

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: Diomedidae 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 Diomedidae. 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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Procellaria cookii G.R. Gray, 1843, Dieffenbach's *Travels* NZ 2: 199 — New Zealand.

Named in honour of Captain James Cook.

OTHER ENGLISH NAMES Blue-footed Petrel.

MONOTYPIC

FIELD IDENTIFICATION Length 25–30 cm; wingspan 65 cm; weight c. 190 g. Typical small Cookilaria gadfly petrel with rather long slender bill; closely resembles at least nine other small Cookilaria petrels. Upperparts, pale grey with dark open M-mark across upperwings and back. Underparts, white. Underwing, nearly all white with small amount of black extending towards wing tip from carpal joint, and also extending as slight diagonal bar across secondary coverts. Sexes alike; no seasonal variation. Immatures similar to adults.

DESCRIPTION ADULT. Forehead, mainly white with grey freckling on forecrown. Narrow white line passes above eye; beneath this, dark grey patch extends from in front of, but mainly below, eye to blend with grey area behind eye. Crown, nape, mantle, lower back, upper tail-coverts and sides of neck and breast, grey; feathers have whitish margins when fresh; pale margins persist on feathers of crown and sides of neck and breast. Upperwing, grey; blackish outer primaries, greater coverts and rump form broad open M-mark from wing-tip to wing-tip. Wings become browner with wear. Inner webs of primaries, largely white from base; white ends in wedge at blackish tip. Central tail-feathers, grey with blackish-brown tips; lateral tail-feathers vary but generally with outer webs uniformly grey to heavily grey-speckled, and inner webs, pale grey through speckled to pure white; outermost pair always palest. Entire underparts from chin and cheeks to under tail-coverts, white. Boundary between grey upperparts and white underparts, more or less mottled. Underwing, mostly white except irregularly and narrowly mottled with black and grey on leading-edge of outerwing to near carpal joint; blackish strip runs from carpal diagonally across white under wing-coverts for short distance. Iris, brown. Bill, black, exceptionally long and slender for *Pterodroma* petrel. Tarsus, most of inner third of foot and inner two toes, bluish; webs, mainly pale yellowish; outer toe and terminal parts of webs and other toes, blackish. **JUVENILE.** Similar to adult except paler and more prominently white-edged contour feathers of upper surface; exposed upper surface of primaries quite black.

SIMILAR SPECIES Cook's Petrel differs from **Black-winged** *P. nigripennis*, **Chatham** *P. axillaris*, and **Gould's** *P. leucoptera* Petrels in having much whiter un-

derwing with only slight black diagonal carpal bar. Differs from above species and **Stejneger's Petrel** *P. longirostris* in having pale crown and nape that do not differ in colour from pale-grey back. **Pycroft's Petrel** *P. pycrofti* probably cannot be

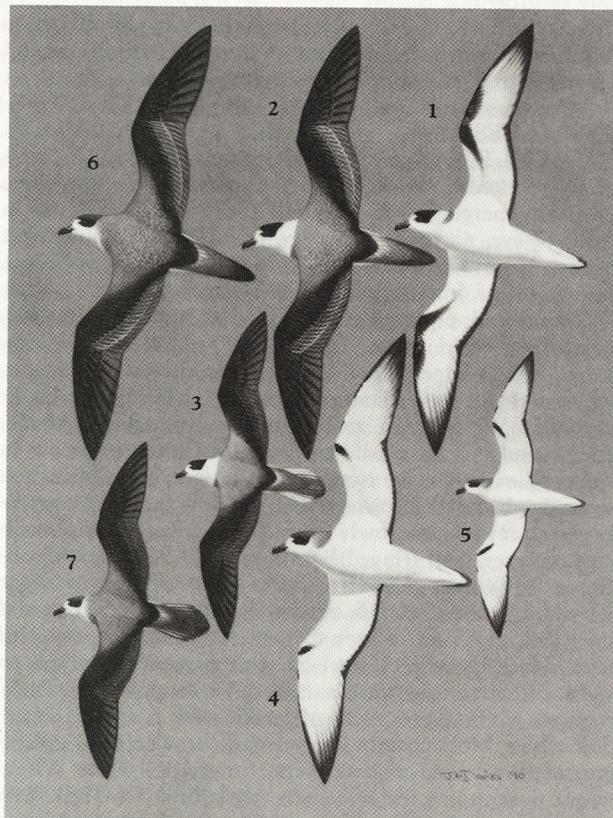


Plate 35

White-necked Petrel
Pterodroma cervicalis
1. Adult, ventral, fresh
2. Adult, dorsal, fresh
3. Adult, dorsal, worn

Juan Fernandez Petrel *Pterodroma externa*
4. Adult, ventral, fresh
5. Adult, ventral, fresh
6. Adult, dorsal, fresh
7. Adult, dorsal, worn

distinguished from Cook's Petrel at sea, but has slightly darker forehead, crown and nape; upperwings browner with less well-defined M-mark; in NZ seas, Pycroft's has not been recorded S of Cook Str., so all more southerly sightings probably Cook's; elsewhere much less abundant than Cook's, so much less likely to be sighted; rare or even absent in Tasman Sea where Cook's Petrel, ranging farther from breeding colonies, occurs. **Mas Atierra Petrel** *P. defilippiana*, not yet recorded in our region, differs in more robust, typical *Pterodroma* bill, darker eye-patch, longer tail but cannot be distinguished from Cook's at sea.

Pelagic; range at sea during breeding season mainly E of NZ; migrates to ne. Pacific (May–Sept.). Flight rapid and erratic with fast jerky wing-beats and much weaving and banking interrupted by high arcs. Ignore ships. Nocturnal feeder. Do not form flocks, but loose groups gather offshore at Little Barrier I. in late afternoon. Silent at sea but vocal over nesting colonies; also notable for giving flight-call when passing over landmarks on flight paths; during summer months (roughly Nov.–Jan.), occasionally heard over Whale I., Bay of Plenty, and North Auckland Pen., mainly W of Little Barrier I., and regularly over Cuvier I. and Great Barrier I. Flight call, nasal-sounding *kek-kek-kek*.

HABITAT Marine, pelagic; subtropical and, rarely, subantarctic waters of Pacific Ocean; cross tropical waters during

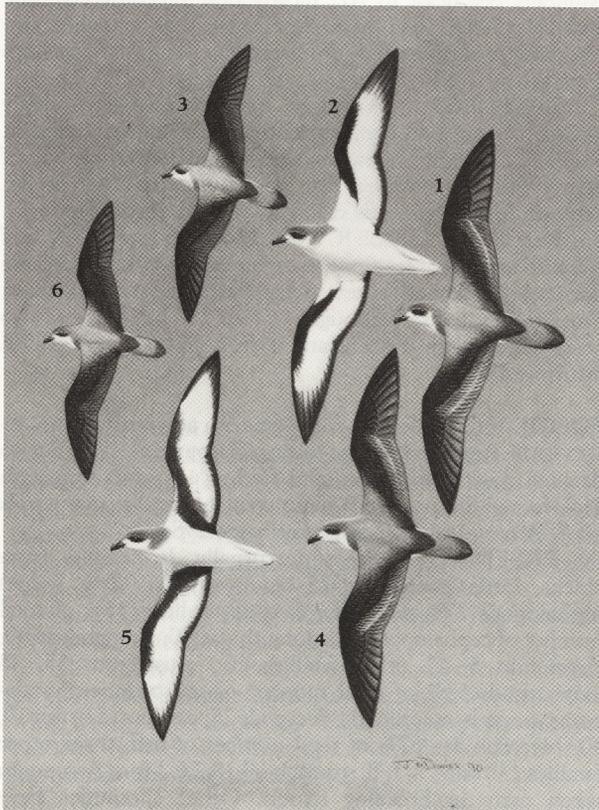


Plate 36

Black-winged Petrel
Pterodroma nigripennis
1. Adult, dorsal, fresh
2. Adult, ventral, fresh
3. Adult, dorsal, worn

Chatham Petrel *Pterodroma axillaris*
4. Adult, dorsal, fresh
5. Adult, ventral, fresh
6. Adult, dorsal, worn

migration to n. Pacific Ocean in non-breeding season (Ainley & Boekelheide 1983; Pitman 1986; Tyler & Burton 1986). Distribution at sea may be related to surface-temperatures and other oceanographic factors (Tyler & Burton 1986). Habitat preferences in A'sian region poorly noted; in Tasman Sea, observed over waters of 20.3–23.0 °C, with large flocks over Gascoyne Seamount, where low surface-temperature (20.3 °C) indicated upwelling of cool nutrient-rich water (Barton 1980). In n. Pacific Ocean, most records in waters of surface-temperature 15–25 °C (Roberson 1980; Gould 1983; Pitman 1986); rare sightings in cold waters (4.0 °C; Wahl 1978). Waters off Californian coast probably usually too cold (10–17 °C), but occasional sightings over persistent warm-water eddies (16–19 °C) when El Niño conditions temporarily increase surface-temperature (Tyler & Burton 1986). In e. Pacific, inhabit waters seaward of coastal, cool-water upwellings (Pitman 1986).

Breeding known from three subtropical islands off NZ coast, where nest in burrows on forested ridges and steep upper slopes (Oliver; Blackburn 1968); 300–700 m asl on Little Barrier I. (Norris 1965) and 4–350 m asl on Codfish I. (Blackburn 1968).

Flight close to surface interrupted by high arcs (Harrison 1983).

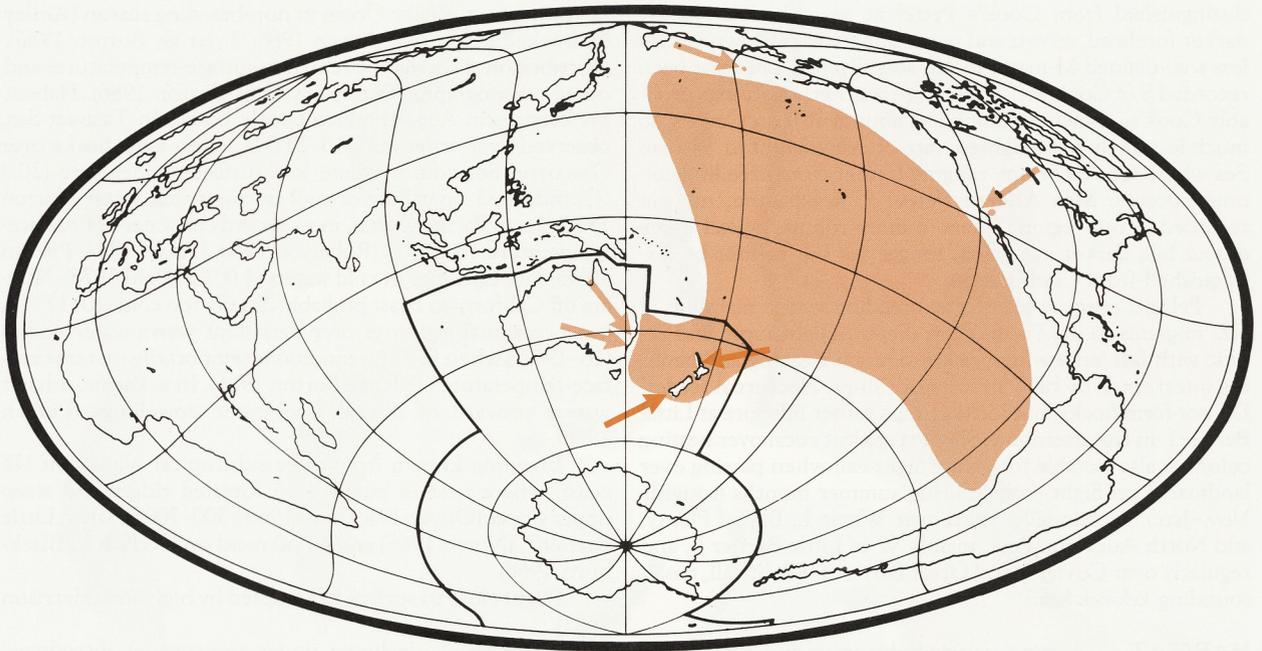
Endangered; declining under pressure of introduced predators (King 1979; Blackburn 1968; Imber 1984). Small quantities of plastic pellets ingested with no evidence of adverse effects (M.J. Imber).

DISTRIBUTION AND POPULATION Breed NZ offshore islands: Little Barrier, Great Barrier and Codfish.

Mainly ranges E of NZ where distribution interrupted by Chatham Rise and adjacent seas; also found Tasman Sea, N of c. 40°S (M.J. Imber). Important feeding areas E of NI between East Cape and C. Palliser (assumed to be Little Barrier population) and between 46–47°S and 172–175°E (assumed to be Codfish I. population) (Murphy 1929; M.J. Imber). Absent from NZ waters, mainly May–Aug. (M.J. Imber). Winter in e. Pacific Ocean between Baja California and Chile (AOU 1983; Murphy), where large numbers found June–July (M.J. Imber). Appear to be separated by equatorial region into wintering groups round 20–30°N and in lower numbers between 10 and 20°S (Pitman 1986). Most abundant off Baja California (Pitman 1986). Also abundant off Peru (Pitman 1986), ranging into Chilean waters.

AUST. Rare visitor to e. coast. **Qld.** One seen, Pt Lookout, 20 Feb. 1983, not authenticated and not acceptable (Smyth & Corben 1984; Qld Bird Rep. 1983). **NSW.** One beachcast, Cronulla, 29 Jan. 1955 (McGill 1955); one beachcast, Port Kembla, 7 Jan. 1967 (Gibson & Sefton 1971); one beachcast, Newcastle Bight, 18 Dec. 1971 (Holmes 1972), unfortunately reported without supporting details. Five or six sightings claimed off Sydney and Wollongong 1984–85, 1989 (NSW Bird Reps 1984, 1985; RAOU *Newsl.* 81) but none with supporting details and so unacceptable. **Tas.** One unsupported sighting (150°E, 44°S) (RAOU *Newsl.* 79). No records elsewhere.

NZ Distribution of beachcast birds (n=434) recovered by regular patrols between 1960 and 1984 reflects proximity to colonies and timing of breeding; numbers of beachcasts peak Dec., rising gradually from Aug. as birds return to breeding colonies, numbers drop during Jan. and Feb. but again increase Mar. and Apr. when fledgelings depart; numbers beachcast very low May to Aug. **NI:** 69% (313) of beachcast



specimens recovered on Auckland East beaches; 26% (116) on Auckland West beaches; ten specimens recovered Bay of Plenty; five Taranaki; seven Wellington West. **SI.** Three specimens recovered Southland.

BREEDING Little Barrier I., tens of thousands of breeding pairs; Great Barrier I., four burrows known, possibly only prospecting pairs and early colonists; Codfish I., c. 100 breeding pairs (M.J. Imber). Exact sites of extinct colonies unknown, but sub-fossil bones found in limestone caves and Maori shelters suggest this species may have formerly bred in inland Taranaki and near Hawke's Bay (R.J. Scarlett).

POPULATION On Codfish I., predation by *Wekas* *Gallirallus australis* has reduced breeding population from c. 20 000 pairs (Stead 1936) to c. 100 pairs (M.J. Imber); with removal of *Wekas* between 1980 and 1985, situation much improved. Similarly, feral cats removed from Little Barrier I. between 1976 and 1980 to benefit of populations; also Polynesian Rats *Rattus exulans*, which eat birds and eggs (Imber 1984). Cats and Polynesian Rats, threaten population on Great Barrier I. (King 1979).

MOVEMENTS Trans-Pacific migration from breeding colonies off NZ to e. Pacific; appear to occur in wintering and breeding areas throughout year though this may indicate loosely synchronized migration with prolonged times of departure and arrival (M.J. Imber).

DEPARTURE Though few heard calling over breeding colonies in June (Powlesland 1987), most successful breeders leave Mar.; chicks, 15 Mar.-15 Apr., mostly 20-31 Mar.; non-breeders, Feb.

NON-BREEDING Common during non-breeding season e. central Pacific between Chile and Baja California (Loomis 1918; Murphy 1929; Meeth & Meeth 1985, 1986; Pitman 1986) with records up to 46°N (Wahl 1978) though apparently avoids equatorial waters except in transit (Bourne 1983; Pitman 1986; Tyler & Burton 1986).

RETURN Breeders assumed to arrive colonies late July-early Sept. with high degree of philopatry (Imber 1983).

Numbers beachcast in NZ, mostly near breeding colonies, peak Nov.-Dec. and Mar.-Apr., first peak possibly representing inexperienced pre-breeders, second, fledglings (Powlesland 1987).

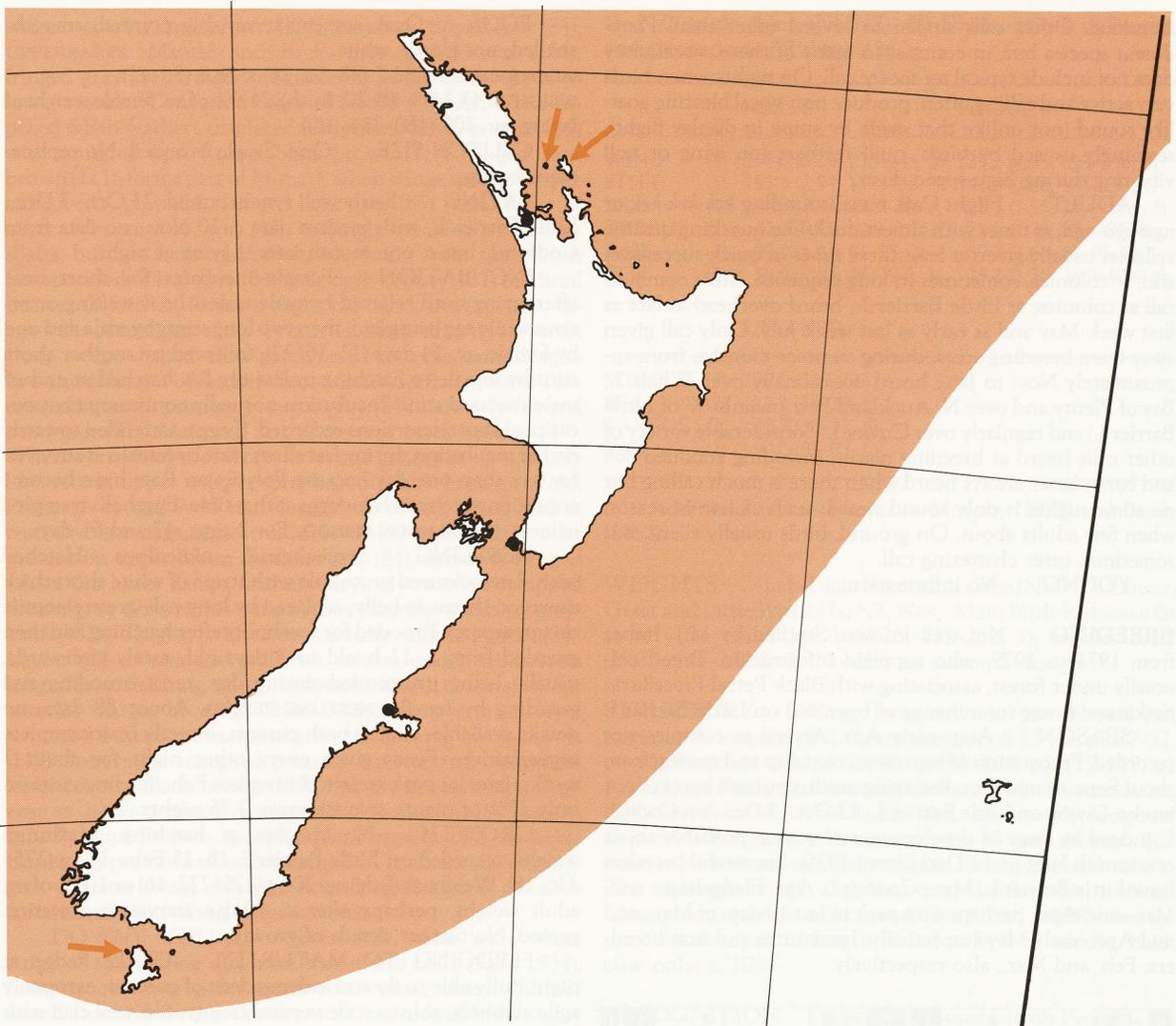
BREEDING At night, pass over land at many places: N. Auckland Pen. particularly near Kaipara Harbour, Cuvier I., Whale I.; possibly across land separating Bay of Plenty from n. Hawke's Bay; possibly across Tararua Ra. between feeding grounds E and W of s. NI; across Stewart I. (J.L. Kendrick; E.K. Saul; R. Russ). Most thought to feed E of NZ with important feeding area, assumed for birds from Little Barrier I., 150 km offshore between East Cape and C. Palliser; those from Codfish I. thought to feed 250 km SE of Otago coast where large concentrations seen 46-47°S, 172-175°E (Murphy 1929).

FOOD Cephalopods with some fish and crustaceans. **BEHAVIOUR.** Reported surface-seizing (Harper *et al.* 1985) but no detailed description. Recorded feeding in association with Pink-footed Shearwater *Puffinus creatopus* and storm-petrels off S. America (Ainley & Boekelheide 1983).

BREEDING Feeds nocturnally. In samples from chicks, **Little Barrier I.** (25 regurgitations) (M. J. Imber) cephalopods 27% vol., 68% freq. (Spirulidae 35% of total number of cephalopods; Histiotteuthidae 10; Cranchiidae 40; *Argonauta* 5; 11 other families 10), crustaceans 15, 48 (euphausiids 53% of total number of crustaceans; mysidaceans, isopods, amphipods, decapods 25; unident. 22), fish 19, 40 (Myctophidae 87% of total number of fish, three other families 13), salps <1, 8, stomach oil 38, 76. More *Argonauta* taken early in breeding season. Other specimens have contained only cephalopod beaks (Falla 1934; Tyler & Burton 1986).

SOCIAL ORGANIZATION Little information; based on information supplied by M.J. Imber. Solitary; gregarious only during breeding. Normally solitary when feeding.

BONDS Sustained or long-term. No data on inci-



dence of divorce or on timing or age of bonding. Birds prepare burrows and copulate between Sept. and mid-Oct., then leave to feed at sea for four to five weeks. Both parents incubate eggs; female normally completes incubation then briefly guards chick for 12–72 h; after this, rarely attended by parent during day. Both parents feed chick until 7–10 days before fledging, from which point young independent.

BREEDING DISPERSION Nest in loose colonies. Territorial, defending nest-site only.

ROOSTING Pelagic or in nest-burrow. Outside breeding season solitary; probably diurnal; may sleep on the wing. During breeding period, in burrow, sleeps much of time particularly when incubating and always during day; at sea, as for outside breeding season.

SOCIAL BEHAVIOUR Based mainly on comments by M.J. Imber. Virtually unknown; difficult to observe as nocturnal and, when on land during breeding, mainly in burrows. To take-off from forested breeding sites, climbs sloping or vertical trees (M.J. Imber). **FIGHT** over ownership of burrows; in two recorded instances on Little Barrier I. this led to death of one of participants. Birds call in flight over breeding col-

onies. **AERIAL DISPLAYS.** Nocturnal high-speed aerial dives over colonies, accompanied by bleating goat-like sound (probably caused by vibration of wing- or tail-feathers), likely to be part of **COURTSHIP** and **PAIR-FORMATION**; sound similar to that heard in display flights of snipe *Gallinago*. Mainly occur during breeding season, but also heard during May. Young deserted 7–10 days before they leave colony; about this time young leave burrow to exercise wings and explore for potential take-off sites. Average fledging period, 88 days.

VOICE No published studies; based on observations by M.J. Imber. Usually silent on ground and at sea but vocal in typical fashion of gadfly petrels over breeding colonies; noted calling when passing over high points of land on flight-paths. Much variation between calls, which can be loud, soft or harsh. Mainly heard in breeding season, but, at Little Barrier I., may be heard nearly all year; most common Oct.–Feb., least from Mar.–July. No information on sexual differences in calls. Appear to be differences in form and quality of calls between individuals. Flight-call not easily, if at all, distinguishable from that of Mottled Petrel's *P. inexpectata*; at Codfish I., where both species occur, birds giving Flight-call must be seen to be

identified. Other calls similar to several other small *Pterodroma* species but, in contrast to many of these, vocabulary does not include typical *tee-tee-tee* call. On nights when birds very active and calling often, produce non-vocal bleating goat-like sound (not unlike that made by snipe in display flight), seemingly caused by birds' quill feathers (on wing or tail) vibrating during high-speed dives.

ADULT **Flight Call.** Nasal-sounding *kek-kek-kek* or *nga-nga-nga*; at times with almost duck-like quacking quality; syllables usually given at least three times in quick succession and, at colonies, sometimes in long sequence. Most common call at colonies; at Little Barrier I., heard overhead as late as first week May and as early as last week July. Only call given away from breeding areas; during summer months, from approximately Nov. to Jan., heard occasionally over Whale I., Bay of Plenty and over N. Auckland Pen. (mainly W of Little Barrier I.) and regularly over Cuvier I. Considerable variety of other calls heard at breeding places, including subdued *oo-i* and *borrrr*; latter always heard when there is much calling but on some nights is only sound heard, such as late in season when few adults about. On ground, birds usually silent, but sometimes utter chattering call.

YOUNG No information.

BREEDING Not well known. Studied by M.J. Imber from 1971 to 1979, who supplied information. Breed colonially under forest, associating with Black Petrel *Procellaria parkinsoni* (some interchange of burrows) on Little Barrier I.

SEASON Aug.-early Apr. Arrival at colonies not recorded. Preparation of burrows, courtship and mating from about Sept. to mid-Oct. Prelaying exodus by both sexes of c. 4 weeks. Laying on Little Barrier I., 23 Oct.-3 Dec.; on Codfish I., judged by stage of development of young, probably about one month later (c. 12 Dec) (Stead 1935). Successful breeders leave Little Barrier I., Mar.; Codfish I., Apr. Fledgelings: mid-Mar.-mid-Apr., perhaps with peak in last 10 days of Mar., and mid-Apr.-early May respectively. Immatures and non-breeders: Feb. and Mar., also respectively.



(Little Barrier I.)

SITE In long established burrows at moderate to low density under subtropical rainforest; usually on high ridges, ridge-tops, steep slopes and valley-sides, of varying aspect but with good sites for take-offs. Burrows usually not more than 30 cm below surface, winding among roots of trees, in rather heavy soil. Because soil generally shallow, burrows often run up against impervious bedrock and become flooded in heavy rain; nests in such poorly drained burrows almost invariably fail during incubation. Burrows 1-5 m long. Used traditionally from year to year. Sometimes adopt burrows of Black Petrel, which have been declining on Little Barrier I., a trend that could be reversing. Glow-worms live on roofs of nest-chambers; Polynesian Rats (kiore) *Rattus exulans* frequent burrows. No data on selection or excavation of burrows but new burrows are rarely found (or dug).

NEST, MATERIALS Enlarged chamber at end of burrow, lined with leaves and twigs. Murphy, quoting Buller and others, claimed two chambers at end of burrow, both lined with leaves and grass and that Tuataras *Sphenodon punctatus* have been found in them.

EGGS Oval, somewhat variably pointed; smooth-shelled, not glossy; white.

MEASUREMENTS: 52.7 (48-56; 26) x 38.8 (36-41).

WEIGHTS: 43.3 (39-48; 20, fresh); 21.6% of av. female weight at laying (av. 202 [180-214; 16]).

CLUTCH-SIZE One. Single brooded. No replacement laying.

LAYING Fairly well synchronized: 23 Oct.-3 Dec., Little Barrier I., with median date c. 10 Nov.; no data from Codfish I. but c. one month later. Laying at night.

INCUBATION Female incubates for short time after laying until relieved by male unless he is waiting or arrives while egg being laid; then two long stints by male and one by female, av. 14 days (12-16; 27), followed by another short stint by female to hatching unless egg has hatched at end of male's second stint. Incubation normally continuous but occasional short desertions recorded; if egg unattended towards end of incubation during last short stint by female, it survives for less than one day because Polynesian Rats have become conditioned to search for eggs at that time. Eggshells trampled in nest. **INCUBATION PERIOD.** For 2 eggs, 47 and 51 days.

NESTLING Semi-altricial, nidicolous. Hatched with slate-coloured proptile with stripe of white short thick down on throat to belly; replaced by long pale-grey teleoptile on upperparts. Brooded for few hours after hatching and then guarded from c. 12 h old to 3 days old, rarely afterwards, usually being unattended during day; most brooding and guarding by female. **NESTLING PERIOD.** About 88 days; no details available. Fed by both parents, directly by incomplete regurgitation. Feeds given every other night for about 2 weeks; later, at peak weight during late Feb., feeding visits on only 27% of nights or once every 3.75 nights.

GROWTH No weights at hatching. Maximum weight, recorded on Little Barrier I. 18-25 Feb.: 347 g (275-436; 18). Weight at fledging: 206 g (175-222; 16) or 108% of av. adult weight, perhaps after c. 10-day starvation-desertion period. No further details of growth.

FLEDGING TO MATURITY Chicks fledge at night, fully able to fly and independent of parents; extremely agile climbers, able to scale vertical tree-trunks well clad with kidney ferns. Take-off points usually on sloping fern-clad trees emerging from canopy. Depart between 15 Mar.-15 Apr., but high proportion between 20-31 Mar.

SUCCESS On Little Barrier I. in eight seasons between 1972 and 1985, av. 32% (22-43); on Codfish I. in five seasons (1982-86), av. 62% (56-68). Survival and longevity not known. In past, predation by feral cats on Little Barrier I., by Wekas *Gallirallus australis* on Codfish I., and by Polynesian Rats on both. Now, only Polynesian Rats, which take unattended eggs and some small chicks. On Great Barrier I., rats (*R. exulans* and *R. rattus*) and feral cats. Formerly, taken by Maori for food by muttonbirding and by attracting adults to fires lit along flight paths.

PLUMAGES

ADULT Age at first breeding unknown. In fresh plumage: **HEAD AND NECK.** Hindcrown, dark brown (121), fringed grey (84); rest of crown, fringed white. White fringes broader on forehead, and largely white. When worn, fringes on forehead and forecrown largely lost, exposing dark brown (121) bases. Narrow white supercilium varies and may not be obvious in some birds (Murphy 1929). Front of lores, malar region, chin, throat and foreneck, white. Posterior lores (in front of eye) and sub-orbital patch, grey-black (82). Hindneck

and ear-coverts dark brown (121), narrowly tipped grey (84). **UPPERPARTS.** Mantle and back, pale dark-brown (121), fringed grey (84); fringes progressively wider from upper to lower mantle. Concealed bases of feathers, white, often exposed when feathers displaced. Scapulars, black-brown (119) with rounded tips. Rump, black-brown (119) fringed dark brown (121); forms part of M-mark when wings spread. Upper tail-coverts, grey (84), fringed light grey (85). **TAIL.** Most of outer web, on t3-t6, grey (84), varying speckled white near shafts, but not forming shaft-streak. Inner webs similar but less speckled. T1-t3 grey (84), pale dark-brown (121) on distal quarter of feather, forming slight tail-band. **UPPERWING.** Inner webs of remiges, white. Primaries, black-brown (119) with sharp wedge-shaped white patch on inner webs, extending to two-thirds length of feather. Secondaries, tertials, greater coverts and greater primary coverts, grey (84), narrowly fringed pearl-grey (81). Alula and rest of coverts, black-brown (119). When worn, fringes of secondaries and greater coverts largely lost; rest of upper wing-coverts become dark brown (119A). Primaries extend 9–33 mm beyond tip of tail, when bird at rest. **UNDERPARTS,** almost entirely white; incomplete collar present on upper breast; feathers grey (84), narrowly fringed white. On lower flanks, feathers varying mottled or tipped brown-grey (79); rachis varies from entirely white to grey-black (82). Thighs, white, occasionally mottled grey (84). Under tail-coverts and axillaries, white; under tail-coverts long, almost reaching tail-tip. **UNDERWING.** All coverts, except anterior margin of wing, white. Marginal coverts at carpal joint and outermost marginal primary coverts, black-brown (119). Innermost marginal primary coverts and outermost lesser coverts, black-brown (119), broadly tipped white. Outermost lesser primary coverts black-brown (119) basally, broadly tipped white, speckled black-brown (119) on webs. General appearance of underwing, dark leading edge on margins of outer wing, diffusely extending diagonally inwards from carpal joint along lesser coverts.

DOWNY YOUNG Protoptile, slate with white stripe of short thick down on throat and belly (Falla 1934). Long woolly mesoptile. **HEAD AND NECK,** down thinner round face and throat. **UPPERPARTS,** mixture of brown-grey (80) and pale grey (86). **UNDERPARTS,** cream-white.

JUVENILE Similar to adult but upperparts paler (Falla 1933).

BARE PARTS Based on photos in NZRD and at NZ-DOC Library, except where stated.

ADULT, JUVENILE Iris, dark brown (219). Bill, black (89). Tarsus and basal third of toes, light violet (170C); rest, dark grey (83). Webs, dark yellowish with black margins (Oliver).

DOWNY YOUNG Undescribed.

MOULTS

ADULT POST-BREEDING Complete; primaries moult outwards; occurs in winter quarters, North Pacific, from May–Sept. Based on skins (AMNH), showing birds in full wing, tail and body moult: on 28 July, 14 skins in full moult at 30°58'N, 124°16'W. Incidence of moulting birds: two in Apr.; one in June; 14 in July; one in Aug. and two in Sept. (J.A. Bartle). Non-breeders and failed breeders begin body moult before leaving breeding grounds (NZRD).

POST-JUVENILE Undescribed.

MEASUREMENTS (1) Cuvier, Great and Little Barrier

Is, NZ, adult skins (NMNZ). (2) Skins, status unknown; straightened wing (Palmer 1962).

	MALES	FEMALES
WING	(1) 236.6 (6.23; 230–245; 3)	229.2 (4.35; 223–236; 8)
8TH P	(1) 153.3 (2.94; 150–156; 3)	146.1 (3.48; 143–153; 7) *
BILL	(1) 26.9 (1.43; 25.9–29; 3)	27.1 (1.55; 24.4–29.9; 8)
TARSUS	(1) 31.2 (0.26; 30.9–31.5; 3)	29.9 (1.34; 27.9–32; 8)
TAIL	(1) 93.0 (1.63; 91–95; 3)	89.7 (3.66; 82–95; 8)
TOE	(1) 38.9 (0.66; 38–39.6; 3)	39.1 (1.35; 36.9–40.8; 8)
UNSEXED		
WING	(2) 230.0 (223–235; 6)	
BILL	(2) 27.2 (26–28; 6)	
TARSUS	(2) 30.7 (30–32; 6)	
TAIL	(2) 90.0 (87–93; 6)	

Additional measurements in Murphy (1929) and Bartle (1967).

WEIGHTS Label data from adult skins (NMNZ): Cuvier, Great and Little Barrier Is, NZ, Nov.–Mar.; birds had some fat to very fat: males 164.0 (61.25; 112–250; 3); females 192.7 (29.33; 149–240.8; 7). No data on seasonal changes.

STRUCTURE Wing, long and narrow. Eleven primaries: p10 longest, p9 2–7 mm shorter, p8 13–19, p7 27–32, p6 41–50, p5 61–70, p4 79–90, p3 98–109, p2 115–127, p1 130–142, p11 minute. No emarginations. Twenty secondaries, including four of tertial form. Tail, moderately long and square; 12 rectrices, t1 longest, t6 13–18 mm shorter. Bill, slender and short; maxillary unguis, hooked. Nasal tube c. 25% of length of bill. Legs and feet, slender; feet, webbed. Claws, long, narrow and curved. Outer and middle toes approximately equal in length. Inner c. 84% of middle, hind, claw only, c. 10%.

RECOGNITION Confusion possible with Pycroft's Petrel *P. pycrofti*, which may have white wedge-shaped marks on inner webs of primaries, as in Cook's (J.A. Bartle). Occurrence of this (now considered diagnostic for Cook's) should be investigated.

GEOGRAPHICAL VARIATION Monotypic (e.g. Bourne 1983). Forms superspecies with *P. defilippiana*, *P. longirostris*, and *P. leucoptera* (Peters).

RMO

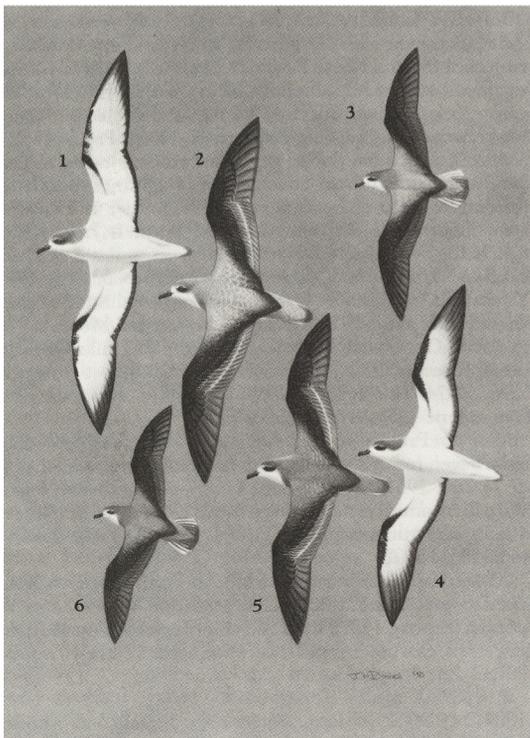
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J.N. Davies '90



Volume 1 (Part A), Plate 37

Cook's Petrel *Pterodroma cookii*

- 1. Adult, ventral, fresh
- 2. Adult, dorsal, fresh
- 3. Adult, dorsal, worn

Pycroft's Petrel *Pterodroma pycrofti*

- 4. Adult, ventral, fresh
- 5. Adult, dorsal, fresh
- 6. Adult, dorsal, worn

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