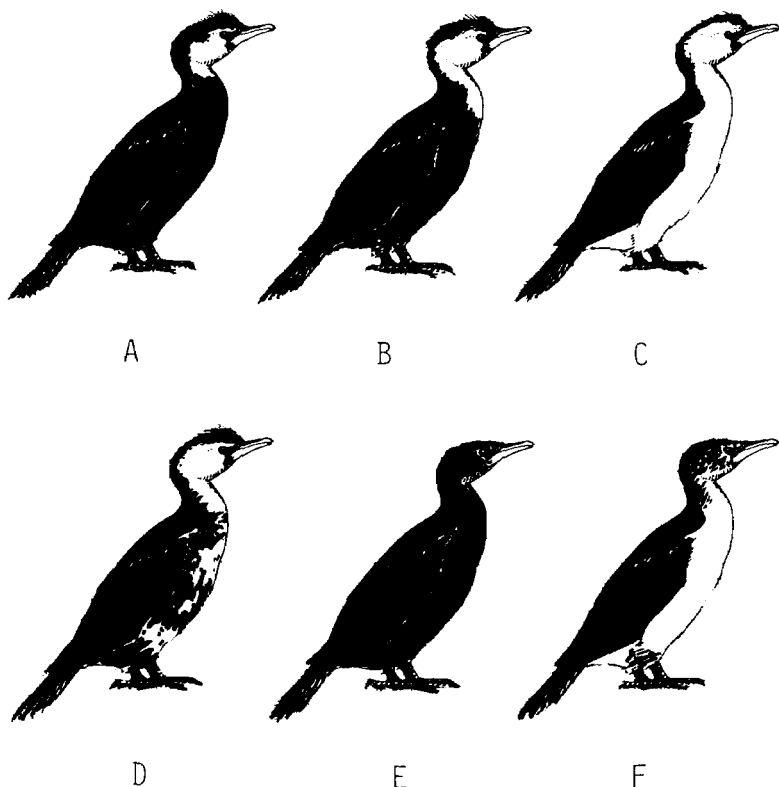


FIGURE 2 — Plumages of the Little Shag. A, B. White-throated form, which may have white throat only or white extending on to neck; C. Pied form; D. An example of the smudgy form, which can vary greatly; E. Dark fledgling; F. Pied fledgling.

As Table 1 shows, at the height of the spring 1978 breeding season the colony had all six mating combinations of the pied, white-throated and smudgy forms. There were more pairings between birds with dissimilar plumage than between like forms, and this situation prevailed for the 1978-79 season as a whole.

The Little Shag nestlings begin life with bare black skin, black bill, and pinkish scalp and gular pouch. A black downy stage follows, during which the pinkish white scalp remains bald and the birds have a bright pink gular pouch. This stage is well illustrated in Vestjens *et al.* (1985). Feathers grow through the down and the young remain in or near the nest until ready

to fly. I was able to keep records of their plumage development through to their leaving the colony. Two types of plumage were encountered: either the fledglings were black over the entire feathered parts or they developed white feathers over the whole of the underparts of the body and extending on to the neck, remaining black elsewhere. See Figure 2, E and F.

TABLE 1 — The plumages of nesting pairs of Little Shags at Hobson Bay

| Combination | Number of pairs | |
|---------------------------------|-----------------|---------------|
| | 10 Oct. 1978 | 1978-9 season |
| White-throated x pied | 20 | 36 |
| White-throated x white-throated | 11 | 18 |
| White-throated x smudgy | 5 | 14 |
| Smudgy x smudgy | 2 | 3 |
| Smudgy x pied | 1 | 8 |
| Pied x pied | 3 | 5 |
| | 42 | 84 |

Black juveniles that have just left the nesting colonies can be distinguished from the Little Black Shag by their short, thick bill, whereas the bill of the Little Black Shag is long and thin. The remains of the gular pouch of nestlings can sometimes also be seen. The age at which the throat feathers become recognisable so as to turn the birds into "White-throated Shags" is not known exactly. Totally black Little Shags have, however, been recorded in August and September around Auckland. These must be from the previous season's nesting and therefore at least 6 months old.

Juvenile Little Shags that are pied can be distinguished from pied adults by the lack of a crest and by appearing darker around the head and neck until feather development is complete in these areas. An Australian study (Miller 1980) recorded that immature Little Pied Cormorants can be "distinguished from adults by lack of broad white superciliary line".

Among my records are several of contrasting pied and black young in the same brood. This striking feature of the nest observations does not seem to have been noted previously. I saw no "smudgy" fledglings. Little Shags in their first feathers are clearly differentiated, being either totally black or black above and white below.

During the 1977-78 and 1978-79 breeding seasons, I made a determined attempt to follow to completion the raising of chicks in all the nests I could see clearly. Over this period 43 pairs raised a total of 62 young (1.4 per nest), and Table 2 gives the numbers of dark and pied fledglings from all 43 matings. The 16 white-throated x pied matings yielded 25 young (1.5 per nest), indicating that there is no disadvantage in mixed pairings. The genetic implications of the parent-offspring data in Table 2 are considered in detail by Dowding & Taylor (this issue). This analysis shows that polymorphism in the Little Shag is controlled by a single gene, with 'dark' incompletely dominant over 'pied'.

TABLE 2 — Relationships between the plumages of adult and fledgling Little Shags at Hobson Bay, 1977-79

| Adult pairing | Number of pairs | Fledglings | Number of occasions |
|------------------------------------|-----------------|---|---------------------|
| White-throated x pied | 16 | 2 dark 1 dark & 1 pied 1 dark 1 pied | 5 4 5 2 |
| White-throated x white-throated | 11 | 2 dark 1 dark | 6 5 |
| White-throated x smudgy | 8 | 2 dark 1 dark | 3 5 |
| Smudgy x smudgy | 1 | 1 dark & 1 pied | 1 |
| Smudgy x pied | 6 | 1 dark 1 pied | 1 5 |
| Pied x pied | 1 | 1 pied | 1 |

CONCLUDING REMARKS

The Little Shag is widespread in New Zealand. During the period of this study Little Shags have nested at six other sites in the Auckland region. Two of these sites are marine and four are on freshwater lakes. All are smaller than the Hobson Bay colony, and some have been used only intermittently.

The Hobson Bay colony has been observed for 8 years. Little Shags have bred successfully each year. In 1978-79 one-third of nesting attempts led to young being raised to fledging, and this proportion probably holds for the other seasons in which the colony was less intensively studied. The nesting of Pied Shags in the same tree has caused some decline in the number of Little Shags attempting to nest.

The various adult and juvenile plumage forms of the Little Shag are described in this paper. All combinations of the white-throated, smudgy and pied forms interbreed at Hobson Bay, and this situation presumably holds elsewhere, although suggestions to the contrary have been published (Oliver 1955). Young birds whose first feathered stage is black and those in which it is pied have been found as siblings in the same brood. This observation and the genetic analysis (Dowding & Taylor, this issue) show conclusively that the plumage forms of the Little Shag constitute a single subspecies. Additional records of the plumage forms of the Little Shag from other parts of the country will enable the genetic analysis to be extended.

This study raises a number of questions which OSNZ members may be able to answer. These include questions of the timing, success and nesting habits at colonies elsewhere in New Zealand. Counts of plumage forms at other Little Shag colonies would be valuable. The plumage development from juvenile to adult requires attention, particularly for smudgy birds. No banding studies have been undertaken for the Little Shag and we do not

know whether this rather shy species would tolerate the disturbance which such studies might entail. Even without banding studies much can be learned by careful watching of behaviour in the field, especially at roosts and nesting sites.

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GENETICS OF POLYMORPHISM IN THE LITTLE SHAG

By JOHN E. DOWDING and MICHAEL J. TAYLOR

ABSTRACT

A genetic model is presented to explain plumage polymorphism in the Little Shag (*Phalacrocorax melanoleucos brevirostris*). Parent-offspring data from an Auckland colony show that expression of the three morphs (white-throated, smudgy and pied) is primarily controlled by two alleles at a single genetic locus. The allele specifying 'dark' (*D*) shows incomplete dominance over that specifying 'pied' (*d*).

Comparison of morph frequencies with calculated genotype frequencies reveals that about 40% of white-throated birds are homozygous dominant (*DD*), the rest of the white-throated birds and all smudgy birds are heterozygous (*Dd*), and pied birds are homozygous recessive (*dd*).

The population mates non-assortively and the Hardy-Weinberg law correctly predicts the frequencies of black and pied offspring from crosses.

Morph frequencies (and allele ratios) show a gradient from north to south in New Zealand, dark birds being more common in the south. The main factor maintaining this cline may be climatic.

INTRODUCTION

Genetic polymorphism is defined as 'the occurrence together in the same habitat of two or more discontinuous forms, or "phases", of a species in such proportions that the rarest of them cannot be maintained merely by recurrent mutation' (Ford 1965). Plumage polymorphism is well known in birds, and in most cases that have been analysed genetically two alleles of a single gene are known to be responsible for the different phenotypes (morphs) observed. Familiar examples are the black and pied morphs of the Fantail (*Rhipidura fuliginosa*) (Caughley 1969), the white and dark morphs of the Southern Giant Petrel (*Macronectes giganteus*) (Shaughnessy 1970) and the yellow-crowned and orange-fronted morphs of the parakeet *Cyanoramphus auriceps* (Taylor *et al.* 1986).

In these examples one allele shows complete genetic dominance over the other and no intermediate morphs occur. In other birds one allele may be incompletely dominant, and so heterozygous individuals (those carrying both alleles) may have intermediate phenotypes. Examples are the dark, intermediate and pale morphs of the Arctic Skua (*Stercorarius parasiticus*) (Berry & Davis 1970) and the pied, intermediate and black morphs of the Variable Oystercatcher (*Haematopus unicolor*) (Baker 1973).

The Little Shag, which is the New Zealand subspecies of the Little Pied Cormorant of Australia (*P. m. melanoleucos*) displays two distinct morphs (white-throated and pied) as well as variable intermediates (smudgy). In this paper we present a genetic model to explain this polymorphism, using data from the study described by Taylor (1987, this issue).

RESULTS

The parent-offspring data shown in Table 1 were collected at the Hobson Bay, Auckland, colony during the 1977-1978 and 1978-1979 breeding seasons. Offspring were either totally black or pied, that is, black above and white below (Taylor 1987, this issue).

Juvenile plumages

It seems likely that pied juveniles develop into pied adults and that black juveniles develop into either white-throated or smudgy adults. That smudgy adults develop from black juveniles seems probable because the plumage of smudgy adults is usually much more like that of white-throated adults than that of pied adults. That is, the white of face and throat extends only to the upper breast of most smudgy birds. The genetic analysis presented below supports this conclusion; smudgy and pied birds combined make up 49% of the population. The Hardy-Weinberg law states that this proportion will be constant from one generation to the next. However, only 13 of 62 (21%) of the juveniles in Table 1 are pied. This difference is highly significant ($\chi^2 = 17.6$, $\nu = 1$, $P < 0.001$).

White-throated and smudgy birds combined make up 68% of the population and 49 of 62 (79%) of the juveniles in Table 1 are totally black. This difference is not significant ($\chi^2 = 2.9$, $\nu = 1$, $P = 0.1$) and supports the theory that black juveniles develop into both white-throated and smudgy adults.

TABLE 1 — Parent-offspring data for the Hobson Bay colony of Little Shags (1977-1979)

| Parental mating combination | Number of pairs | Offspring | |
|--------------------------------|--------------------|-----------|------|
| | | Dark | Pied |
| Wh x Wh | 11 | 17 | 0 |
| Wh x Sm | 8 | 11 | 0 |
| Wh x Pd | 16 | 19 | 6 |
| Sm x Sm | 1 | 1 | 1 |
| Sm x Pd | 6 | 1 | 5 |
| Pd x Pd | 1 | 0 | 1 |
| Totals | 43 | 49 | 13 |

(Wh = white-throated, Sm = smudgy, Pd = pied)

Genetic model

Our model proposes that polymorphism in the Little Shag is controlled by two alleles (designated *D* and *d*) of a single gene. From the predominance of dark offspring evident in Table 1, our first hypothesis was that 'dark'

is dominant over 'pied'; white-throated birds being homozygous dominant (DD), smudgy heterozygous (Dd) and pied homozygous recessive (dd).

Such a hypothesis would require, however, that all the offspring of matings of the two homozygous forms (white-throated x pied) be heterozygous i.e. scored 'dark', but 6 of the 25 offspring were pied.

We therefore proposed that white-throated birds consist of both homozygous dominant (DD) birds and heterozygous birds and that pied birds are homozygous recessive (dd). Probably all smudgy birds are heterozygous (Dd) – of the eight smudgy parents in smudgy x smudgy and smudgy x pied crosses in Table 1, seven must have been heterozygous (because they produced pied offspring) and the eighth could have been.

All the data in Table 1 fit this interpretation. That 'pied' is not dominant can be demonstrated by considering the offspring of the white-throated x pied crosses in Table 1. At one extreme, all pied birds would be homozygous dominant (PP) and all offspring of Wh x Pd matings would be pied. At the other extreme, all pied birds would be heterozygous (Pp) and black and pied offspring would occur in equal numbers. Of the 25 offspring of Wh x Pd matings, 19 were black. 'Pied' is therefore clearly not dominant over 'dark'.

We therefore tested the hypothesis by using the Hardy-Weinberg model to calculate genotype frequencies and so to predict the ratio of black to pied offspring in crosses. This model requires that the population is at genetic equilibrium (we have no evidence that it is not) and that the population mates non-assortively.

Non-assortive mating

The 84 pairs formed at the Hobson Bay colony during the 1978-1979 season were tested for non-assortive mating and the results are shown in Table 2. The 84 pairs consisted of 86 white-throated, 28 smudgy and 54 pied birds. Phenotype frequencies were thus:

white-throated = 0.512, smudgy = 0.167, pied = 0.321

These frequencies were used to calculate the number of pairs of each mating combination that would be expected if pairing were random.

There is good agreement between observed and expected values ($\chi^2 = 5.10$, $v = 5$, $0.5 > P > 0.3$) and mating is thus shown to be random as to plumage type.

Genotype frequencies

In the Hardy-Weinberg model, the frequency of the allele D is designated p and the frequency of d is q , where $p + q = 1$. Genotype frequencies are calculated from the binomial $p^2 + 2pq + q^2$, using the frequency of homozygous recessive (pied) birds, 0.321, as q^2 . Thus $q = 0.566$ and $p = 0.434$. Genotype frequencies are therefore:

$$\begin{aligned} p^2 &= 0.188 = DD \text{ (homozygous dominant)} \\ 2pq &= 0.491 = Dd \text{ (heterozygous)} \\ q^2 &= 0.321 = dd \text{ (homozygous recessive)} \end{aligned}$$

We can now calculate the numbers of black and pied offspring to be expected from each of the mating combinations shown in Table 1. As an

TABLE 2 — Non-assortive mating in the Hobson Bay colony of Little Shags

| Mating combination | Observed number of pairs | Expected number of pairs | (Observed - expected) ² |
|--------------------|--------------------------|--------------------------|------------------------------------|
| | | | Expected |
| Wh x Wh | 18 | 22.01 | 0.73 |
| Wh x Sm | 14 | 14.36 | 0.01 |
| Wh x Pd | 36 | 27.64 | 2.53 |
| Sm x Sm | 3 | 2.35 | 0.18 |
| Sm x Pd | 8 | 8.99 | 0.11 |
| Pd x Pd | 5 | 8.65 | 1.54 |
| | 84 | 84.00 | $\chi^2 = 5.10$ |

example, we will consider the 16 white-throated x pied crosses, which yielded 25 offspring. White-throated birds are a mixture of *DD* and *Dd* and all pied birds are *dd*. The proportion of Wh x Pd crosses that are *DD* x *dd* therefore

$$= \frac{DD}{DD + Dd} = \frac{0.19}{0.19 + 0.49} = 0.28$$

All offspring from these crosses will be *Dd* and therefore black. The proportion of Wh x Pd crosses that are *Dd* x *dd*

$$= \frac{Dd}{DD + Dd} = \frac{0.49}{0.19 + 0.49} = 0.72$$

Offspring from these crosses will be *Dd* and *dd* in equal numbers and therefore half will be black and half pied.

The expected and observed numbers of black and pied offspring from Wh x Pd crosses are shown in Table 3.

The differences between expected and observed are not significant ($\chi^2 = 1.08$, $\nu = 1$, $P = 0.3$).

The numbers of black and pied offspring to be expected from all other mating combinations were also calculated and the results are summarised in Table 4.

The differences between observed and expected numbers for the first three combinations (Wh x Wh, Wh x Sm and Wh x Pd) are not significant ($P = 0.22$, 0.25 and 0.3 respectively).

The sample sizes of the other three combinations are too small to analyse. Finally, the differences between observed and expected totals in Table 4 are also not significant ($\chi^2 = 1.4$, $\nu = 1$, $P = 0.24$).

The lack of significance in all cases provides strong support for the proposed model.

TABLE 3 — Expected and observed phenotype frequencies among 25 offspring of Wh x Pd matings

| Parental genotypes | Frequency of crosses | Offspring phenotype | |
|-----------------------|-------------------------|---------------------|------|
| | | Black | Pied |
| <u>DD</u> x <u>dd</u> | 0.28 x 25 = | 7.0 | 0.0 |
| <u>Dd</u> x <u>dd</u> | 0.72 x 25 = | 9.0 | 9.0 |
| | Expected = | 16.0 | 9.0 |
| | Observed = | 19 | 6 |

TABLE 4 — Summary of the expected and observed phenotype frequencies among offspring of all crosses

| Crosses | Total offspring | Black offspring | | Pied offspring | |
|---------|--------------------|-----------------|-----|----------------|-----|
| | | Exp | Obs | Exp | Obs |
| Wh x Wh | 17 | 14.8 | 17 | 2.2 | 0 |
| Wh x Sm | 11 | 9.0 | 11 | 2.0 | 0 |
| Wh x Pd | 25 | 16.0 | 19 | 9.0 | 6 |
| Sm x Sm | 2 | 1.5 | 1 | 0.5 | 1 |
| Sm x Pd | 6 | 3.0 | 1 | 3.0 | 5 |
| Pd x Pd | 1 | 0.0 | 0 | 1.0 | 1 |
| | — | — | — | — | — |
| Totals | 62 | 44.3 | 49 | 17.7 | 13 |

Gradient of genotype frequencies

The frequency of dark and pied morphs varies in different parts of New Zealand, the pied morph being more common in the north (see Taylor, this issue). Assuming these populations to be at equilibrium, we can calculate genotype and allele frequencies as before, from the frequency of homozygous recessive (pied) birds. The results are shown in Table 5.

TABLE 5 — Calculated genotype and allele frequencies for the Little Shag in different parts of New Zealand

| Location | Frequency of pied morph ⁽¹⁾ | Genotype frequencies | | | Allele frequencies | |
|--------------------------|--|-------------------------|-----------|-----------|-----------------------|----------|
| | | <u>DD</u> | <u>Dd</u> | <u>dd</u> | <u>p</u> | <u>q</u> |
| Far North | 60% | 0.05 | 0.35 | 0.60 | 0.22 | 0.78 |
| Auckland (this study) | 32% | 0.19 | 0.49 | 0.32 | 0.43 | 0.57 |
| Rest of North Island | 15% | 0.38 | 0.47 | 0.15 | 0.61 | 0.39 |
| South Island | 8% | 0.51 | 0.41 | 0.08 | 0.72 | 0.28 |

(1) Data from Taylor (1987)

There is a clear gradient of allele frequencies from north to south, reflecting the observed morph cline.

DISCUSSION

Our evidence supports the conclusion that plumage polymorphism in the Little Shag is controlled by two alleles at a single genetic locus, the allele specifying 'dark' being incompletely dominant. This genetic evidence also supports the current classification of *P. melanoleucos* in New Zealand as a single subspecies.

On comparing the phenotype (morph) frequencies observed in Auckland with the calculated genotype frequencies, we find that about 60% of the Auckland birds scored white-throated must, in fact, be heterozygotes. A similar situation has been described for the Arctic Skua where dark, intermediate and pale morphs occur. "... a large proportion (45% according to O'Donald) of birds classified as Dark are in fact heterozygotes" (Berry & Davis 1970). 'White-throated' Little Shags having any extension of white on to the upper breast or a few white feathers on the flanks or belly are therefore likely to be heterozygotes (and should probably be scored as smudgy).

We do not know what mechanism controls how much black develops on the underparts of heterozygotes. There may be additional genetic effects at other loci, as Baker (1973) suggested for the Variable Oystercatcher, or environmental effects or a combination of both. Heterozygotes of the Little Shag, however, seem to vary less than do intermediate Variable Oystercatchers. About two-thirds of heterozygous Little Shags in Auckland

are similar in appearance to white-throated birds. That is, they are class A or B in Figure 2 of Taylor (this issue). About one-third are smudgy, i.e. class D.

The factors maintaining this polymorphism need further study. The 'dark' phenotype has presumably evolved since the Little Shag arrived in New Zealand because the Australian subspecies *P. m. melanoleucos* is pied. The large difference in allele ratios in different parts of New Zealand (Table 5) suggests that one or more selective forces are constantly in operation. One obvious suggestion is that these are climatic. The dark morphs may be at an advantage in areas of lower temperature because the greater amounts of solar heat absorbed by an all-dark bird would reduce the amount of energy expended on the maintenance of body temperature.

Perhaps morph frequencies are altered locally by the occasional arrival of Little Shags from Australia, but large numbers would probably be needed to have a significant effect. Such immigrants would have to be more common in the north than in the south if invasion plays a part in maintaining the cline.

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SHORT NOTE

Homing ability of the House Sparrow

The House Sparrow (*Passer domesticus*) is a social species that is throughout New Zealand. Sparrows are highly sedentary birds, 92% of recoveries of banded sparrows in Great Britain being within 2 km of their banding site (Summers-Smith 1963). In Illinois the longest movement of 89 sparrows recaptured from 1785 banded was 3.2 km (Will 1973). In New Zealand, 97% of 2237 recoveries of individual banded sparrows were at their banding site. Twelve birds were recovered within 15 km, 35 birds from 15-30 km, 15 birds from 30-100 km and six birds further than 100 km from their banding site. The recoveries include one bird at 236 km and one at 317 km. We report here movements of House Sparrows of up to 5.7 km in returning to their original capture site after escaping from an aviary.

House Sparrows were captured in mist nets and cage traps during a study of their annual reproductive cycle. They were caught at a grain store in Lower Hutt and at Belmont, Petone and Wainuiomata. The birds were individually marked with bands and held in three large aviaries at the DSIR Taita Research Station.

On 19 August 1985 the aviaries were vandalised and all 58 sparrows (39 males, 19 females) were released. Over the next few days up to 15 of the birds were seen in and around the aviaries. Three of these were recaptured beside the aviaries 10 days after their release and two more the next day. One male had been in captivity for 38 days and the other two males and two females had been in captivity for 70 days.

Each month for the next 11 months we trapped sparrows at the grain store. Six of the 20 released birds we had originally captured at the grain store were recaptured there. Three were recaptured at the next trapping (24 days after release), and three more were caught at different times up to 186 days after release. These birds (30% of those released) had travelled 5.7 km as the sparrow flies. We do not know how quickly the birds returned to the grain store. Moreover, only some of the birds were captured each month, and so more birds may have returned than were recaptured.

Two of the eight sparrows originally captured at Belmont were subsequently caught at the same site by a cat. One bird was caught 72 days after release and the other 130 days after release. Both these birds had been in captivity for 21 days and had travelled 4.7 km. No birds were recaptured during further trapping at Petone and Wainuiomata (8.6 km and 10.5 km from release site).

Clearly, House Sparrows have strong homing ability. Furthermore, four of the five birds recaptured at the aviary had been in captivity for longer than those recaptured elsewhere (70 days as against 21-50 days). The homing inclination of House Sparrows may thus decline with the time in captivity.

We thank the Manager of Sharpes Grain and Seeds Ltd for permission to capture sparrows, and the Banding Office, NZ Wildlife Service, for providing records of the recoveries of sparrows in New Zealand.

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BIRDS FROM A TE KUITI GARDEN

By ROB and GILLIAN GUEST

“... there is more to a garden than its produce: it provides opportunity to see, hear and smell the living world, to appreciate the changing seasons and for me added delight lies in finding out what insects, birds and other animals live there, and in tracing their complex interactions with one another and with garden plants.”

So Jennifer Owen (1983) introduced her meticulous and detailed studies of wildlife in her garden, which clearly demonstrated the satisfaction and value of investigating the rich (somewhat surprisingly so) animal communities found therein.

In May 1980 we moved to Te Kuiti, to a house with a garden that is relatively large (c.1600 m²) and varied, providing a good habitat for birds. We wanted to formalise our observations in an attempt to understand when and how the different species of bird were using this habitat.

STUDY AREA AND METHODS

Te Kuiti, a small town in the northern King Country, has about 5000 inhabitants and is on the hill slopes on both sides of the Mangaokewa River. The valley floor is at 52 m a.s.l., and the hills rise to 277 m a.s.l., still with some remnants of native bush. Our garden in the town is flat to very steep, has many shrubs, an orchard, a few larger trees, flower borders, a vegetable garden and a small creek, choked with watercress, which flows for much of the year.

We decided that keeping a record of all species seen and heard in or from the garden each calendar month would satisfy most of our requirements. The method has the virtue of being simple, and monthly records allow easy analysis of seasonal trends. We were aware of the effect that observation period has on the number of species observed, and a month seemed to allow relatively similar amounts of time to be spent on the property for observation. (After 5½ years we still consider this to be so – but during this time we have had few periods away from Te Kuiti and have spent a reasonable proportion of our time throughout the year in the garden.)

We were also aware that the inclusion of species not actually using the garden created some bias. The criteria for recording did not change from month to month, however, and so the records do give some indication of the birds' presence on a scale beyond that of the individual garden.

Observations were made from May 1980 to November 1985 inclusive, a total of 67 months.

RESULTS AND DISCUSSION

During the study period we observed 33 species from the property. Table 1 lists these species and the percentage of months in which each was recorded.

Nine species were noted every month; most of these were the common introduced species, but three native species, the Fantail, Grey Warbler and Silvereye were also regular inhabitants. We stress that these summaries in no way indicate the abundance of individuals within each species – the numbers of House Sparrows, for example, far exceed those of Grey Warblers. Only the 14 species recorded most often could be considered to be resident in the vicinity all year round, and even these showed some transient trends. The Tui, for example, was not recorded in March of 1983, 1984, and 1985; they are known to travel widely in the area, frequenting fruiting kahikatea trees in March.

The number of species observed each month varied throughout the year (Figure 1), and it varied from year to year from a low of 11 species in March 1983 to a high of 25 in December 1980.

Autumn was consistently the quiet period with fewest species observed. This may be partly because of the retiring and quiet behaviour of some species during moult and partly because the main fruiting and seeding period elsewhere reduced the birds' dependence on garden foods. Increasing numbers of species were observed as winter and spring progressed, most being recorded towards the end of the year. This may reflect various trends such as more diverse foraging behaviour during winter months, more species using the garden in summer, and many species being more conspicuous during the breeding season.

Figures 2 and 3 show the trends in occurrence of some species. The spring records of Shining Cuckoo reflect the national trend (Cunningham 1985). The birds arrived in early October and at night during October could be heard calling overhead – presumably birds migrating further south. No northward movement was discerned during the autumn, and no birds were seen after mid-February.

Greenfinches and Welcome Swallows visited the garden regularly in summer but tended to be sporadic at other times.

Records of California Quail are strongly influenced by their increased calling in spring and early summer, that is, by their conspicuousness rather than their presence. This factor almost certainly accounts for the records of the Pheasant, which reached a peak in early summer. We always detected Pheasants by ear, and the histogram reflects the main calling period.

The records of Black Shag are of interest. This species was not associated with the garden but was observed flying along the Mangaokewa Valley above the river. Black Shags were present all year on local ponds but were markedly fewer in winter. The pattern suggests observations of birds flying to or from nests, although the nest sites are not known (Myk Davis, pers. comm.).

Records of species observed more often in winter months clearly indicate changes in distribution. The Falcon, Bellbird, Yellowhammer and Hedgesparrow were rarely or not seen in summer months, and the records of them probably indicate actual absence rather than reduced conspicuousness, although the Yellowhammer and Hedgesparrow were seen elsewhere in the town during the summer months (Myk Davis, pers. comm.). Whenever Falcons were in the area, they were seen regularly – one even plucked prey on top of a telegraph pole in the garden.

TABLE 1 — Relative occurrence of birds in a Te Kuiti garden, May 1980 to November 1985.

| SPECIES | Months When Observed (%) |
|---|--------------------------|
| Starling, House Sparrow, Grey Warbler, Goldfinch, Fantail, Blackbird, Indian Myna, Silvereye, Song Thrush | 100 |
| Chaffinch, Tui | 95 |
| White-backed Magpie | 94 |
| Kingfisher | 92 |
| Morepork | 89 |
| Welcome Swallow | 79 |
| Mallard/Grey Duck, Greenfinch | 62 |
| Australasian Harrier | 56 |
| Hedgesparrow | 43 |
| White-faced Heron | 40 |
| Yellowhammer | 32 |
| Shining Cuckoo | 31 |
| Pheasant, Pied Stilt, California Quail | 20 |
| Black Shag | 16 |
| Falcon, Paradise Shelduck, Southern Black-backed Gull | 10 |
| Redpoll | 8 |
| Bellbird | 7 |
| Skylark | 4 |
| Shoveler | 2 |

AVE. NO. OF SPECIES PER MONTH

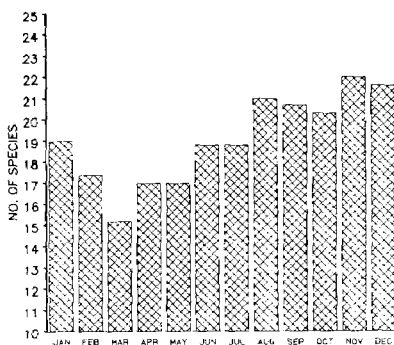


FIGURE 1 — Average number of species observed each month from a Te Kuiti garden, May 1980 — November 1985

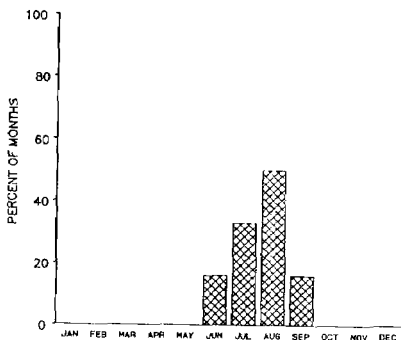
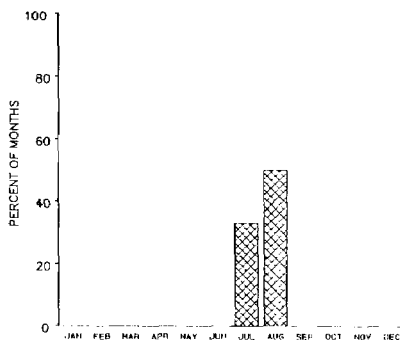
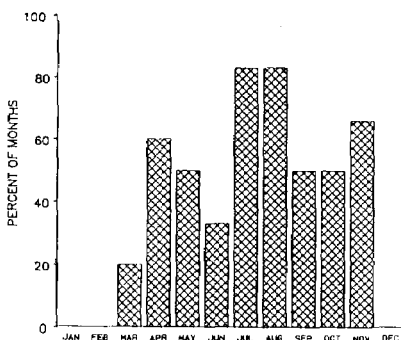
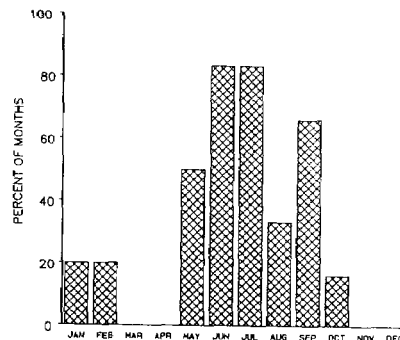
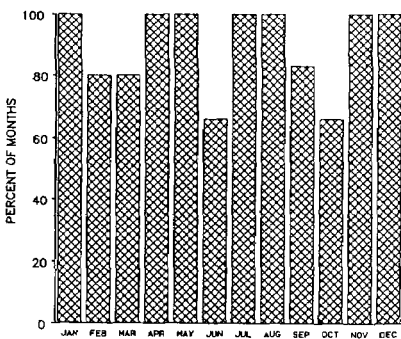
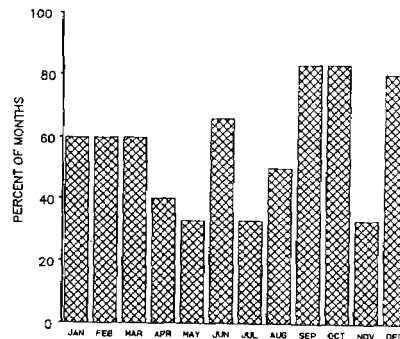
N.Z. FALCON**BELLBIRD****HEDGE SPARROW****YELLOWHAMMER****MOREPORK****HARRIER**

FIGURE 2 — Occurrence, by month, of six species recorded from a Te Kuiti garden, May 1980 — November 1985

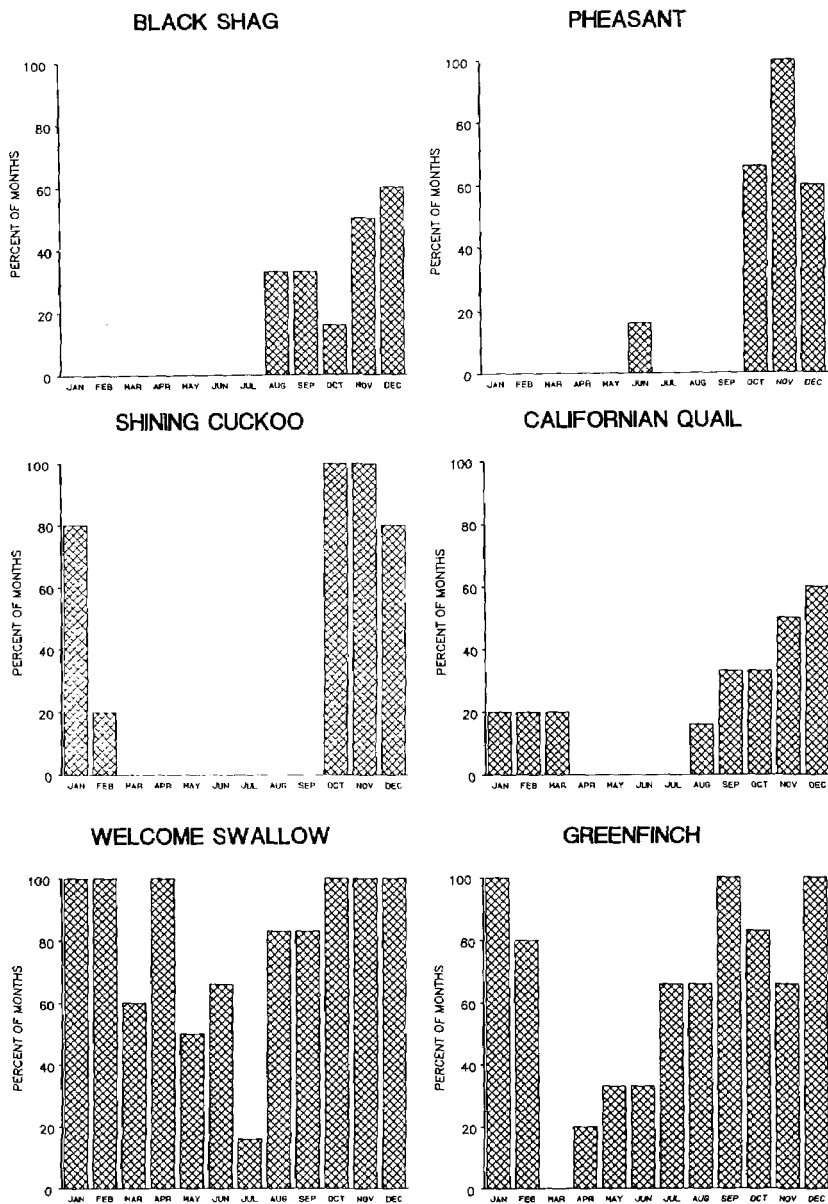


FIGURE 3 — Occurrence, by month, of six species recorded from a Te Kuiti garden, May 1980 — November 1985

Harrier and Morepork observations are included to illustrate that seasonal trends are not obvious with all species. The sightings of Harriers, which were not associated with the garden or the immediate surroundings, were probably chance events, as the histogram seems to show.

Moreporks on the other hand did inhabit the garden and the surrounding area. The periods of apparent absence were neither regular nor readily explicable.

Although the patterns observed from this garden are of interest, they are not necessarily typical of other gardens in the town. Gardens closer to the river are likely to give more regular sightings of such water birds as ducks, shag, herons, stilts and Pukeko. Gardens with more birch trees tend to be more attractive for Redpolls, and those with native bush closer by have more Bellbirds and also New Zealand Pigeon.

The number of species to be observed reflects the wide range of habitats to be found within the town, from open pasture to well-grown stands of trees, the Mangaokewa River and the remnant stands of native bush adding to the variety.

This study was undertaken after data collection for the *Atlas of Bird Distribution in New Zealand* had ended. The atlas recorded 38 species based on 7 cards but did not record the Shoveler and Black-backed Gull observed by us. The species recorded from the square but not seen by us from the garden were generally less common or associated with other habitat types. They were Dabchick, Brown Quail, Banded Rail, Pukeko, New Zealand Pigeon and New Zealand Pipit. The comparison indicates both the comprehensive coverage of the atlas project and the high proportion of species in the area that may be observed from one small area of limited habitat.

We readily acknowledge that a simple study such as this can have only limited conclusions. Most of the advantages lie in the execution. The requirements of the study heighten one's awareness of birds' activity at home and increase the interest of observations. The patterns observed raise further questions and stimulate other studies. In addition, the perception of trends in occurrence, conspicuousness and frequency of the birds adds to the enjoyment of birdwatching in the most convenient place possible – at home.

ACKNOWLEDGEMENTS

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PLASTIC PELLETS IN NEW ZEALAND STORM-KILLED PRIONS (*Pachyptila* spp.) 1958-1977

By P. C. HARPER and J. A. FOWLER

Since the problem of plastic pollution of the oceans was recognised in the early 1970s, there has been a steady increase in reports of seabirds ingesting plastic particles. This has culminated in an excellent synthesis of the subject by Day *et al.* (1985), who showed that most of the pellets from 50 species of seabirds were polyethylene fragments 3-5 mm in diameter, probably from larger pieces used in protective packaging, fishing buoys and other sources associated with fishing and marine shipping. Many other types of multicoloured plastics from toys, bottle caps, and clear plastic sheets have also been found in birds' gizzards. According to Day *et al.*, procellariiform species had the highest overall occurrence of plastic ingestion – 28 (90%) of the 31 specimens examined.

Plastic pellets occur in New Zealand waters, where Gregory (1977) found their abundance to be highly variable on New Zealand beaches: from 5-10/m in the more remote areas such as Ninety Mile Beach, Castlepoint, and the northern side of Farewell Spit, to dense in places close to industrial centres such as Petone, where pellets exceed 40 000/m. Gregory anticipated that New Zealanders would "sunbathe on 'plastic sand' beaches – a development already being approached at Oriental Bay in Wellington Harbour".

The aims of this paper are:

1. To report the incidence of plastic pollution in beach-wrecked prions, thus providing information on the unreferenced comments of Bourne & Imber (1982) that plastic pellets have been found in the stomachs of many beach-caste Salvins, Antarctic and Thin-billed Prions (*Pachyptila salvini*, *P. desolata* and *P. belcheri*) and Blue Petrels (*Halobaena caerulea*) in New Zealand.
2. To see whether the abundance of plastic pellets in prions has changed over the years.
3. To examine relationships between the number of pellets and the weight or age of prions.

METHODS

During the 21 year period from 1958 to 1977, PCH examined *Pachyptila* representing five species. The birds had been driven ashore dead or dying during the windy months of late summer and after the gales that sweep New Zealand in winter.

From 1979 of these 9247 birds, PCH removed the gizzards and proventriculi and examined them for plastic pellets. These birds were all freshly cast ashore on exposed coast from Otaki to Pukerua Bay, north of Wellington, and on the south Wellington beaches, including Petone and

Palliser Bay. A single wreck of 323 young Salvin's Prions about 30 June 1966 was large enough to examine statistically the relationship between the number of ingested plastic pellets and the weight of the birds.

TABLE 1 — Occurrence of plastic pellets in five prion species collected from New Zealand beaches, 1958-1977

| Species | Age Class | | Gizzards Examined | Number with Plastic Pellets | | % Total with Pellets | | Species Status |
|---|-----------|-------|-------------------|-----------------------------|-------|----------------------|-------|-------------------------|
| | Imm* | Adult | | Imm | Adult | Imm | Adult | |
| Brood-billed Prion <i>Pachyptila vittata</i> | 170 | 140 | 310 | 18 | 33 | 10.6 | 23.6 | NZ resident |
| Salvin's Prion <i>Pachyptila salvini</i> | 651 | 12 | 663 | 133 | 0 | 20.4 | 0 | Indian Ocean migrant |
| Antarctic Prion <i>Pachyptila desolata</i> | 29 | 6 | 35 | 4 | 1 | 13.8 | 16.7 | NZ subantarctic migrant |
| Thin-billed Prion <i>Pachyptila belcheri</i> | 147 | 5 | 152 | 10 | 0 | 6.8 | 0 | Indian Ocean migrant |
| Fairy Prion <i>Pachyptila turtur</i> | 714 | 105 | 819 | 88 | 13 | 12.4 | 12.4 | NZ resident |
| TOTALS | 1711 | 268 | 1979 | 253 | 47 | | | |

*Immature = birds of the year; adults = all others.
Age determined by bone ossification, gonad condition,
bill & feet shrinkage, measurements, plumage

RESULTS

Table 1 shows the occurrence of plastic pellets in immature and adult prions of five species. The Fulmar Prion (*P. crassirostris*) was not represented in the results because this prion is rarely beach-wrecked: its numbers are small, and it breeds on and remains near islands to the south or east of the country, whereas the prevailing winds are from the west.

All prions had an empty proventriculus and their emaciated condition clearly showed that they had not eaten for at least a week and probably much longer. The body weight of beached birds varies from 5% to 45% of that of adult breeding birds in good condition. An incubating Fairy Prion (*P. turtur*) will remain at its nest for five days before deserting the egg in order to feed (Harper 1976; 1980, pers. obs.).

Most of the migratory species examined were fledglings not long out of their nests. Of 663 Salvin's Prions, 651 or 98.2% were birds of the year, as were 82.8% of the 35 Antarctic Prions, 96.7% of the 152 Thin-billed Prions and 87.2% of the 819 Fairy Prions.

Whereas the glandular stomach was empty, gizzards contained squid beaks, an occasional fish otolith, and two types of abiotic gastroliths: small pieces of pumice and plastic pellets, both 2.5-3.5 mm in diameter.

Table 1 shows that, of the 1979 birds examined 300 (15.1%) contained plastic pellets. There was no statistically significant difference between the percentage incidence of pellets in immature (14.78%) and adult (17.54%) birds ($\chi^2 = 1.16$, NS).

Figure 1 shows the years in which enough data were collected on three species to make a useful comparison. Because of the small sample of both the Antarctic and Thin-billed Prions, these data have been omitted from Fig. 1 and 2. Some years produced more prion wrecks than others. This variability is probably due to three factors: variations in distant oceanic and local storms, food availability, and the yearly recruitment of young birds.

Figure 1 shows also the percentage of gizzards examined which contained plastic pellets. For all species there was an increasing trend over the study period, and for the Fairy Prion and Salvin's Prion, the trend was statistically highly significant ($r_s = 0.66$ and 0.82 respectively). The data for the three species are combined in Figure 2.

Table 2 shows the relationship between the body weight of birds and the number of pellets found. Of a sample of 323 Salvin's Prions cast ashore in June 1966, 78 birds (24.15%) contained pellets; the median number of pellets was 2.8, the mean 2.71 and the variance $s^2 = 3.54$. There is a statistically highly significant inverse correlation between the number of pellets in each bird and the mass of the bird ($r = -0.686$, $t = 8.27$, $P < 0.01$; counts of pellets were square-root transformed to normalise the distribution). The prion containing 13 pellets was also the lightest; its weight of 76 g represents only 48.4% of the mean 157 g departure weight of fledglings leaving a breeding station at Hog Island, Crozet Islands (Despin *et al.* 1972).

The mean weight of the 78 birds which contained plastic pellets was 93.1 g (range 76-114 g) and that of 244 birds which did not contain pellets 91.3 g (range 78-105 g). The difference is not statistically significant.

DISCUSSION

With their feeding methods prions can retrieve very small prey from the sea's surface. They can therefore easily collect plastic pellets floating on the water. We believe that, because the prions are so widespread and abundant, they may well be a useful natural monitor of plastic pollution in the southern oceans. Our data from three species suggest that prions began ingesting plastic pellets in the early 1960s and still do. The fact that both the Fairy and Broad-billed Prions do not range far would strongly indicate that plastic debris has been available to the birds in New Zealand seas since the early 1960s. Prions feed by contact dipping, surface seizing, hydroplaning (larger species of prions only) and surface diving. Food includes euphausiids, amphipods, cephalopods, fish and molluscs (Harper *et al.* 1985).

Our information from starved beached birds strongly suggests that prions will eat anything resembling food before they die – the lightest birds had the most pellets. It also shows that adults and immatures ingest pellets equally often when starved. We do not know whether birds in good condition are as easily deceived by plastic pellets.

We also do not know where migrating birds collect plastic pellets. From the observations by Falla (1937) and because the first Indian Ocean migrant prions reach New Zealand in May, we think that the birds take the most direct, wind-assisted route across the subantarctic water zone to New Zealand

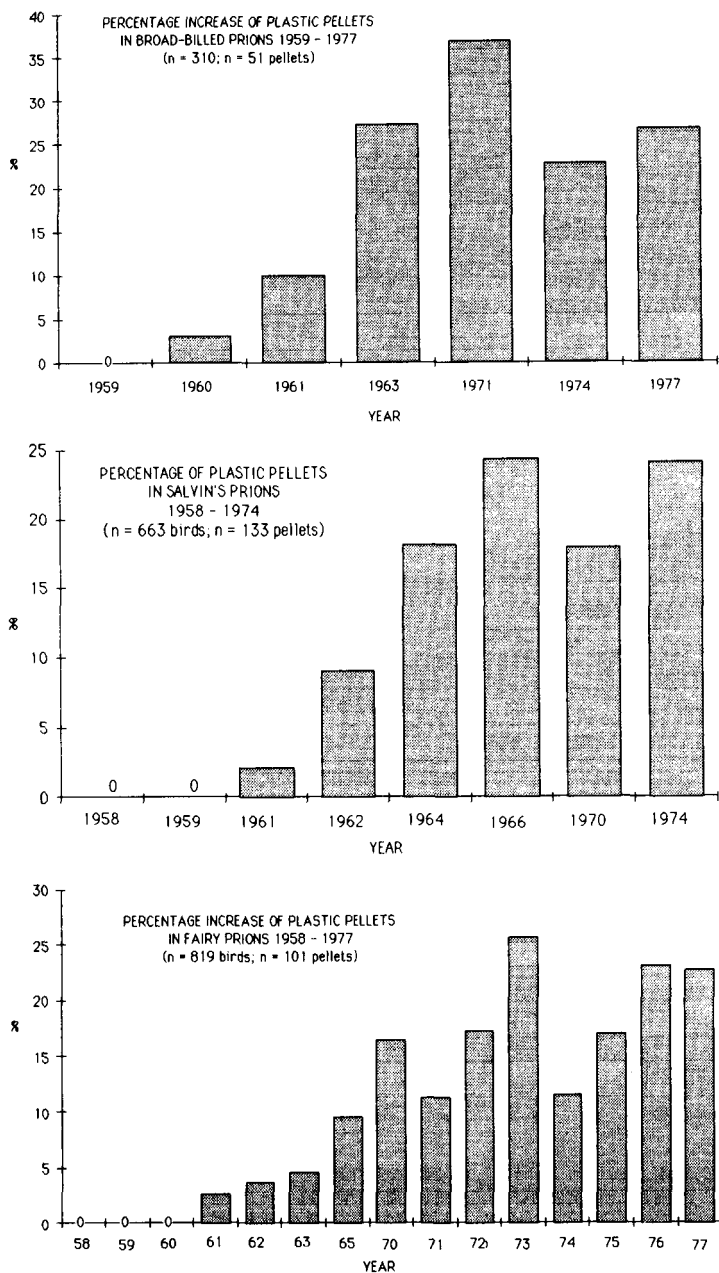


FIGURE 1

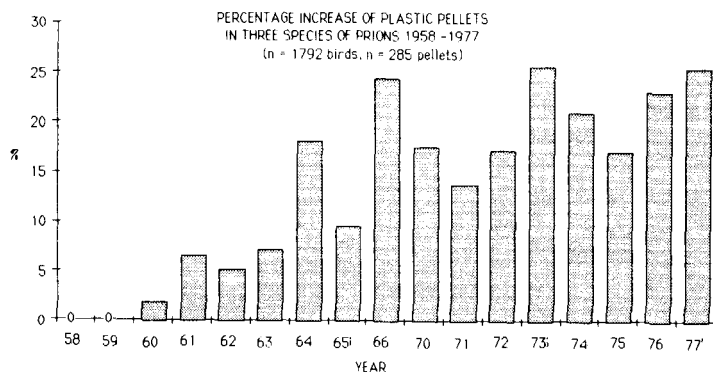


FIGURE 2

TABLE 2 — Relationship between body weight and number of plastic pellets in 79 Salvin's Prions cast ashore in June 1966

| Weight in gm | Number of Birds | SEX | | Number of Pellets in each Bird |
|--------------|-----------------|-----|----|--------------------------------------|
| | | M | F | |
| 114 | 1 | 1 | | 1 |
| 112 | 0 | | | |
| 110 | 2 | 1 | 1 | (1)(1) |
| 108 | 0 | | | |
| 106 | 2 | 1 | 1 | (1)(1) |
| 104 | 0 | | 0 | |
| 102 | 3 | 2 | 1 | (2)(1)(1) |
| 100 | 12 | 6 | 6 | (3)(1)(2)(1)(2)(1)(2)(1)(1)(2)(3)(1) |
| 98 | 5 | 3 | 2 | (1)(1)(1)(2)(2) |
| 96 | 7 | 5 | 2 | (3)(2)(2)(1)(2)(2)(1) |
| 94 | 11 | 6 | 5 | (4)(2)(3)(1)(2)(2)(4)(3)(2)(2)(2) |
| 92 | 2 | 1 | 1 | (4)(2) |
| 90 | 8 | 5 | 3 | (3)(2)(1)(1)(4)(3)(2)(2) |
| 88 | 7 | 4 | 3 | (4)(5)(4)(4)(6)(1)(1) |
| 86 | 6 | 0 | 6 | (5)(5)(3)(3)(4)(5) |
| 84 | 5 | 4 | 1 | (3)(6)(5)(4)(3) |
| 82 | 3 | 1 | 2 | (3)(5)(4) |
| 80 | 2 | 0 | 2 | (4)(5) |
| 78 | 1 | 0 | 1 | 6 |
| 76 | 1 | 0 | 1 | 13 |
| TOTALS | 78 | 41 | 37 | 211 |

— a journey of some 6000 km. They could collect pellets anywhere along this tract of ocean or could take them from convergence or upwelling zones where the pellets might be concentrated.

We also do not know how long plastic pellets remain in the gut of the birds. Because plastic has not been found in the intestinal tract or faeces, Day *et al.* (1985) assumed that the passage of plastic through the intestines does not occur, and yet prions can void intact fish vertebrae the same size as plastic pellets without apparent difficulty (PCH, pers. obs.). Procellariiform birds which feed their young by regurgitation may well regurgitate plastic pellets with squid beaks, but precise information is lacking.

If plastic pellets are passed normally in faeces, the prions in our study would indeed be ingesting pellets in the Australasian region, at a time when the birds' energy reserves were exhausted and shortly before the birds died.

Whether plastic pollution causes damage to seabirds, physically or in their ability to reproduce, is a matter of concern. Our 1966 data showing that the mean body weights of 323 beached Salvin's Prions with and without plastic pellets were similar ($p = \text{NS}$) suggest that the plastic was not primarily responsible for the birds' death. The cause of death was, in this case, probably starvation. Further studies are needed to confirm this finding for the 1980s.

ACKNOWLEDGEMENTS

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THE CHESTNUT-BREASTED SHELDUCK IN NEW ZEALAND 1983-1986

By B. D. HEATHER

The Chestnut-breasted, or Australian, Shelduck (*Tadorna tadornoides*) is a bird mainly of south-western and south-eastern Australia. Its closest relatives are the Paradise Shelduck (*T. variegata*) of New Zealand and the Radjah, or Burdekin, Shelduck (*T. radjah*) of northern Australia, New Guinea and the Moluccas. In eastern Australia, the Chestnut-breasted Shelduck is especially common in south-eastern South Australia, western Victoria, Tasmania, and the southern Tablelands of New South Wales (Frith 1977). After breeding, the shelducks make complex and often long-distance movements to moulting sites. At Lake George near Canberra, for example, the numbers increase from November to a peak of several thousands in January. The numbers decline in late summer and autumn, and only the few resident pairs remain by May (Frith 1977).

This rough background may give perspective to some of the events in New Zealand in 1983-1986.

NEW ZEALAND RECORDS

The first positive record was of a female at Lake Ellesmere, Canterbury, on 11-12 December 1982 (Fennell *et al.* 1983). By 3 January, a male had joined the female, and so the OSNZ regions were asked to look out for the shelducks.

The result was a scattering of reports, ranging eventually from the far north of the North Island to the subantarctic Auckland, Campbell and Snares Islands.

At first, in January 1983, the shelducks were seen in the South Island – Golden Bay-Nelson, Marlborough, Canterbury (Ellesmere, Cass River delta, Washdyke Lagoon), and Southland, but two appeared also in the Bay of Plenty, North Island. In February-March, several appeared in the central North Island (Rotorua, Waikato, north Taranaki). Most birds seemed then to wander, being seen unexpectedly in places that ornithologists had visited often, and usually not being seen there again. Reports almost ceased after April 1983, which coincided with the start of the gamebird-shooting season in May and roughly with the normal dispersal of Paradise Shelducks to their breeding territories (Williams 1979). Three are known to have been shot in 1983 (Northland, Nelson, West Coast).

With the birds being erratic in many places, I cannot give accurate numbers in New Zealand; however, I have in Table 1 grouped the records for the few periods when they give a rough idea of likely totals. The full records follow.

TABLE 1 — Australian Shelducks recorded in early months of the years 1983-1986

| | 1983 (Jan-Mar) | 1983 (Apr-May) | 1984 (Jan-Feb) | 1985 (Jan) | 1986 (Jan-Feb) |
|-------------------|-------------------|-------------------|-------------------|---------------|-------------------|
| Far North | | | | 3 | 1 |
| Northland | | 1 | | | |
| Waikato | 1 | | | | |
| Bay of Plenty | 2 | | | | |
| Volcanic Plateau | 2 | 6 | | | |
| East Coast | | 4-8 | | | |
| Taranaki/Wanganui | 1 | | | | 1 |
| Manawatu | | 4 | 1 | | |
| Wairarapa | | 1 | | | |
| Nelson | 8 | | | | |
| West Coast | 6 | | | | 1 |
| Marlborough | 11 | 12 | | | |
| Canterbury | 11 | 1 | 1 | 4 | 1 |
| Otago | | | 6 | | 1 |
| Southland | 11 | | | | 6 |
| Auckland Is | 3* | 3 | 3 | 3* | 0 |
| The Snares | | | | 1* | |
| Campbell I. | | | | 22 | |
| Likely Totals | 56 | 31-35 | 8 | 33 | 11 |

*Presence inferred from birds seen shortly before or afterwards

Contributors: The following names are available to me. Many others languish under *et al.* I am grateful for the care with which many of these reports were kept. B. Armstrong, P. Anderson, C. Batchelor, D. J. Bate, P. Battley, B. D. Bell, T. Blake, B. Brown, W. A. Campbell, W. F. Cash, M. W. Cawthorn, P. & M. Child, J. Cockrem, L. J. Davies, K. J. Fisher, G. A. Foreman, A. J. Goodwin, J. M. Hawkins, B. D. & R. H. Heather, V. Hensley, R. N. Holdaway, L. & A. V. Howell, W. M. Hutton, J. G. Innes, R. W. Jackson, W. R. Jackson, P. Jenkins, B. R. Keeley, P. C. M. Latham, S. Leitch, R. Maloney, J. Marshall, I. Mathieson, D. G. Medway, P. & K. Miller, C. M. Miskelly, J. L. & M. Moore, P. J. Moore, K. Morrison, M. Neilsen, C. F. J. O'Donnell, R. Ollington, M. Olsen, R. J. Pierce, G. Pulham, G. Quayle, H. A. Robertson, P. M. Sagar, P. Schweigman, B. H. Seddon, R. B. Sibson, R. W. H. Simpson, M. Sutton, R. R. Sutton, G. A. Taylor, T. J. Taylor, R. W. Wheeler, A. Wright.

January-March 1983

Nelson: Pakawau, Golden Bay, one on 17/1, one male one female on 19-24/1 (BDB, JMH, BDH, PMS, RBS *et al.*); none on 5-11/3 (JMH). Nelson sewage ponds, six (2 males, 2 females, 2 ?) on 21/2 (GQ). Lake Rotoiti, one on 17/2, reported to PMS by L. W. McCaskill.

Marlborough: Lake Grassmere, one female on 5/2, five birds on 13/4 (TJT). Lake Elterwater, eight birds on 29/1 (DJB, PJ). Ward, two in pea stubble on 26/1 (BDB, PJ, TJT).

Canterbury: Lake Ellesmere, one female on 11-12/12/82 (Fennell *et al.* 1983); one male one female on 3/1 (BA, CFJO'D). Cass River delta, one female from 7/1 to Feb (RJP). Washdyke Lagoon, Timaru, eight (1 male 7 females) on 30/1 (PMS).

West Coast: Cook River-Fox flats, six on 12/3 (*per* RWHS). Other reports not confirmed.

Southland: Waimatuku River mouth, two on 24/1 and 7/2. Jacobs River estuary, Riverton, one male one female on 21/1 and 24/1 (RRS). Lake George, seven on 2/2 (IM).

Bay of Plenty: Kaituna Cut-Maketu, one male one female from 15/1 to 27/1; none on 16 or 27/2 (PCML, GAT), but one female at nearby Little Waihi on 16/2 (none on 27/2) (GAT).

Volcanic Plateau: Sulphur Bay, Rotorua, one female on 13/2, one male one female 21/2 to 29/3 (JGI, GAT). Lake Rotoehu, one female on 1/3 (GAT).

Waikato: Lake Whakamaru, one male on 26-27/3 (JGI, BHS, GAT, *et al.*).

Taranaki: Barrett's Lagoon, New Plymouth, one female on 5/3 (DGM, RWW).

April-May 1983

South Island records fell off, and a widely scattered few appeared in the North Island. The first subantarctic island birds were seen.

Nelson: Takaka district, one subadult female shot 30/4; skin in National Museum, Wellington.

Marlborough: Blenheim sewage ponds, seven (2 males 5 females) on 2/4 (RNH, CMM).

Canterbury: St Anne's Lagoon, Cheviot, one female on 2/4 and 16/4 (SL, PMS).

Northland: Dargaville, one female near Lake Kahuparere, Pouto, on 1/5; presumably the same bird shot on 2/5 at Lake Rototuna, c.15 km north of first sighting (WAC). None in February survey of Pouto lakes.

Volcanic Plateau: Lake Aniwhenua, one pair on 11/4 (WMH). Sulphur Bay, Lake Rotorua, four (1 male 3 females) from mid to late April, last seen 23/4 (GAT).

Taranaki: Mimi River, two reported on 12/5 (JM).

Wairoa: Whakaki Lagoon, none in Jan (A. Blackburn), four males on 24/4 (GAF); eight or nine birds on 25/4 (BRK).

Manawatu: Manawatu River estuary, one female on 30/4 (JLM, MM). Lake Papaingtona, Levin, one male one female on 17/4 (BDH, RHH).

Wairarapa: Lake Wairarapa, eastern shore, one female on 1/4 (PJM).

Auckland Islands: Derry Castle Reef, Enderby I, one pair and a single female in April (none seen in previous years); still there in Dec 1984; none in 1986 (MWC).

Rest of 1983

Very few records. Birds may have accompanied pairs of Paradise Shelduck in their dispersal to farmland breeding territories; more than the three known may have been shot; others may have returned to Australia.

Volcanic Plateau: Lake Rotomahana, one female in reserve area on 19/6 (JGI, RWJ, GP, GAT).

Taranaki: Barrett's Lagoon, one female on 11/6 (TB, RO).

Marlborough: Lake Grassmere, one female on 10/7 (WFC).

West Coast: Whataroa River Flats, eight (one shot accidentally) on 6/7; unconfirmed reports of two at Totara Lagoon and about six at Kowhitirangi/Kokatahi in May-June (RWHS).

1984

Records were few and, at the time, seemed to indicate that most shelducks had gone or died.

Manawatu: Lake Horowhenua, one female on 6/2 (WRJ, MO). Lake Wairongomai, one female on 31/3 (JC, HAR). No others in full survey of lakes on 31/3 and 1/4 (LJD).

Marlborough: Lake Grassmere, one female on 1/7 (WFC, PJ).

Canterbury: Washdyke Lagoon, Timaru, one female on 13/1 (P. Langlands, P. & M. Child, *et al.*).

Otago: Maniatoto, six males on 24/1 (M. Wright, Acclimatisation Society staff).

Auckland Islands: Same three still present in Dec (MWC).

The Snares: One female 27/11 to 22/12 (CMM). See Figure 1. This may have coincided with the influx to Campbell I (see below).

1985

As Table 1 shows, either the apparent drop-off of numbers in 1984 was not real or a fresh influx of shelducks occurred. Notable were the number (for New Zealand) at Campbell Island and the record of breeding in inland Canterbury. The 22 on Campbell Island in January were definitely new there. GAT was there from April 1984 to April 1985 and saw none until Jan 1985. The first report by meteorological staff was in late Dec 1984.

Northland: Lake Half, Aupouri Peninsula, one female on 27/1 (PM, KM). Karikari Peninsula, one female on 14/1 and 28/1; Tokerau Beach swamp, one male on 13-28/1 (PA, LH, AVH, *et al.*).

South Auckland: Karaka, one female on 2/5 (KJF).

Marlborough: Lake Grassmere, two on 16/11 (PJ); one female on 28/12 (BDH, PCML).

Canterbury: Glenmore tarns, near Lake Tekapo, 16/1, a pair with two young two-thirds grown; the female was with the young, the male keeping apart, sometimes on the margin of a flock of c.50 Paradise Shelduck (RJP). Lake Wainono, one female on 14/2 (RM, RJP). Washdyke Lagoon, one female on 30/12 (RM). Temple Stream, one male on 11/10 (RJP).

Otago: Patearoa, Maniatoto Plain, one female on 9/7 (M. Wright); none found on full survey of the Plain over rest of year (PS). Pleasant River, near Palmerston, two males one female on 29/4 (MN). Waikouaiti, one male one female on 26/4; same behind Cherry Farm, Karitane, on 25/5 (PS). Diamond Lake, Lake Wakatipu, four seen on 4/5; one shot, skin in National Museum. *Southland*: Te Anau, one on a farm pond, mid-Oct (AW). Waiau River mouth, one Aug-Oct (MS). Waituna Lagoon, 14 on 14/12 (M. Rodway, A. Russell, Acclimatisation Society staff).

Auckland Islands: Three still present, Dec (MWC).

Campbell Island: Camp Cove, 4/1, meteorological staff reported 18 in morning, 22 by evening; several had been seen a week before; 11/1, flock

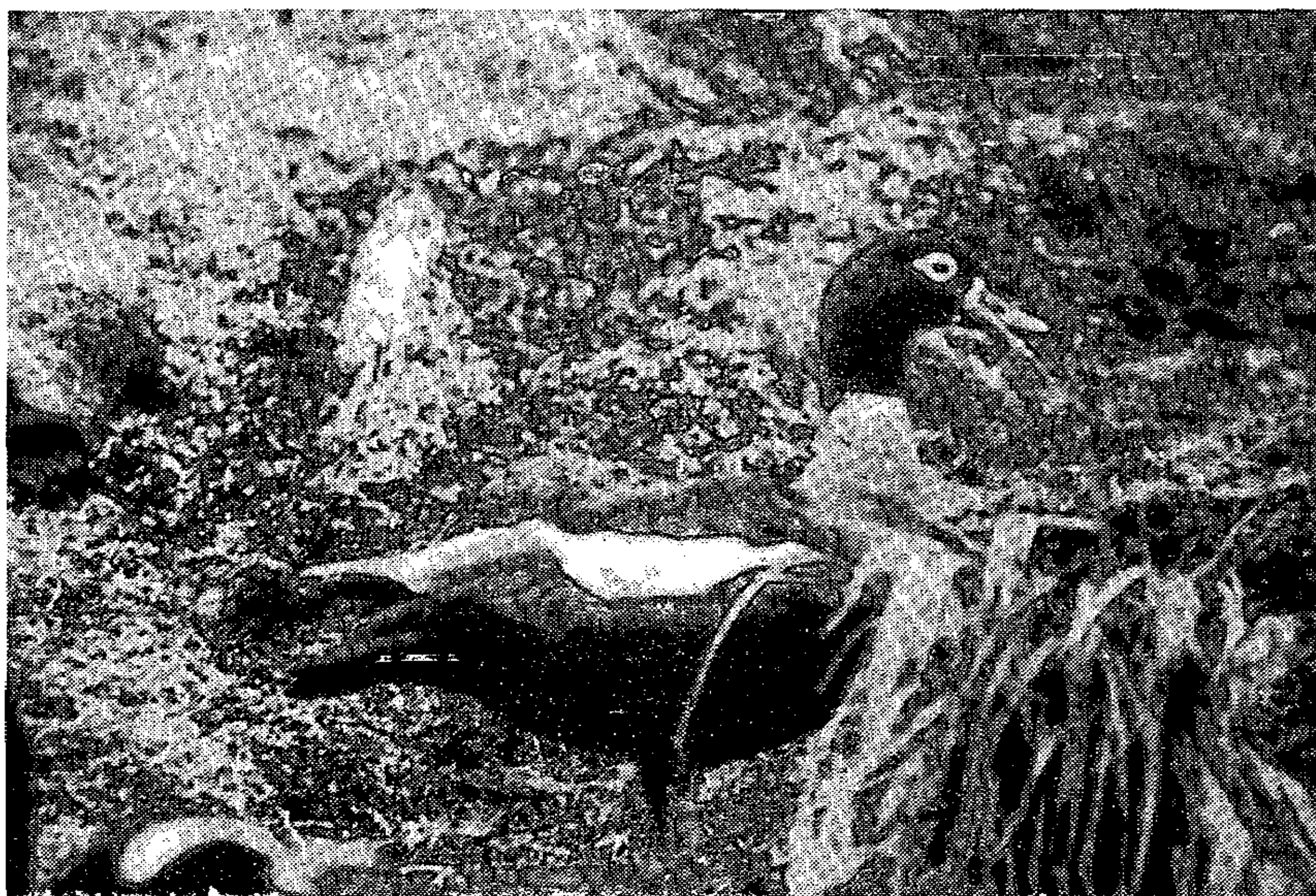


FIGURE 1 — The female Chestnut-breasted Shelduck in Station Cove, The Snares, 7 December 1984

Photo: C. M. Miskelly

of 12 (2 males 10 females); 18/1-20/1, 13 reported; last seen five on 28/1 and 15/2, two on 16/2; none in March-April (GAT).

1986

In the summer and autumn of 1985-86, few were seen, the only small concentration being in the Te Anau district. In the Te Anau Basin and lower Eglinton Valley, moreover, Paradise Shelducks have increased to c.8000 (CB, KM), and so Chestnut-breasted are easily missed.

Northland: Lake Half, one male on 26/1 (BB, AJG, VH). None seen on Karikari Peninsula in Jan (LH).

Taranaki: Lake Waikato, Nukumarū, south Taranaki, one female on 6/2 (PB).

Canterbury: Lake Wainono, one male one female on 26/1; none on Glenmore tarns (RJP).

West Coast: Lake Hochstetter, Ahaura district, one female on 29/1 (A. Tweed, Acclimatisation Society staff).

Otago: Toko River mouth, one on 2/5 (PS). Lake Kirkpatrick, near Moke Lake, Queenstown, late Jan, a female reported by G. A. Tunncliffe, associating with a female Paradise Shelduck with three half-grown young. Confirmed on 26/1 by Margaret and the late Peter Child, who described the bird as presumably subadult female, the white eye-ring being unusually broad and the chestnut band barely noticeable, being suffused heavily with blackish feathers.

Southland: Te Anau district. Lake Thomas (a Paradise Shelduck moult site), four males on 19/1; six birds on 20/1; four males one female on 24/1, two on 1/2; one male on 22/3; Dawson dam, one male on 1/2; none seen anywhere on 6/4 (KM, AW, R. Barker, J. V. Morrison, C. Wright). Te Anau Downs, two on 6/5; Te Anau rodeo grounds, one on 6/5 (AW). Two near Upukerora River estuary one day in April (CB). None seen since or elsewhere in Southland.

OTHER FEATURES

Field characters: Seen from front or side on, the Chestnut-breasted Shelduck is easy to pick from Paradise by the chestnut breast (paler, cinnamon in males), by the narrow white ring round the base of the neck, and in females by the white ring round the eye and at the base of the bill. Adults in eclipse plumage after the post-nuptial moult, and immatures, may not be so easy, the chest being paler, browner and duller and the white neck-ring often indistinct. Immatures may have white flecking on the head (Frith 1977, Simpson & Day 1984).

A useful feature pointed out by G. A. Taylor is, when shelducks are on water upending to feed, to look for the undertail – glossy black in Chestnut-breasted and bright chestnut or rusty red in Paradise. Compare the top plate on p.92 of Moon (1979) and the top right plate on p.38 of Moon & Lockley (1982) with the paintings on p.59 of Simpson & Day (1984).

R. J. Pierce has noted that, when swimming, the Chestnut-breasted has a flat-backed profile, whereas the Paradise has a more humped-back profile. He noted the same profile in the two chicks at the Cass delta.

Their voice may help at times. The flight calls of Chestnut-breasted are not unlike those of male and female Paradise, but noticeably different to the experienced observer. However, the Chestnut-breasteds in New Zealand have usually been silent.

Moult: The only direct evidence was an apparently flightless male seen by G. A. Taylor at Rotorua on 21 February 1983. When chased by a Black Shag (*Phalacrocorax carbo*), it flapped awkwardly across the water, showing no primaries.

Habitat: Most records (December-May) were of birds with flocks of Paradise Shelducks at lakes, lagoons, ponds, and estuaries, and on pastures adjacent to these places. They fed by upending in shallow water, wading in shallow margins, and grazing on pasture. Among hundreds, sometimes thousands, of Paradise feeding on pasture or swimming about on a lake or pond, they could be hard to count and identify to sex. Often, however, they tended to keep apart, attached to, not mingling with, the Paradise. Aggression between the species was not reported.

At The Snares, the bird of 1984 was seen just beyond the forest margin, above the splash zone, in Station Cove and Hotto Bay. It was feeding on the *Callitriche antarctica* sward (CMM). At Campbell Island, the birds of 1985 were in sheltered coves at the head of Perseverance Harbour. Shoreline habitats available were tidal mudflats, seaweed beds, and low-cropped pasture grasses with scrub behind these margins. The birds were seen on the mudflats and the grass margins (GAT). The Auckland Island (Enderby) birds were seen on the grass sward and other habitats but probably spent much of their time elsewhere on Enderby Island (MWC).

Breeding: The only report of breeding was the pair with half-grown young at the Cass River delta on 16 January 1985. The outcome of this breeding attempt is not known.

I have discounted the several reports of "hybrid" Chestnut-breasted x Paradise Shelduck offspring as being improbable because immature or adult eclipse plumage in Chestnut-breasted Shelducks may have a "hybrid" appearance. In addition, Paradise Shelducks have permanent pair-bonds and no shortage of partners and so hybridising is unlikely.

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SHORT NOTES

Painted Snipe (*Rostratula benghalensis*) at Lake Ellesmere

On 6 August 1986, we observed an unusual wader at Wolfe's Road, Lake Ellesmere. This bird caught our attention when it flew in and landed in a large patch of dried rushes in marshy ground near the end of the road. Members of a Workers' Educational Association course joined us and we watched the bird for several minutes from about 10 metres away. At first, we thought the bird might be a Marsh Crake (*Porzana pusilla*) for it was behaving in a secretive crake-like manner, crouching and freezing in the vegetation, then moving forward very slowly, seeming aware of our presence. It was very hard to locate, even with 12x50 field glasses, and not until it stood with head raised did we realise it was much larger than a Marsh Crake. We noticed brilliant white underparts, green legs and outstanding markings on the head and back.

Size and appearance: Larger than a Sharp-tailed Sandpiper (*Calidris acuminata*) but smaller than a Knot (*C. canutus*); more streamlined than the plump, rounded shape of a Knot. Movements jerky as it crept through the reeds with its rear parts bobbing and its head kept low.

Plumage: Its head markings were outstanding. Round each eye, a pale ring, extending back towards the nape. The crown was intersected by a buff stripe, which extended from the base of the bill to the nape. The upperparts were marbled mid-grey with a bronze tinge and an almost metallic sheen. A broad, creamy stripe extended down each side of the back and framed the upper wings to form a V over the rump. The wings were speckled black and white. Breast streaked grey, lighter in front and forming a pectoral band. Rest of underparts brilliant white.

Bare parts: Bill yellowish horn, substantial and longer than the head. The decurved tip was darker and appeared slightly bulbous. Legs green and of medium length. Feet not seen.

More people arrived on the scene and the excitement of the discovery intensified. Much talk ensued and this disturbed the bird, which flew suddenly, keeping fairly low. It disappeared into distant reed beds on the property of Mr C. Hills. We could not see the bird's rump as it flew but we noticed that it trailed its legs, somewhat in the manner of a rail, which made the flight rather ungainly.

When at home we consulted Pizzey's *Field Guide to the Birds of Australia* (1980) and were in no doubt that the bird was a Painted Snipe (*Rostratula benghalensis*). Because the bird had no rufous on the head and breast, which distinguishes male from female, we believe that the bird was male.

The Painted Snipe family (*Rostratulidae*) has only two members worldwide. *Rostratula benghalensis* ranges through Africa, India, China, south-eastern Asia and the Pacific. Two subspecies are recognised, with *R. b. australis* breeding in Australia. In the Tasmanian region the only record is of a specimen from Sandford in July 1910. In western Australia the species has not been recorded since a sighting near Derby in the 1950s. Breeding reports are confined to the Murray-Darling, South-East and the South

Australia Range regions except for one in the 1950s of the bird arriving to breed at Ayr in March-April each year. Occasional records from remote places show that the Painted Snipe can move far. This and its apparently erratic appearances, common in some years, scarce or absent in others, led earlier writers to consider it nomadic, e.g. birds at Laverton, May-September 1951, were the first recorded there since 1897. In southern Australia the Painted Snipe was reported to be present only during floods at long intervals, but the *Atlas of Australian Birds* (Blakers *et al.* 1984) and other observations suggest that movements are mainly north in winter and south in summer. Reports imply that the species may even migrate out of Australia, though there is little evidence of overseas populations migrating or of a possible wintering ground for Australian birds. The largest flock reported is of 25 birds near a nesting colony on the Murray River.

Although we have searched for the Painted Snipe on many occasions since 6 August, we have been unsuccessful. Conditions at Lake Ellesmere changed during the rest of August, owing to prolonged and heavy rain, and the area of dry rushes in which we saw the bird was inundated for many weeks. Lake Ellesmere has a vast expanse of suitable marshy terrain and so the chances of finding the bird again were remote.

An interesting report was received on 12 August. A shooter operating in the Wolfe's Road area flushed what he described as a strange bird with a white mark around its body and reddish colour on the plumage from reed beds near where we had seen the Painted Snipe. It disappeared without his being able to gain more information.

On being shown Pizzey's Field Guide, he seemed fairly certain that the Painted Snipe resembled the bird he had flushed. The reference to a reddish colour on the plumage may indicate that a female as well as a male Painted Snipe have been observed. Various sources state that male-female pairs often fly around together.

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Light-mantled Sooty Albatross at Lake Manapouri

At 1100 hours on 2 June 1986, R. T. Johnston, a Fiordland Travel bus driver, saw a Light-mantled Sooty Albatross (*Phoebastria palpebrata*) on the ground near the vehicle garages at West Arm Power Station, Lake Manapouri. The bird was examined at Te Anau Wildlife Centre and found to be in good health.

On 3 June, after 30 hours' captivity in a tourist bus and car, the albatross was released on Oreti Beach, Invercargill. We yelled encouragement as the bird did a minute's vigorous wing flapping before rising to 8 m in the fresh on-shore breeze. After a brief mobbing by some Black-billed Gulls (*Larus bulleri*) the albatross glided along the dunes towards Bluff Hill.

Light-mantled Sooty Albatrosses are occasionally seen on the Fiordland coast in winter (KM, pers. obs.) and during 28 May-6 June 1986 a few were seen there (L. A. Shaw and P. A. Brotherston, pers. comm.).

A very strong south-west airstream, with winds averaging 35-45 knots, had spread from south of the Tasman Sea on to southern New Zealand during 31 May-1 June 1986 (R. Holloway, Meteorological Service, pers. comm.). The West Arm albatross was c.44 km from Fiordland's open coast. However on 12 June 1980 single Light-mantled Sooty Albatrosses were found blown inland at Lumsden and Wendon in Southland, both c.74 km from the nearest open sea (*Notornis* 28: 60).

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King Shags – a correction

Nelson (*Notornis* 18 (1971): 30), purportedly quoting Hutton (*Trans. NZ Inst.* 11 (1878): 332-7), stated that “in 1773, J. R. Forster, naturalist on Cook's second voyage, collected the first King Shags from White Rocks outside Queen Charlotte Sound; he estimated the total population at about 160 birds”. I do not know where Nelson got this erroneous information from for Hutton in the paper referred to said no such things. He said only that “during his voyage with Captain Cook, in 1773, J. R. Forster described a shag, which he said was found in New Zealand and Terra del Fuego, under the name of *Pelecanus carunculatus* . . .” We also now know that Forster did not collect the first specimens from White Rock (which, incidentally, was not known to support a breeding colony until one was discovered there by Henry H. Travers in 1875) and did not anywhere give the stated total population estimate. He is known to have collected only two specimens: the first on 20 May 1773 between Ship Cove and Hippa Island (or on Hippa Island itself) and the second on 6 November 1774 between Ship Cove and Long Island. The first specimen, an adult, was the basis of Forster's description and his son's drawing (Hoare, M. E. (ed.) *The Resolution Journal of Johann Reinhold Forster 1772-1775*, The Hakluyt Society (1982); 283, 681). The only information we have on population size at the time of Forster's visits to Queen Charlotte Sound appeared in a manuscript catalogue in the British Museum (Natural History), compiled under the direction of Forster, where it is said of this species “NZ Charlotte Sound . . . very few in N. Zeland”. This entry clearly formed the basis of Latham's statement that his Carunculated Shag “inhabits New Zealand; found in Queen Charlotte's Sound, though not in plenty” (*A General Synopsis of Birds* 3 (1785): 603).

D. G. MEDWAY

**More Laishleyana:
Red Wattlebird and White-faced Heron**

Most of the 50 or so native birds, including some albatrosses and petrels, which Richard Laishley painted during the first eight years after he settled at Onehunga in 1860 were the common species such as a well-schooled naturalist could expect to find locally or on excursions which he made to Nelson and the Bay of Islands. The omission of two species, Piopio and Pied Stilt, is noteworthy and may support Buller's judgement that by the middle of the century *Turnagra tanagra* was already very rare north of the Waikato and that *Himantopus leucocephalus* had not yet reached the vicinity of Auckland.

Notes on two unexpected rarities, Red-necked Stint (*Calidris ruficollis*) and Blue Petrel (*Halobaena caerulea*), have already been published in *Notornis* 26: 120 and 30: 166-167. Their faithful recording by an expert naturalist of the mid-19th century came as something of a surprise. But still more shocks await the researcher among Laishley's diaries and sketchbooks. Some of these I now propose to discuss.

The fourth bird plate in the folder (Figure 1) depicts two birds of somewhat similar size and proportions, Long-tailed Cuckoo (*Eudynamis taitensis*) and Red Wattlebird (*Anthochaera carunculata*). There can be little doubt that Laishley handled the distinctive Australian honeyeater which is said to have turned up at Matakana, north of Auckland, just in time to gain mention under the name of *Mimus carunculatus* in 1865 in Buller's prize-winning Essay on the Ornithology of New Zealand. Buller assigned the bird to the Turdidae, and Laishley called it a Northern Thrush. It was a stranger to him and he may have thought he was painting a Piopio. Some years later in his Gleanings, Laishley wrote: "This is a species which we have never seen alive nor have we met with those who have observed it in its natural haunts. The description which follows is given from a well preserved specimen in the Auckland Museum, where it is marked 'Thrush Matakana' ". The specimen is no longer to be found in the collection at the Auckland Museum.

Several questions naturally arise. How did this common southern Australian honeyeater, which is not a markedly migratory species, reach Matakana? Had it flown the Tasman under its own power or had it come aboard a ship along the Australian coast, had an assisted passage and then been fraudulently passed off as a genuine straggler to New Zealand? In the 19th century the little anchorages of the east coast north of Auckland were much used by sailing ships.

The long synonymy given by Buller (1888, 2nd edition p.106) bears witness to the problem presented to the early taxonomists by this large long-tailed honeyeater. For many years after Latham had called it Wattled Bee-eater, it had been placed in *Merops*. Then, according to the whims of subsequent systematists, it flitted in and out of various genera, *Corvus*, *Creadion*, *Mimus*, of which the last is now the generic name of the American mockingbirds. Eventually, with other big Australian honeyeaters, it became

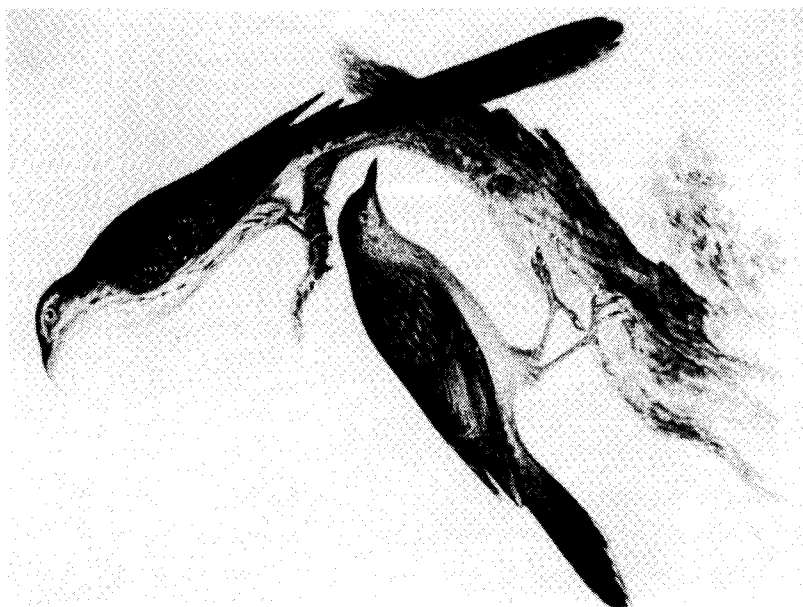
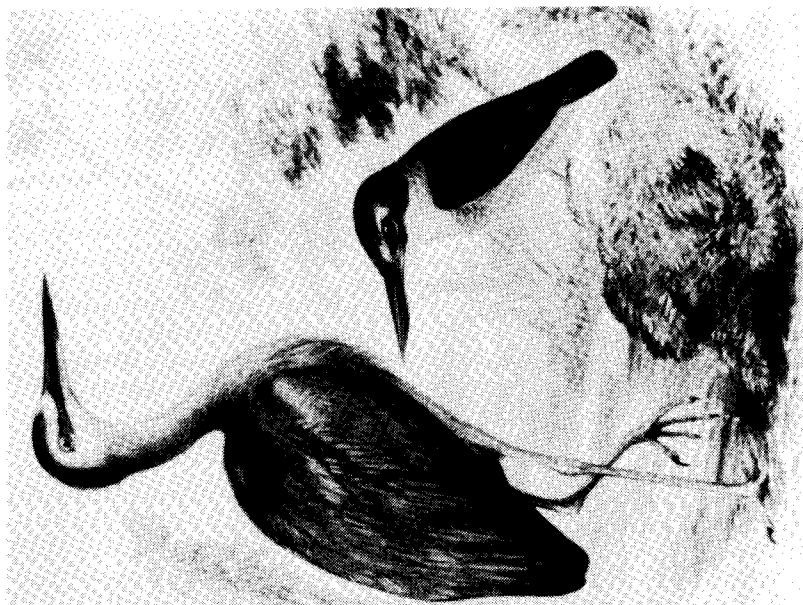


FIGURE 1

stabilised as *Anthochaera*; and there it abides. The meaning seems to be something like 'Joyful greeter of flowers'.

When we examine Laishley's painting closely, we notice not only the shape and the feathering, but also how carefully he reproduced the small red wattles and the pale yellow wash on the belly. The identity of Laishley's so-called Northern Thrush is beyond question. We would like to know the truth behind its arrival in New Zealand.

A painting dated August 1865 depicts a Kingfisher (*Halcyon sancta*) and a heron which is clearly not a Reef Heron (*Egretta sacra*) but a White-faced Heron (*Ardea novaehollandiae*), which rather revealingly Laishley calls *Ardea leucops*, using the name given by Wagler in his *Systema Avium* of 1827. As was his wont, Laishley was quick off the mark. He was also aware that the White-faced Heron was at that time a very rare bird in New Zealand; and he adds a note "Shot in Manukau. Regarded by the person who forwarded it to me and who had been long a resident, as uncommon." This seems to be by far the earliest record of this species as far north in New Zealand as Auckland; and indeed, there are few, if any, earlier recorded occurrences elsewhere in the whole country. Buller does not mention White-faced Heron in his 1865 Essay.

Formerly the typical heron of the rocky bays and basaltic reefs of the cone-ringed Mangere Inlet was *sacra*. Then in the late 1940s a few White-faced Heron began to appear. Their subsequent increase was dramatic. In 1960, when winter and summer censuses of shore birds covered most of Manukau Harbour, the counts of White-faced Heron were respectively 42 and 40. Ten years later in 1970, the respective figures were 362 and 418. Meanwhile Reef Herons had virtually disappeared from the upper reaches of the harbour, although a few persisted on the Awhitu Peninsula and towards the seaward end.

Laishley's painting of a White-faced Heron must predate by several years that of J. G. Keulemans which appeared in Buller's first edition of 1873.

I thank the British Museum (Natural History) and the Alexander Turnbull Library for letting me have 35 mm colour slides of the bird paintings which I have here discussed.

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An Arctic Skua taking passerines at sea

On 27 April 1986, about 3 km to sea east of Wollongong, Australia (34°25'S, 150°57'E), I watched an adult dark phase Arctic Skua (*Stercorarius parasiticus*) pursue a Silvereye (*Zosterops lateralis*). The two birds passed about 10 m above the boat, heading west. After about 5 min I saw the same skua chasing another passerine, about 1-2 m above the water. The skua forced the passerine, possibly a *Petroica* sp. (M. Carter, pers. comm.) into the water, and itself landed, but I could not see whether it ate the bird.

During the day I saw two more groups of small passerines, one being a group of pardalotes (*Pardalotus* sp.) over 5 km out to sea. These birds may have been driven out by the high westerly winds of the previous day. Land birds swept to sea are undoubtedly left vulnerable, while fatigued, to opportunistic predators such as the Arctic Skua.

The behaviour of Arctic Skuas in pursuing other seabirds, forcing them to drop food, is well known. Predation, although less studied, can also be an important way for Arctic Skuas to feed. Martin & Barry (1978) found that, of 173 food pellets examined, 81.4% contained remains of passerines. Thus, birds may be important in the Arctic Skua diet, especially during the breeding season, when Martin & Barry did their study. My observation, to the best of my knowledge, is the first of such behaviour by Arctic Skuas while they are in Australian seas and perhaps elsewhere in the non-breeding period.

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- M. J. LEWIS, *Department of Zoology, Australian National University, P.O. Box 4, 2600 Canberra, ACT*



Unexpected reaction of Bar-tailed Godwits to a rain squall

On 6 February 1986, L. Paterson, J. Engebretsen, S. M. Widgery and I were at Access Bay, on the Miranda coast of the Firth of Thames. The weather was overcast with a light northerly wind. A fairly heavy rain squall came through at about 11.15 a.m., but otherwise the day was dry. The temperature was about 24 °C.

With a 3.1 metre high tide due at 5.57 p.m., a large number of birds had gathered by 5.20. On the shellbank were 2 Pied Shags, 3 Black-backed Gulls, 20+ Red-billed Gulls, 20+ White-fronted Terns and perhaps 1500 South Island Pied Oystercatchers. On the mudflat nearby were a flock of 500+ Wrybills and a group of dotterels with a few Knot. Much nearer on the mudflat was a close-packed group of 1000+ Bar-tailed Godwit (*Limosa lapponica*).

At about 5.30, a very narrow-fronted band of rain was seen moving in from the north-northwest. When this squall suddenly reached the mudflat, 90% of the godwits turned their bills skywards, standing rather like alarmed bitterns. This presumably reduced their exposure to the heavy rain. During the 10 minutes or so that the downpour lasted the godwits held their bittern-like pose, but the Wrybills ran about their roosting area in an apparently aimless agitated way. The dotterels, knots and the birds on the shellbank just sat it out.

The rain stopped as suddenly as it had started, and the godwits simply shook themselves and began feeding. Although the tide had not yet been over the feeding area, the rain had so thoroughly wetted the mudflat that the birds did not bother to await the arrival and passage of the tidal peak.

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REVIEWS

Shorebirds: an identification guide to the waders of the world by Peter Hayman, John Marchant and Tony Prater. 1986. Croom Helm Ltd., London and Sydney. 412 pages, 88 colour plates and distribution maps. UK price £19.95. Distributed in New Zealand by Benton Ross Publishers Ltd., P.O. Box 33-055, Takapuna, Auckland.

Ever since inquisitive and artistic man began to watch animals, the seasonal comings and goings of migratory birds warned or enheartened, perplexed and fascinated all who eyed them intelligently. Of the more than 200 species which are classed as waders, only a few are more or less sedentary; and at one time or another most travel and visit the seacoast or the shores of lakes and rivers. Many breed in such remote places and undertake such long journeys that even now towards the end of the 20th century few of their nests have been found and there are still many gaps in Man's accumulated knowledge of their way of life. An added complication is that the plumages of many strongly migratory species undergo spectacular colour changes both seasonally and between youth and a maturity which may come one, two or three years later.

Here we have a masterly publication which deserves to become the bible of dedicated wader-watchers across the globe; a classic in the best modern style which does for shorebirds what W. B. Alexander did for the birds of the oceans 60 years ago. Text, format, maps, cross references and indexing are all of the highest standard.

The plates at once catch the eye; an immediate excuse for hours of enchanted browsing, recalling experiences in many lands and likely to arouse an itch to travel in search of the unknown or simply to see once again and perhaps look a little more critically. Whether they be lapwings or dotterels, shanks or stints, phalaropes or pratincoles, all have been meticulously painted or sketched with consummate skill by a very gifted artist, who has studied most of his subjects in their different plumages and in their native habitats; and who with an eye for significant detail has caught the individual jizz and the subtle tones of both adults and young. An almost black-chested Pectoral (Plate 82) seems to solve the enigma of a sandpiper which puzzled Ross McKenzie and others at Miranda in November 1949. When I saw my first American Long-billed Curlew in California in March 1983, its 'yellowness' as compared with our Far-Eastern Curlews at once called for comment; a feature which is clearly illustrated in plate 83. Especially helpful too are the fine drawings which show patterns of tails and wings.

The authors are fully aware of the difficulties of identifying correctly in the field, sometimes even in the hand, the smaller closely related species. No problem is shirked and the analysis of the stints or peeps is impressively thorough.

The data on *Pluvialis* (pages 278-280; & 392 & plates 31 & 32) should stimulate our plover-lovers and rarity-seekers to examine closely any golden plovers which they may find, especially solitary birds or small parties which are obviously tired or off course. Among the 600-1000 *fulva*, rightly given

full specific status, that summer in New Zealand, are there no lost *dominica*? Is it not true that American Golden Plovers, greyer and slightly larger, have already be suspected at Farewell Spit?

Australasian ornithologists have reason to be grateful for the generous treatment which their many endemic plovers and far-travelling arctic migrants have received. One query. What is the basis for the often repeated statement that our Shore Plover was once widespread in the North Island? Is there any real evidence, archeological or corporeal? If *Thinornis* did visit the North Island in numbers, it is likely to have been before the arrival of Polynesian Man, together with kuri (dog) and kiore (rat). By the time of Captain Cook's Second Voyage, it seems to have been surviving only along a few remote South Island inlets and, of course, in the Chatham Islands.

The authors have combined to produce a specialist book which will be thumbed and treasured by all who have experienced the lure and thrill of studying shorebirds. It is just the book to have handy not only for understanding the 'common or garden' waders, but also when some exotic stranger, such as Wilson's Phalarope, Asiatic Dowitcher or Painted Snipe, miraculously appears in one's field of view.

R. B. Sibson

Penguins of the World: A Bibliography by A. J. Williams, J. Cooper, I. P. Newton, C. M. Phillips, B. P. Watkins. British Antarctic Survey, 1985. 255 pp. ISBN 0-85665-112-5. £11.50.

This bibliography lists 1942 numbered citations arranged alphabetically by senior author. There are two indexes, one to species, the other to 17 broad subject categories such as Ecology, Behaviour etc. Both fossil and living species are covered but the Royal/Macaroni and Little/White-flippered Penguins are regarded as conspecifics and hence separated in the species index.

Recent research up to and including 1984 is strongly represented but early papers containing type descriptions are deliberately omitted on the grounds that these are readily available in the 2nd (1979) Edition of Vol. 1 of Peter's 'Checklist of Birds of the World'. Also missing are many of the early notes on Penguins. For example, there are three entries for W. L. Buller but many more are listed in Mrs Oliver's *Annotated Index to Some Early Bird Literature* (1968). Similarly there is but one entry for F. W. Hutton and none of Otto Finsch's notes from the Trans. NZ Inst. is listed. On the other hand a number of popular articles, some of marginal scientific value, are included. On the credit side, the authors have listed some general works and publications with useful but mainly incidental references to penguins: such citations are often missed by 'Zoological Record' and 'Biological Abstracts'. The result is an excellent compilation that will be particularly helpful for those wishing to get into the Russian, Japanese and German literature. It is planned to update the work with supplementary lists from time to time.

John Warham

A Field Guide to Australian Bird Song: cassette two. Bird Observers Club 1985.

This eagerly awaited second cassette in the series covers species from Rufous Night Heron to the Chestnut Rail and further extends the range of commercial recordings available on Australian birds.

It covers 69 species, including waterbirds, hawks, megapodes, quail and ends with four rails. The localities in which these recordings were made range from Nepal, Lord Howe Island, New Zealand and many widely separated localities throughout Australia with a solitary example from Great Britain. The oldest recording was made in 1958 and the most recent in February 1985.

The recordings are generally of a high standard, given the original field conditions and the great variety of recording equipment used. How Rex Buckingham and Len Jackson are able to 'clean up' recordings like the Mute Swan which has a water pump in the background defies a written description. Congratulations on a job very well done. The spoken identifications are by Len Grice. The folio that comes with this tape tells us the Latin names, the vernacular names of the species, *what the bird(s) are doing and the* running time of each recording, as well as who made the field tape and where it was made. Such data are rarely supplied with recordings these days, and so it is good to see a publication that supplies notes in a model form. At least 25 of the species on this second tape are on the New Zealand list, some like the Little Bittern being rare.

Many of the species on this tape are first releases and should create considerable interest among ornithologists for this reason alone.

Available from The Bird Observers Club, Box 185, P.O. Nunawading, Victoria 3131, Australia. Price \$A10.00. For a review of cassette one, see *Notornis* 31: 335 (1984).

L. B. McPherson

LETTER

An attempt to restore sex to the Cape Pigeon

For some time, by a quirky ruling of the International Commission for Scientific Nomenclature, this splendid petrel has borne a scientific name the gender of which is neuter.

Pintado, of which *Daption* is an anagram, is naturally pronounced with its final o long. Accordingly, if the anagram is correctly formed, it is daptiōn, not daptiōn. Thus it is allied, not with a big clutch of ancient Greek neuter nouns signifying diminutives, but with a substantial group of masculine and feminine names and nouns which end with long -ōn or -ion, e.g. *chelidon* (swallow), *aëdon* (nightingale or warbler), *halcyon* (kingfisher), *prion* (saw or sawyer). The word *prion* is especially interesting and relevant. As a bird name it goes back at least to 1800; yet another proof of the sound classical learning of most 18th century naturalists. Its gender was masculine. Buller's Broad-billed Prion was *vittatus*; and when later a subspecies of the Antarctic Prion was named *desolatus alter* it was doubly masculine. But the law of

priority forced *Prion* to give way to *Pachyptila*, and so currently the gender of the genus is feminine.

Even *Creadion*, a pure Greek neuter diminutive noun denoting 'a little piece of red flesh', doubtless in reference to the bird's wattles, was treated as masculine and so the Saddleback was *Creadion carunculatus* from at least Buller to Moncrieff; and the North Island form was *rufusater*, not *rufumatrum*. Now *Creadion* has been supplanted by the infelicitous *Philesturnus*. This presumably is intended to mean 'starling-like', whereas, if etymology carries any weight, it can only mean 'liking or loving starlings'. The rejected name *Creadion psaroides*, given in 1823 by two French naturalists, is perhaps the most precise and meaningful of all the scientific names our saddlebacks have had. *Psaroides* means just what *Philesturnus* is supposed to mean. This compound specific epithet is derived from a Greek word *psar*, which is so old that it is used by Homer. In the synonymies of Buller's first (1873) and second (1888) editions, it is misspelt *pharoides*.

Let us now examine some other anagrams used in ornithological nomenclature. Since 1854 the House Martin of the Old World has been *Delichon urbica*, *Delichon* being an anagram of *Chelidon* and treated as feminine.

Alcedo is a Latin adaptation of a Greek noun, *alcyon* (no h) which may or may not mean a kingfisher. Both Vergil and Pliny preferred to retain Greek form. Pliny's description of *alcyon* leaves no doubt that he has the European Kingfisher (*Alcedo atthis*) in mind; but Vergil's *alcyones* which make the seashore resound with their cries seem curiously out of character.

Alcedo has spawned two anagrams, *Dacelo* and *Lacedo* for distinctive genera of kingfishers, which occur in Australia, New Guinea and South-east Asia. Neither is neuter. The Australian Kookaburra was named *gigas* by Gould in 1844; and *Lacedo* may be both *pulchella* and *amabilis*, a charming lovable lady.

With regard to *Daption*, a little judicious lumping will cut the Gordian Knot. Is it in truth justifiable to allow three distinct genera for the three robust fulmarine petrels of the deep south, *Fulmarus glacialisoides*, *Thalassoica (Priocella) antarctica*, and *Daption*? If the many prions, whose bills show such diversity in size and shape, are placed in a single genus, *Pachyptila*, would it not make sound biological sense simply to call the Cape Pigeon *Fulmarus capensis*? Is this asking too much?

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