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Order PROCELLARIIFORMES

A rather distinct group of some 80–100 species of pelagic seabirds, ranging in size from huge to tiny and in habits from aerial (feeding in flight) to aquatic (pursuit-diving for food), but otherwise with similar biology. About three-quarters of the species occur or have been recorded in our region. They are found throughout the oceans and most come ashore voluntarily only to breed. They are distinguished by their hooked bills, covered in horny plates with raised tubular nostrils (hence the name Tubinares). Their olfactory systems are unusually well developed (Bang 1966) and they have a distinctly musky odour, which suggest that they may locate one another and their breeding places by smell; they are attracted to biogenic oils at sea, also no doubt by smell. Probably they are most closely related to penguins and more remotely to other shorebirds and waterbirds such as Charadriiformes and Pelecaniiformes. Their diversity and abundance in the s. hemisphere suggest that the group originated there, though some important groups occurred in the northern hemisphere by middle Tertiary (Brodkorb 1963; Olson 1975).

Structurally, the wings may be long in aerial species and shorter in divers of the genera *Puffinus* and *Pelecanoides*, with 11 primaries, the outermost minute, and 10–40 secondaries in the Oceanitinae and great albatrosses respectively. The tail varies in length, being forked in *Oceanodroma*, forked to pointed in other forms, usually with 12 rectrices but up to 16 in fulmars. The tarsi are light and cylindrical in aerial forms; strong and laterally compressed with legs set far back in aquatic ones. The front toes are webbed; hind toe small or absent. The proventriculus is long and glandular; the gizzard small and twisted; and the small intestine often spiral in *Pterodroma*, presumably to aid absorption of the unusual lipids in their food. Chicks are helpless and covered in down, with two coats except in some Oceanitinae. Some larger species have a darker immature plumage, and the female is often darker than the male in the great albatrosses. The male is usually larger than the female, though smaller in the Oceanitinae and some other small species. Otherwise there is little difference in appearance with sex or age, except that young birds may have more pronounced pale or dark edges to the feathers. Many have simple counter-shaded markings that often appear to have given rise to uniformly dark or, less often, to pale derivatives; some species in most groups are dimorphic or polymorphic. The more complex groups have often developed distinctive markings of the extremities.

Breed more or less colonially on offshore islands, coastal cliffs, or on hills and deserts inland, where they perform complex vocal and aerial displays. The nest is a simple scrape or cup in a burrow or natural hole, sometimes under vegetation. The s. albatrosses build large cone-shaped nests in the open; may be lined with any debris available in the area. Smaller species visit it only at night, though larger ones and those breeding on remote islands may come to nests in the open by day. Parents incubate for spells of several days in turn and generally leave the chick alone soon after it hatches, only returning at long intervals to feed it by regurgitation. In consequence the chick is vulnerable to introduced predators and some species are now greatly reduced and at least two are now extinct. Some species also periodically liable to have unsuccessful breeding seasons. Many young or even old birds may be wrecked ashore and die when they meet bad weather or suffer shortage of food on migration or in the winter. Though it has been claimed that they are also vulnerable to all sorts of pollution, the evidence is weak (Bourne 1976). There is at present anxiety about the effect of some fishing methods, such as long-lining, which may be endangering species such as the great albatrosses.

All species feed at sea on a variety of fish, cephalopods and small marine invertebrates, either socially or alone; larger species may scavenge all sorts of offal or prey on other birds. Most, except perhaps *Pelecanoides*, can digest the complex lipids formed by some marine animals (Clarke & Prince 1976), and may eject them to soil the plumage of their enemies with lethal results (Swennen 1974). Some species can digest wax (Obst 1986). Many now take wastes from whaling and fishing operations (Fisher 1952). All have long life-cycles in proportion to their size; they disperse on fledging and then prospect for nest-sites for 2–12 years in their youth. They usually lay a single large white egg annually; though a successful breeding cycle may be completed in less than a year in at least one tropical species, *Puffinus lherminieri*, it may take 2 years in larger southern ones. Before laying, the birds court for weeks or months, then go to sea for feeding. Incubation lasts 6–8 weeks, and fledging 2–9 months. Once the fat chick fledges it fends for itself, even in species that immediately make a long migration, sometimes to the opposite hemisphere.

Tendency for failed breeders and non-breeders to begin moult before successful breeders. Five strategies of wing-moult in breeding adults: (1) In albatrosses, remiges replaced in staffelmauser interrupted while breeding; in nearly all other species, primaries moulted outwards; possibly simultaneously in some diving-petrels. (2) In most subantarctic and temperate species, moult begins soon after breeding and is completed shortly before next breeding season. (3) In most tropical species, moult aseasonal, between breeding attempts; resumption of breeding apparently depends on when moult completed. (4) In trans-equatorial migrants, wing-moult delayed until they reach non-breeding quarters, where it is completed; moult rapid but no satisfactory evidence for flightlessness. In

some species, body-moult also in winter quarters; in others, at breeding grounds. (5) In some species of high latitudes, rapid moult completed in summer when they breed; some begin moult long before breeding finished.

The history of the classification of the Order is very confused, as is seen by comparing Timmermann's (1965) discussion of their Mallophagan parasites with that by Klemm (1969) of their leg muscles and that by Harper (1978) of their proteins, but it is now widely agreed that the Order is best divided into four families: Diomedeidae or large to huge aerial albatrosses; Procellariidae or medium-sized, mainly aerial but sometimes aquatic, petrels, shearwaters and prions; Hydrobatidae or small to tiny, aerial storm-petrels; and Pelecanoididae or small aquatic diving-petrels.

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Family PROCELLARIIDAE fulmars, petrels, prions, shearwaters

The family Procellariidae represents the main radiation of medium-sized 'true petrels', characterized by having united nostrils with a median septum and the outer functional primary at least as long as the next. It tends to be dominant among the birds of the Southern Ocean, though in the n. hemisphere the Charadriiformes are more numerous. The giant-petrels *Macronectes* have also developed as large scavengers and predators, showing some convergence in appearance and behaviour with the Diomedeidae. The Procellariidae may be divided into four main groups with some intermediate species, which makes it hard to draw distinctions between them.

(1) The fulmars *Macronectes, Fulmarus, Thalassoica, Daption* and *Pagodroma* consist of seven species of surface predators and filter-feeders of rather varying structure and appearance (Voous 1949) that breed in high latitudes but may migrate along cool currents into much lower ones. *Fulmarus* appears to have colonized the n. hemisphere in the Tertiary. Six of the seven species are essentially confined to our region.

(2) The gadfly-petrels *Pterodroma* are a large series of some 30 agile species; 16 breed in our region and another six occur rarely or rather rarely. Their short sturdy bills are adapted for seizing soft prey at the surface, and their twisted intestines, for digesting marine animals with an unusual biochemistry, which are also found throughout the warmer oceans (Imber 1985). They show complex markings of face and wings that must serve as interspecific recognition-marks (Murphy & Pennoyer 1952). Some species placed in this group have an intermediate structure and intergrade with all other groups distinguished here: *Pterodroma* (*Lugensa*) *brevirostris*, which moves S in winter, has distinctly big eyes like *Pagodroma*; *Halobaena caerulea* has a plumage similar to that of prions; *Bulweria* has some structural resemblance to shearwaters. At present it is difficult to determine their precise relationships.

(3) The prions *Pachyptila* are a specialized group of six (perhaps five) very numerous species, all in our region, that show a progressive adaptation of a small, agile, cryptically coloured, fulmarine form for filter-feeding on zooplankton. There has been dispute over their classification (Cox 1980; Harper 1980) but the arrangement discussed by Fleming (1941) seems best except that the Broad-billed Prion *P. vittata* appears to intergrade with Salvin's Prion *P. salvini* through *macgillivrayi* of Ile St Paul; so they may be better treated as subspecies of the same species.

(4) The shearwaters *Procellaria, Calonectris* and *Puffinus* include some 20 agile species with long bills adapted to catch prey more or less under water throughout the warmer seas (Kuroda 1954); 13 species breed in our region, some migrating into the n. hemisphere; six others are chance or perhaps regular visitors. From the fossil record (Brodkorb 1963; Olson 1975); they seem to have been particularly common in the great Tethys Ocean of the middle latitudes of the n. hemisphere in the Tertiary, so this development of aquatic habits may have occurred there without competition from penguins with a subsequent return S by the more successful forms.

General features of the family are: body, ovate, or elongate in shearwaters; wings, long and narrow, 11 primaries, p10 longest, p11 minute; 20–29 secondaries, short, diastataxic; tail, short, 12 feathers; bill, heavy (*Macronectes*), slender (shearwaters), broad (prions) or stubby (gadfly-petrels), hooked, formed of several horny plates; nostrils in dorsal tube of varying length; legs set far back, laterally flattened but round in gadfly-petrels; three toes, webbed, hind toe vestigial, raised. Oil-gland feathered. Peculiar musky odour. Sexes similar, male usually larger than female. Plumage, black or grey above, white below, or all dark; light and dark morphs in some species. Juveniles and immatures usually like adults.

Cosmopolitan throughout the oceans, essentially pelagic; more abundant in cool or cold waters rich in plankton and mostly away from ice. Swim well but usually aerial except when feeding or resting. Fly with alternate swooping and flapping action close to the surface but often arcing high in some gadfly-petrels. Gait on land, a shuffling crouch, being unable to walk properly with feet set so far back; generally avoid open areas on land, being thus vulnerable to predators. Nest colonially; for the most part in burrows and cavities in all sorts of terrain, sometimes far from the sea and in mountainous areas but some species, e.g. *Macronectes*, nest on open ground. Hole-nesters usually nocturnal at colonies, when often extremely vocal, though generally silent at sea. Migratory and dispersive. Some species divide the year between s. and n. hemisphere, often migrating in large flocks that may settle on the sea in huge dense rafts. Feed mostly on fish, cephalopods and crustaceans obtained by flight-feeding, plunge-diving, surface feeding, surface-diving and underwater pursuit; hydroplaning (Murphy) is a characteristic method used particularly by prions.

Probably all defend small nesting territories to which they return regularly while undisturbed; certainly so in some hole- and burrow-nesting forms. Agonistic and sexual behaviour of nocturnal, hole-nesting species very poorly known but generally seem to have little specialization for visual displays. Tactile actions such as allopreening and billing used but olfactory and vocal communication is probably important. Breeding is usually seasonal, generally with synchronized laying, often after a pre-laying exodus but some may not nest annually; some have shorter

cycles or nest continually. For the most part, little attempt to make substantial nests. Eggs, ovate, mat, white. Clutch-size, invariably one; single-brooded; no replacement laying. Incubation by both sexes in alternate spells of 1–11 days. Single median brood-patch. Incubation period, 45–55 days. Eggshells probably always trampled in nest. Young, semi-altricial, nidicolous; hatched in down. Rarely left alone in nest for first 1–2 weeks. Cared for and fed by incomplete regurgitation by both parents. Nestling period generally shorter in cliff- and ledge-nesting species than in hole-nesters. Young attain greatest weight, often well above that of adult, some days before fledging, by which time weight has been reduced to about the same as an adult, but no clear evidence that young are totally deserted for last few days in nest. Adults and young of most species liable to eject stomach-oil in defence. Young independent at fledging. Maturity reached at minimum of 3–4 years, in some 6–12 years.

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Pterodroma leucoptera Gould's Petrel

COLOUR PLATE FACING PAGE 496

Procellaria leucoptera Gould, 1844, *Ann. Mag. nat. Hist.* 13: 364 — Cabbage Tree Island, Port Stephens, New South Wales.

The specific name (λευκός and πτέρον wing) no doubt refers to the underwing pattern, which however resembles that of some other species of *Pterodroma*.

OTHER ENGLISH NAMES White-winged Fulmar or Petrel, White-throated or Sooty-capped Petrel.

Gould's (as suggested by W.B. Alexander *vide* Hindwood & Serventy 1941) is preferred because the other names are not distinctively descriptive and because **Gould's** is most widely used.

POLYTYPIC Nominate *leucoptera* (treated separately in this work for practical reasons) breeds only on Cabbage Tree I., NSW; *caledonica* de Naurois, 1978, breeds central mountains New Caledonia; *brevipes* (Peale, 1848) (extralimital and sometimes treated as full species) breeds Fiji Is, Cook Is and possibly Solomon Is. Other extralimital populations known to occur in sw. Pacific, for example Vanuatu; but these as yet not properly defined. All of these and *P. longirostris* from se. Pacific (vagrant to our area; *q.v.*) and possibly *P. pycrofti* might best be treated as single superspecies complex. Extralimital *P. hypoleuca* (n. Pacific) may be part of this complex.

As a matter of convenience, standard practice of this work is varied. Main account is for subspecies *leucoptera*, the only form breeding in our region; an account for *caledonica* follows.

FIELD IDENTIFICATION Length 30 cm; wingspan 70 cm; weight 180 g. Small, slightly built gadfly petrel, contrastingly marked with dark brown and grey above, and white below. Long narrow wings marked with dark indistinct M-mark across upper surfaces. Upperparts, particularly head, darker than in any other small *Pterodroma*. Tail short and rounded. Underwing, white with conspicuous blackish diagonal bar from carpal joint inwards along leading-edge. Best field characters are the dark head with diagonal line dividing white chin and forehead from crown and nape with smudge on sides of upper breast sometimes almost as collar; pale mantle; dark back and detail of underwing pattern. Very similar to Stejneger's Petrel *P. longirostris*. Cook's *P. cookii*, Black-winged *P. nigripennis* and extralimital Bonin *P. hypoleuca* Petrels also similar; all differ in extent and intensity of blackish feathering on crown, nape and breast, and in amount of black on underwing. Sexes similar, with no seasonal variation. Immatures resemble adults. Closely related *P.l. caledonica* ('New Caledonian Petrel') and *P.l. brevipes* ('Collared Petrel') of tropical w. Pacific very similar; see account below for *P.l. caledonica* for differences.

DESCRIPTION ADULT. Forehead, white but freckled with black, merging into sooty brown to sooty black crown and nape. Dark crown- and nape-feathers extend forward to join very dark, suborbital patch, making sides of face appear blackish, contrasting strongly with white area at base of bill. Upperwing, dark brownish-grey; dark primaries and greater coverts form indistinct open M-mark linked across lower back. Primaries, brown-black with white wedge at base of inner webs. Secondaries, grey with white inner webs. Mantle and back, blue-grey to dark grey; rump and upper tail-coverts, darker. Tail, grey tinged with brown, darkening at tip. Outermost tail-feather has inner web grey to brownish grey, except for off-white basal half. Chin, lores and rest of underparts, white, although dark-grey feathers extend from nape to form large patch on sides of breast and rarely may almost form collar across throat. Underwing, white with dark remiges and dark leading-edge to outerwing, angling in at carpal joint to form prominent blackish diagonal carpal bar across secondary coverts. This underwing bar much more pronounced than in Stejneger's *P. longirostris*, which is otherwise similar; Cook's *P. cookii*, and Pycroft's *P. pycrofti* Petrels also have much less black on underwing but are pale-headed; pattern is less extensive than in Black-winged *P. nigripennis*, Chatham *P. axillaris* and Bonin *P. hypoleuca* Petrels. Bill, black. Iris, dark brown. Legs and feet and upper webs, off-white; toes, joints, lower webs and claws, dull black.

SIMILAR SPECIES Pelagic range probably overlaps with most other small similar *Pterodroma* petrels, but as yet only **Cook's** and **Black-winged Petrels** (and *P.l. caledonica*) have been recorded in w. Tasman Sea. **Cook's** and **Pycroft's Petrels** have whiter underwings and much paler crowns and napes that do not contrast markedly with backs. **Stejneger's Petrel** has whiter underwing, slightly more white on forehead than Gould's Petrel; also, dark crown and nape-patch not so black nor so large. **Black-winged** and **Chatham Petrels** have much more black on underwing; crown and nape are grey, not contrasting with mantle and back.

Generally pelagic, but occasionally sighted offshore. In high winds, fly 5–6 m above water (Brown 1948), weaving with rolls and dips. Flight swift with banks and arcs, occasionally gliding; slower than other petrels, more resembling shearwaters; interspersed with sudden bursts of speed and agile twisting and banking, or low glides with wings stiffly held parallel to waves, before resuming leisurely flight (Harrison 1983). Ignore ships. Circle above nesting grounds at night. Usually seen singly at sea; gregarious at night over colonies. Breeding colonies in forested rocky gullies on Cabbage Tree I. After dark at Cabbage Tree I., in flight utters harsh staccato cicada-like call most of the time at heights of 80–100m

above I. On ground, call with piping *pee-pee peeoo* or low and tremulous growl.

HABITAT Marine; at-sea range in Aust. waters poorly known. Probably in cooler tropical waters. Observed over warm East Aust. Current (Norris 1965; Blaber 1986), where sea surface-temperature 16.5 °C or more (se. Tas.) (Blaber 1986) and 20.3–23.0 °C (Tasman Sea) (Barton 1980). Small numbers of birds observed over seamounts, where upwelling probably occurs (Barton 1980; Blaber 1986). Pelagic and occasionally offshore; rarely observed less than 10 km from breeding island (Hindwood & Serventy 1941).

Breed only Cabbage Tree I., NSW; birds nest in rock crevices, under fallen palm *Livistona australis* fronds or in hollows in fallen palm trunks and buttresses of figs *Ficus*; in sloping gullies under palm-forest, from just above sea-level to 120 m asl (Fullagar 1976). Few records of nesting in tussock grass *Lomandra* or on bare rocky slopes or cliff tops (D'Ombrain 1970), but breeding distribution mainly determined by availability of deep litter of palm-fronds and rock crevices (Fullagar 1976).

In strong wind, rise to 4–6 m above sea surface in flight (Brown 1948); fly at considerable heights over breeding island when arriving at night, and circle at tree-top level before landing (D'Ombrain 1970). D'Ombrain describes observation near Cabbage Tree thus: 'I usually see them in small groups of about a dozen, floating near the shore on the lee side, generally late in the afternoon. Mr Jensen [boatman] informed me, however, that it was not an uncommon sight to come across small parties of them well out from land, say six miles out' (Hindwood & Serventy 1941). May roost on open ground or under rocks (D'Ombrain 1964).

Population small but apparently stable. Important that mammalian predators not introduced to island (King 1979). Rabbits introduced to island in 1906 (Clough & Werren 1980). In 1943, island was used for gunnery practice for short time, until successful protest (Hindwood 1944). Cabbage Tree I. declared 'John Gould Nature Reserve' in 1954 to protect breeding site of this petrel.

DISTRIBUTION AND POPULATION Rarely seen away from Cabbage Tree I., though apparently absent from there between May and Oct. Where it moves to, unknown but most likely n. Tasman Sea possibly e. to central Pacific (P.J. Fullagar). Few beachcast specimens collected (Hindwood & Serventy 1941). Gibson & Sefton (1957) collated known records up to 1956. No summary of recent records but most from NSW with few from Qld and Vic. (e.g. Richards 1973) but none confirmed from SA (Parker & May 1982) or Tas.

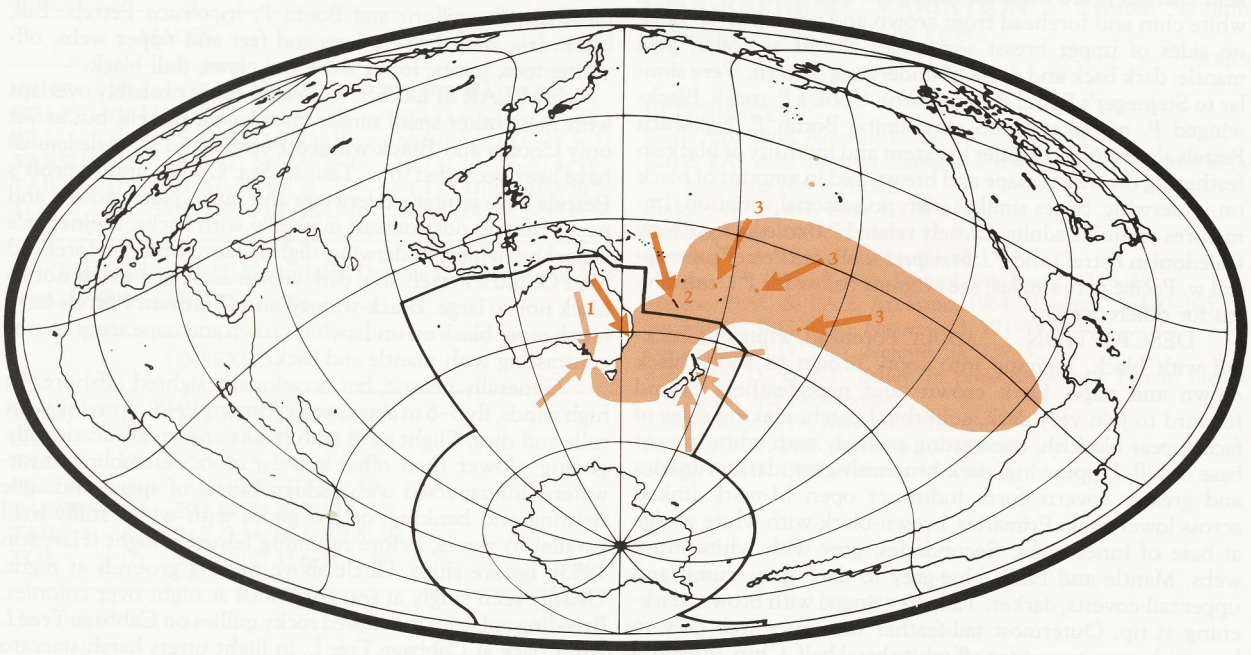
The following are data extracted by C.C. Davey. Between 1957 and 1986 a total of 1788 birds banded of which 1522 adults (all but two on Cabbage Tree) and 266 pulli. There have been 291 birds recaptured on the island (at 1 year or more from time of capture); 220 once, 52 twice, 14 three times, 3 four, 1 five and 1 six times. Six pulli have been recaptured on the island. The earliest recovery on the island was at age 3 years 10 months for two birds. Others have been recovered at 5, 7, 12 and 13 years old. The last two were breeding when recaptured. The oldest recoveries of birds banded as adults have been at 19 and 20 years; the latter was incubating when recaptured 1 year after banding.

MOVEMENTS Movements unknown away from breeding island. Leave Cabbage Tree I., Apr. (Fullagar 1976); return, mid-Oct. (Hindwood & Serventy 1941). Thought to feed locally during breeding season though records few (Hindwood & Serventy 1941).

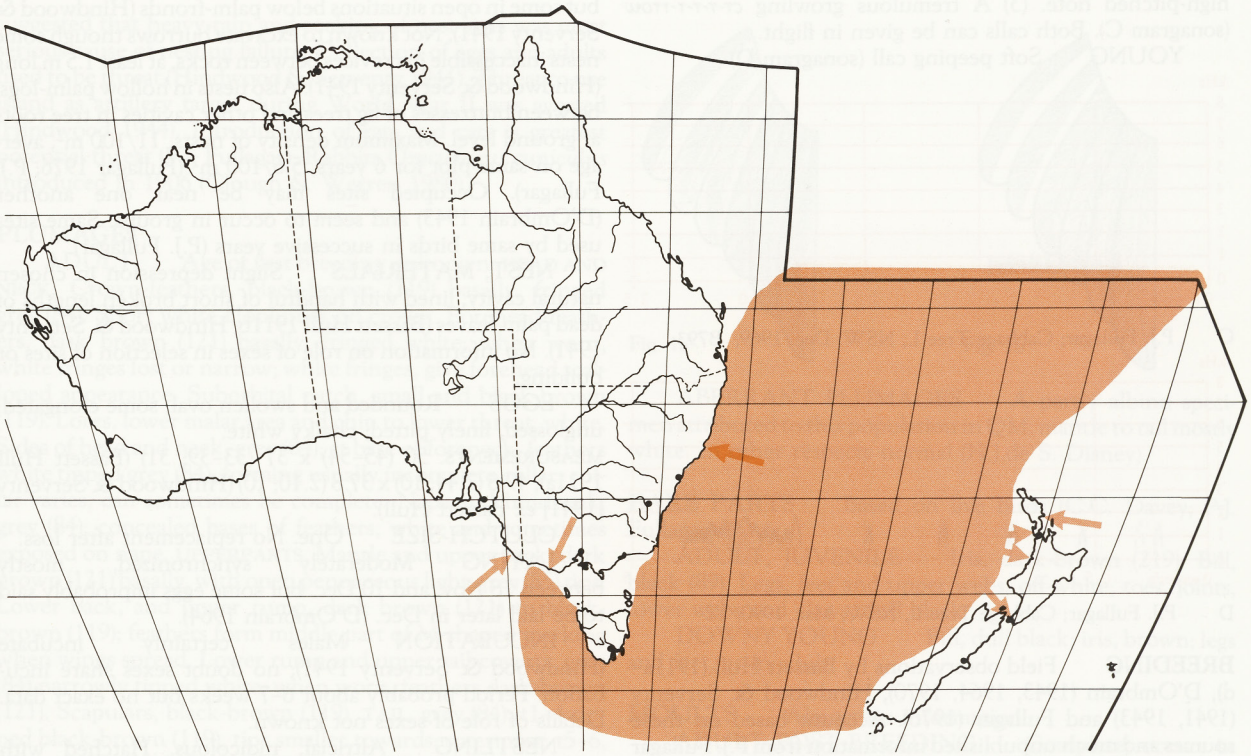
BANDING

32S152E 12 1+ U 37 148 215 ABBBS
32S152E 12 1+ U 13 283 208 ABBBS

FOOD Includes cephalopods but otherwise unknown. Feeding behaviour not described. Seven specimens contained remains of small cephalopods (Hindwood & Serventy 1941).



1 Subspecies *leucoptera*; 2 Subspecies *caledonica*; 3 Subspecies *brevipes*



Recorded feeding in association with **Black-winged Petrel** *Pterodroma nigripennis* and **White-bellied Storm-Petrel** *Fregetta fregetta* (Ainley & Boekelheide 1983) but these observations may not have been for birds from Cabbage Tree I.

SOCIAL ORGANIZATION Little information. Usually seen singly during non-breeding period, but nests in colonies of up to 200 pairs.

BONDS Monogamous. Age at first breeding unknown. Suggested at 4–5 years (D'Ombrain 1964). The only known-age birds breeding were 12 and 13 years old at time of recapture (see above).

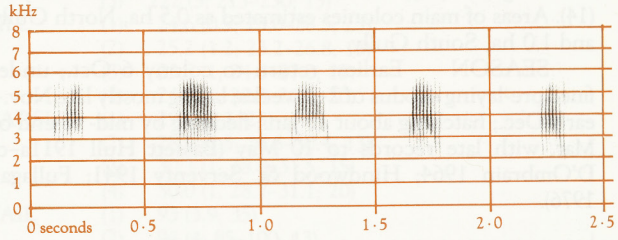
BREEDING DISPERSION Colonial. Nests may be less than a metre apart (D'Ombrain 1943; P.J. Fullagar; C.C. Davey) and often clumped.

ROOSTING At night, often in pairs in cavities beneath rocks, arrive after dark and leave before dawn (D'Ombrain 1964).

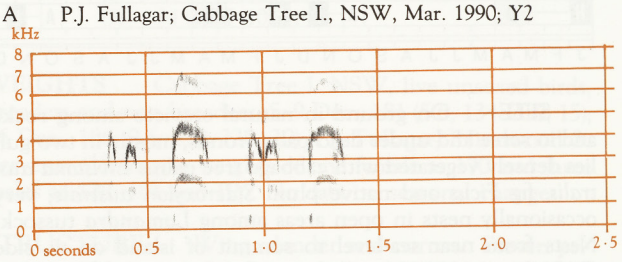
SOCIAL BEHAVIOUR No information. Earliest return to the island was 6 Oct. 1947. Birds arrive to take up nest-sites and then return to sea for a period of possibly 2 to 3 weeks (D'Ombrain 1964).

VOICE Information based on observations by P.J. Fullagar and C.C. Davey. In flight over breeding site most commonly utter staccato, rapidly pulsed call; on ground different squeaky call given much more often and occasionally a tremulous growl. Seems that flight-call uttered throughout season well after dark and given by birds wheeling and dipping above breeding sites. Calls increase in rapidity as birds chase each other, with occasional inclusion of aerial versions of the two other types of call more commonly heard from birds on the ground. Excited aerial calling given particularly by two- and three-bird flights that form and break up as the birds dash to and fro up to 100m or more above the island. No information on differences between sexes or individual variation. No information on calls when away from breeding area; probably silent.

ADULT (1) In flight at night above Cabbage Tree I., thin, cicada-like *zit-zit-zit-zit*. . . (sonagram A) each *zit* being a set of rapidly pulsed notes. Versions of calls heard from birds on ground or from nest-sites also given in flight. (2) Main calls from birds on ground variously described by Bassett Hull (1911b); Hindwood & Serventy (1941) and D'Ombrain (1970). Shrill, rapidly repeated *peep-peep-peeoo* (sonagram B) seems most common call or other variations on this squeaky,



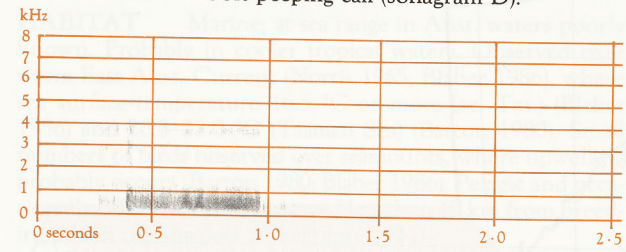
A P.J. Fullagar; Cabbage Tree I., NSW, Mar. 1990; Y2



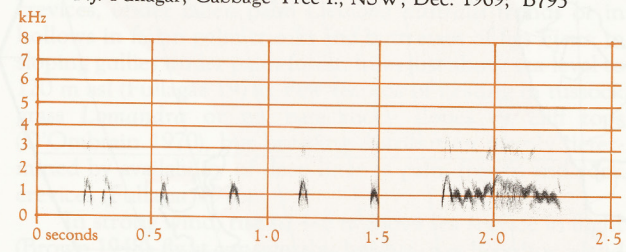
B P.J. Fullagar; Cabbage Tree I., NSW, Dec. 1969; B793

high-pitched note. (3) A tremulous growling *cr-r-r-r-rrow* (sonagram C). Both calls can be given in flight.

YOUNG Soft peeping call (sonagram D).



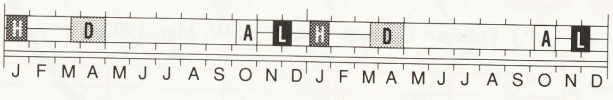
C P.J. Fullagar; Cabbage Tree I., NSW, Dec. 1969; B793



D P.J. Fullagar; Cabbage Tree I., NSW, Mar. 1990; Y2

BREEDING Field observations by Bassett Hull (1911a–d), D'Ombrain (1943, 1964, 1970), Hindwood & Serventy (1941, 1943) and Fullagar (1976). Account based on these sources and much unpublished information from P.J. Fullagar and C.C. Davey. Breed colonially and only on Cabbage Tree I. at entrance to Port Stephens, central NSW, but Bassett Hull (1911b; see also Hindwood & Serventy 1941) took egg from nearby Boondelbah I. on 7 Dec. 1910, which now cannot be traced. Mostly in areas not much colonized by **Wedge-tailed** *P. pacificus* or **Sooty** *P. griseus* **Shearwaters** or **Little Penguins** *Eudyptula minor* (Fullagar 1976). Mark and recapture data from five nights in early Dec. 1970 gave estimate of 2000 individuals (P J Fullagar). During same period estimates from searching 37 sample plots (each 4.5 m^2) on 30 m grid within breeding areas gave number sitting on eggs as 375 (SE:102); North Gully (17 plots) 141 (75) and South Gully (20 plots) 234 (68). Numbers of birds breeding estimated in 1989–90 by line transects through same breeding areas (C.C. Davey) gave following: 142 (18); North Gully 43 (10) and South Gully 99 (14). Areas of main colonies estimated as 0.5 ha, North Gully and 1.0 ha, South Gully.

SEASON Earliest return to colony 6 Oct.; undefined pre-laying exodus of 2–3 weeks; laying mostly late Nov.–early Dec.; hatching about 10 Jan.; fledging by mid- to end of Mar. with late records to 10 May (Bassett Hull 1911a–c; D'Ombrain 1964; Hindwood & Serventy 1941; Fullagar 1976).



SITE On ground in natural crevices among rocks and in scree and under dead palm-fronds, mostly in two gullies densely vegetated with cabbage tree palms *Livistona australis*, fig *Ficus* and native plum *Sideroxylon australe*; very occasionally nests in open areas among *Lomandra* tussock. Nests from near sea-level to summit of island on w. side (D'Ombrain 1970). Usually nests cannot be seen from above but some in open situations below palm-fronds (Hindwood & Serventy 1941). Not known to excavate burrows though some nests inaccessible in crevices between rocks, at least 1.5 m long (Hindwood & Serventy 1941). Also nests in hollow palm-logs; between buttresses of fig trees and other cavities in tree roots at ground level. Maximum density of nests, 11/100 m^2, average on same plot for 6 years, 5.6/100 m^2 (Fullagar 1976; P.J. Fullagar). Occupied sites may be near one another (D'Ombrain 1943) and seem to occur in groups. Same sites used by same birds in successive years (P.J. Fullagar).

NEST, MATERIALS Slight depression in chosen natural cavity, lined with handful of short broken lengths of dead palm-leaves (Bassett Hull 1911b; Hindwood & Serventy 1941). No information on role of sexes in selection of sites or building.

EGGS Rounded and swollen oval, some elongated; unglossed, finely pitted; chalky white.

MEASUREMENTS. 50 (45–54) x 37 (33–39; 31) (Bassett Hull 1911a); 49.8 (2.44; 10) x 37.8 (2.10; 10) (Hindwood & Serventy [1941] *ex* Bassett Hull).

CLUTCH-SIZE One. No replacement after loss.

LAYING Moderately synchronized, mostly between 18 Nov. and 10 Dec. but some eggs improbably said to be laid later in Dec. (D'Ombrain 1964).

INCUBATION Males certainly incubate (Hindwood & Serventy 1941); no doubt sexes share incubation. Period probably about 6–7 weeks but no exact data. Details of role of sexes not known.

NESTLING Altricial, nidicolous. Hatched with dark-grey down; head and upperparts covered with dark blue-grey down extending onto flanks; chin, throat, upper breast, abdomen and undertail, white; bill, black; webs of feet, fleshy white, basal half, black (Bassett Hull 1911c). No information on parental care or feeding. Period in nest more than 2 months (Hindwood & Serventy 1943); probably about 11–12 weeks (C.C. Davey; P.J. Fullagar). Parents defend small young by pecking and lunging with open beak (Bassett Hull 1911c; D'Ombrain 1928, 1964). Same action used in defence by chicks. Age of first breeding not known.

GROWTH Weight of chicks over six seasons, during last month in nest, increased from 181 (47; 108–207; 25) on 14 Feb. to 248 (63; 50–320; 24) on 8 Mar. Thus, chicks reach maximum of *c.* 135% of average adult weight before fledging (P.J. Fullagar).

SUCCESS Out of 69 eggs recorded in Dec. of six seasons, 26 (38%) produced well-grown chicks in late Feb., ranging from 17 to 57% (P.J. Fullagar). Out of 51 eggs recorded in Dec. 1989, 13 (26%) resulted in chicks surviving to early Mar. 1990; 13% of those laid in North Gully and 31% of those laid in South Gully (C.C. Davey). No further information.

PREDATORS. D'Ombrain (1970) claimed that Peregrine Falcons *Falco peregrinus* took adults at night, which seems unlikely, though they probably take them on arrival very late in evening and on departure early in morning. Other predators: White-bellied Sea-Eagles *Halaieetus leucogaster*, owls, ravens *Corvus* spp and Grey Goshawks *Accipiter novaehollandiae* (D'Ombrain 1964, 1970). Worse menace seems to be sticky seeds of bird-lime tree *Pisonia umbellifera*, which entangle plumage of adults and incapacitates them (Hindwood & Serventy 1941, 1943; D'Ombrain 1952). From 95 skeletal remains collected between 1968 and 1975, 64% were birds that died of unknown causes; the rest showed signs of predation by raptors. All might have died directly or indirectly by being entangled with *Pisonia* seeds (C.C. Davey). Fullagar (1976)

suggested that heavy rain and soaking of nest-sites was most serious cause of nesting failure. Collection of eggs and adults used to be threat (Hindwood & Serventy 1941). Threat to use island as artillery target during World War II was averted (Hindwood 1944). Introduction of rats and cats is greatest potential threat (P.J. Fullagar). Rabbits *Oryctolagus cuniculus* introduced in 1906 (Clough & Werren 1980).

PLUMAGES

ADULT Age of first breeding unknown. HEAD AND NECK. Crown-feathers, black-brown (119) basally, fringed grey (84). Short white filoplumes on crown. Forehead-feathers, dark brown (121) basally, fringed white; when worn, white fringes lost or narrow; white fringes, give forehead scalloped appearance. Suborbital patch, small and black-brown (119). Lores, lower malar area and chin to lower throat, white. Sides of head and neck, grey (84); at base of foreneck, feathers white tipped grey (84), forming usually incomplete collar; collar varies, can sometimes be complete. Nape and hindneck, grey (84); concealed bases of feathers, white and sometimes exposed on nape. UPPERPARTS. Mantle and upper back, dark brown (121) basally, with open pennaceous light-grey (85) tips. Lower back, and upper rump, dark brown (121) to black-brown (119); feathers form middle part of M-shaped marking when wings spread. Lower rump and upper tail-coverts, grey (84) narrowly tipped white; when worn, feathers dark-brown (121). Scapulars, black-brown (119). TAIL, grey (84); t1–4 tipped black-brown (119), tips smaller towards outermost; t5–6, white with mottled pale grey tips (see Fig. 1). UPPERWING. Primaries, black-brown (119) with white basal inner margins to inner webs (see underwing), and exposed when wing spread. Secondaries and tertials, grey (84) with basal white inner webs. Greater coverts, dark grey (83), narrowly edged white on outer web. Median coverts, grey (84) fringed pale grey (86). Lesser and marginal coverts, dark brown (121) and form part of M-shaped marking when wing spread. UNDERPARTS, mostly white. Outer breast-feathers, mottled dark grey (83) on webs. Lower flank-feathers, dark grey (83) on inner web; outer web, white mottled dark grey (83) on webs. Axillaries, white. UNDERWING. Primaries, black-brown (119) with white inner margins to basal inner webs, extending for half of length as moderately sharp wedge; outer margin of web, distally edged dark brown (121) for short distance. Outer web of outermost greater primary covert, glossy brown-grey (79), rest white. Outermost median primary covert, dark brown (121); next innermost, white with pale dark-brown (121) outer web; rest, white. Outermost marginal primary coverts, dark brown (121), tipped white, rest white. Marginal, lesser and basal halves of median coverts at carpal joint, dark brown (121), extending diagonally towards innerwing for three-quarters of length of radius-ulna bone; distal halves of median coverts and narrow fringes on marginal coverts, white; towards innerwing, median coverts, white with dark-brown (121) mottled webs, giving underwing-stripe faded appearance towards innerwing. Rest of coverts, white.

DOWNY YOUNG Upper body and wings covered in dark grey down, narrow whitish area on underparts. White on chin, breast and upper belly; dark-grey down on lower belly to vent; pale undertail. Grey down of upper sides extends across upper breast and down flanks (from live chicks; C.C. Davey; P.J. Fullagar). Two down stages occur.

JUVENILE Similar to adult; differs as follows. HEAD AND NECK. White fringes on forehead, broader. UPPERPARTS. Feather-tips, paler.

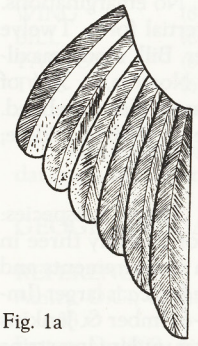


Fig. 1a

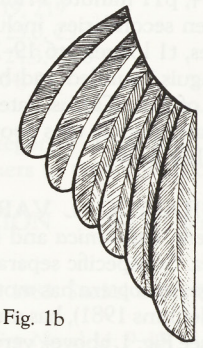


Fig. 1b

ABERRANT PLUMAGES A partly albino specimen attributed to this population in QM; mantle to tail mostly white. In other respects normal (H.J.de S. Disney).

BARE PARTS Based on live birds (C.C. Davey; P.J. Fullagar).

ADULT, JUVENILE Iris, dark-brown (219). Bill, black (89). Legs, feet and upper webs, off-white; toes, joints, lower webs and claws, dull black.

DOWNY YOUNG Bill, dull black; iris, brown; legs and feet, as in adult.

MOULTS Almost no information.

ADULT POST-BREEDING Complete; occurs in unknown wintering area.

POST-JUVENILE Undescribed.

MEASUREMENTS (1) Cabbage Tree I.; pooled data (from Hindwood & Serventy 1941). Sexes significantly different for culmen and tarsus (males average larger by about 1.5–2 mm); but not for wing and tail; they warn museum skins often incorrectly sexed. (2) Cabbage Tree I., adult skins; pooled (AM; H.J. de S Disney). (3) Cabbage Tree I., live adults, unsexed, 5–9 Dec. 1970 (P.J. Fullagar). (4) As (3) but 16 Dec. 1969; note smaller bills (more with worn tips?).

WING	(1)	225 (5.2; 213–238; 48)
	(2)	224 (6; 215–235; 13)
	(3)	222 (5; 213–230; 15)
BILL	(1)	24.6 (0.9; 23.0–26.5; 23)
	(2)	25.2 (1.2; 23.2–26.8; 13)
	(3)	25.5 (1; 24.8–27.2; 15)
	(4)	24.9 (1; 23.3–26.4; 20)
TARSUS	(1)	29.2 (1.3; 23)
	(2)	28.9 (1.5; 26.3–30.4; 13)
	(3)	30.3 (1; 28.8–31.5; 15)
	(4)	30.0 (1; 28.7–31.1; 20)
TAIL	(1)	93 (3.9; 35)
	(2)	94 (4; 85–100; 13)
	(3)	94 (4; 87–102; 14)

WEIGHTS Cabbage Tree I. NSW, live unsexed birds, breeders and non-breeders: 5–9 Dec., 181 (5.6; 134–210; 15); 16 Dec., 186 (9.5; 170–220; 20) (P.J. Fullagar). Hindwood & Serventy (1941) give weights of one female as 170 and three males as 179, 181 and 196. No data on seasonal changes.

STRUCTURE Wing, slender and narrow. Eleven primaries: p10 longest, p9 1–7 mm shorter, p8 10–17, p7 22–31, p6 38–50, p5 56–67, p4 72–88, p3 92–106, p2 108–120, p1

121–134, p11 minute. Primaries tapering. No emarginations. Nineteen secondaries, including five of tertial form. Twelve rectrices, t1 longest, t6 19–24 mm shorter. Bill, stout; maxillary unguis rounded and hooked at tip. Nostrils, *c.* 30% of length of bill. Tarsus, laterally compressed. Feet, webbed. Outer and middle toes about equal, inner *c.* 84% of middle; hind, claw only.

GEOGRAPHICAL VARIATION Three subspecies: *leucoptera, caledonica* and *brevipes*; two or possibly three in our area. Subspecific separation based on measurements and plumage: *leucoptera* has mottled t5–6; *caledonica* is larger (Imber & Jenkins 1981), has much whiter t5–6 (Imber & Jenkins 1981) (see Fig. 1, above); very slightly lighter underwing-stripe and is said to have different colour of feet (Bull 1943; Imber & Jenkins 1981); *brevipes* smallest and polymorphic with dark, light and intermediate morphs; inner margins of primaries lack white wedges (Murphy 1929; Watling 1986); for full details of polymorphism and bare parts in *brevipes* see Watling (1986). Tail of *brevipes* like *leucoptera*. Most reliable distinguishing feature between *leucoptera* and *caledonica* in hand is white or mainly white inner web of outer tail-feather of latter (grey or brownish grey distally in *P.l. leucoptera* and *P.l. brevipes*).

Pterodroma leucoptera caledonica

FIELD IDENTIFICATION Recently described (de Naurois, 1978); *P.l. caledonica* larger than other closely similar populations with whiter outer tail-feathers (see Imber & Jenkins 1981) but otherwise very similar; averages larger than **Gould's Petrel** *P.l. leucoptera* in all measurements (Imber & Jenkins 1981) and differs in having back and upper tail-coverts grey contrasting more with sooty-black nape and dark upperwings, but this difference likely to be unreliable. Also less tendency towards having breast-band than in *P.l. leucoptera* or *P.l. brevipes* (see later). Most reliable distinguishing feature in hand is white or mainly white inner web of outer tail-feather (grey or brownish grey distally in *P.l. leucoptera* and *P.l. brevipes*). Feet said to be pale blue (see Imber & Jenkins 1981), with outer toe, front two thirds of middle and inner toes, and front half of webs, brown-black. This sometime claimed for **Gould's Petrel** but seems not to be true in life (C.C. Davey; P.J. Fullagar). 'Collared Petrel' *P.l. brevipes* polymorphic with varying amounts of black and grey on underparts; many birds have partial or complete collar across upper breast. Darkest examples have wholly grey underparts except for white chin and throat and blackish upper breast. Palest examples resemble nominate; pattern of tail as in nominate; tarsus and foot bi-coloured as in nominate but pale areas vary from very light grey to an intense blue (Watling 1986). Breed in central mountains of New Caledonia; several records from NZ; occur in tropical and subtropical waters of Pacific Ocean; *P.l. caledonica* may occur in Tasman Sea (Imber & Jenkins 1981) but few reliable records. Several specimens from se. Aust. claimed to be *P.l. caledonica* not substantiated on re-examination (C.C. Davey; P.J. Fullagar). One specimen (ANWC 17832) at sea, near Noumea, New Caledonia, closely resembles nominate *P.l. leucoptera* (C.C. Davey; P.J. Fullagar). For characters of *P. longirostris*, see that text. For differences from other small *Pterodroma* see nominate *leucoptera*.

HABITAT Marine; range at sea poorly known but probably cooler tropical waters ranging into temperate seas in s. Tasman Sea. Evidence circumstantial for movement e. in Pacific of populations from our region.

DISTRIBUTION AND POPULATION Probably widespread in subtropical South Pacific Ocean range from e. Aust. to w. coast of central and South America: Chile, Peru, Equador, Panama, Costa Rica and Mexico. Description confused by lack of information on exactly which population involved and indeed confusion between similar species in this complex of small species of *Pterodroma*. Petrels of this group, probably *P.l. leucoptera* and *P.l. caledonica*, numerous Tasman and Coral Seas during summer with many records Dec.–Apr. but none May–Nov. (Rancurel 1976; de Naurois 1978; Imber & Jenkins 1981). *Pterodroma l. caledonica* recorded in Aust. waters in s. Aust. Oct. and May (Parker & May 1982), Tas. (Green 1984) where common off both e. and w. coasts Dec.–Apr. (Carter 1980; Mochizuki & Kasuga 1985; Blaber 1986; D.W. Eades) and possibly this species in w. Coral Sea in May (Stokes & Corben 1985). Recorded at sea in Tongan waters in Apr. (Jenkins 1980b; Imber & Jenkins 1981). Some non-breeders may remain in e. Pacific, though some sightings probably represent start and end of migration (Meeth & Meeth 1985, 1986).

Extralimital *P.l. brevipes* typically from Fiji and thought to be the form breeding at Vanuatu has also been recorded breeding (fledgeling collected Sept. 1984) at the Cook Is (Watling 1986). Claimed to breed in Samoa but there are no confirmed records (Watling 1986). A larger form may indeed breed in that area (Bourne 1974, 1983).

MOVEMENTS Thought to be migratory from New Caledonia to e. and s. tropical Pacific at least; though known to breed in summer (Imber & Jenkins 1981; Watling 1986); timetable of Vanuatu population unknown. Maybe *P.l. brevipes* sedentary in Fiji region because reported in all months (Watling 1986).

NON-BREEDING Sightings (Jenkins 1980a) and specimen (Imber & Jenkins 1981) from n. Tonga in late Apr., sightings near Fiji, 26 Feb.–8 June (Jenkins 1986) and near Pitcairn I., 25 May (Imber & Jenkins 1981), probably of birds on outward migration to e. tropical South Pacific where abundant round and to E of Galápagos (Loomis 1918; Pitman 1986). Records near Fiji, 9 Aug. (Jenkins 1986) and 10 Nov. (Jesperson 1933), presumably birds returning to New Caledonia. Alleged type-locality of *P.l. brevipes* (S of Antarctic Circle) and a specimen claimed to be from Wales (UK) wisely questioned by Bourne (1967).

FOOD One *P.l. caledonica* beachcast NZ contained two small fish and numerous cephalopod beaks (Bull 1943).

SOCIAL ORGANIZATION AND BEHAVIOUR No information.

VOICE Calls of *P.l. brevipes* at Fiji like those described for nominate *leucoptera* (*q.v.*; see details and sonagrams given by Watling 1986). No other information.

BREEDING *P.l. caledonica* breeds New Caledonia, on steep, forested sides of valleys in central mountain chain, at 450–500 m asl (Imber & Jenkins 1981). Fresh eggs found at one site on Mt Dzumac in Humboldt Massif on 30 Dec. 1979 (Imber & Jenkins 1981). Hannecart & Letocart (1980) illus-

trate adults at nesting sites and downy young; claim breeding season is Dec. to Apr.; that burrows are dug but some pairs use rock crevices and that during season hundreds of adults can be seen flying up certain valleys at nightfall. Young in the nest of *P.l. brevipes* from Fiji known from May to Aug. (Watling 1986). At Vanuatu (Aneiteum) small downy young in mid-Feb. (MacGillivray 1860).

PLUMAGE Insufficient local material available for detailed description of *P.l. caledonica* (recently collected specimen in AM O.61920). Descriptions of beachcast birds from NZ in Bull (1943) and Falla (1962) refer to this subspecies (*vide* Imber & Jenkins 1981). See Watling (1986) for description of *P.l. brevipes*.

MOULTS Believed to be in central n. Pacific, from Feb.–Oct. Moult in *P.l. caledonica* occurs in Tasman Sea, based on beachcast records NZ (Imber & Jenkins 1981). Primaries moult outwards; up to three innermost primaries lost simultaneously.

MEASUREMENTS *Pterodroma l. caledonica*. (1) New Caledonia, exact locality unknown, female (AM O.61920; measured by H.J. de S Disney). (2) NZ; pooled data (from Bull 1943). (3) Otaki Beach, NZ, adult female, 25 June 1961 (Falla 1962). (4) Tasman Sea, unsexed, 19 Apr. 1956 (BMNH 1956.4.9.2; measured by H.J. de S Disney).

WING	(1)	218
	(2)	229 (3.4; 9)
	(3)	232
	(4)	220
BILL	(1)	25.2
	(2)	25.1 (0.9; 8)
	(3)	25
	(4)	25.4
BILL W	(3)	11
BILL D	(3)	10
TARSUS	(1)	28.4
	(2)	29.9 (0.4; 9)
	(3)	30.5
	(4)	29
TAIL	(1)	92
	(2)	96 (0.9; 6)
	(3)	92
	(4)	93

See also measurements from various sources summarized by Imber & Jenkins (1981) and Bourne (1983).

Pterodroma l. brevipes. (5) Fiji, skins; pooled data (MM, AM, BMNH; measured by H J de S Disney).

WING	(5)	212 (3.9; 203–218; 12)
BILL	(5)	23.9 (1.2; 22.2–25.9; 12)
TARSUS	(5)	26.7 (1.3; 25.0–29.7; 12)
TAIL	(5)	96 (3.5; 90–100; 12)

For additional measurements including weights see Watling (1986) but some of these data may include birds from sites other than Fiji.

(6) Vanuatu, New Hebrides, representing *P. torquata* MacGillivray (1860); listed respectively as two males and ? (BMNH; see Salvin 1896; measured by H.J. de S Disney).

WING	(6)	218, 219, 219
BILL	(6)	25.8, 25.0, 25.4
TARSUS	(6)	23.5, 24.3, 29.6
TAIL	(6)	101, 104, 98

The second agreed with category 4 of Watling (1986) for darkness of underparts; the others to type 3 with collars.

GEOGRAPHICAL VARIATION See *P.l. leucoptera*.

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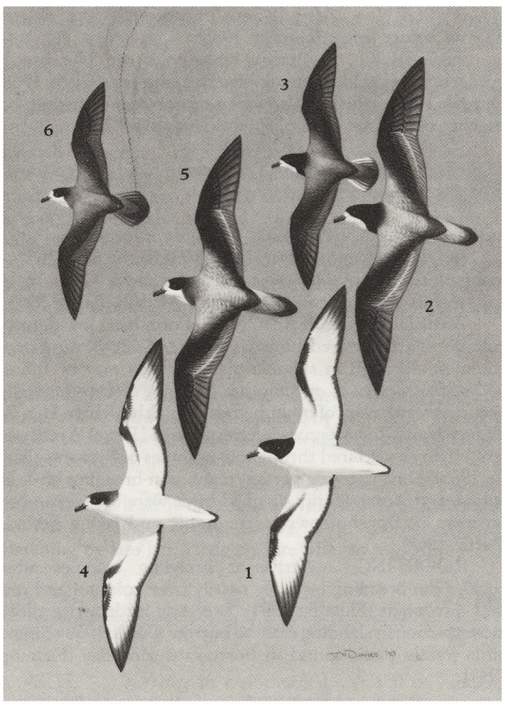

Volume 1 (Part A), Plate 38

Gould's Petrel *Pterodroma leucoptera* Subspecies *caledonicus*
1. Adult, ventral, fresh
2. Adult, dorsal, fresh
3. Adult, dorsal, worn

Stejneger's Petrel *Pterodroma longirostris*
4. Adult, ventral, fresh
5. Adult, dorsal, fresh
6. Adult, dorsal, worn

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