

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.

References

- Bang, B.G. 1966. *Acta anat.* 65: 305-415.
 Bourne, W.R.P. 1976. Pp 403-502. **In:** Johnston 1976.
 Brodkorb, P. 1963. *Bull. Flor. St. Mus. biol. Sci.* 7: 179-293.
 Clarke, A., & P.A. Prince. 1976. *J. Exp. mar. Biol. Ecol.* 23: 15-30.
 Fisher, J. 1952. *The Fulmar*.
 Harper, P.C. 1978. *NZ J. Zool.* 5: 509-549.
 Johnston, R. (Ed.). 1976. *Marine Pollution*.
 Klemm, R.D. 1969. *S. Ill. Univ. Monogr. Sci. Ser.* 2.
 Obst, B.S. 1986. *Wilson Bull.* 98: 189-95.
 Olson, S.L. 1975. *Smithson. Contr. Paleobiol.* 23.
 Swennen, C. 1974. *Ardea* 62: 111-117.
 Timmermann, G. 1965. *Abh. Verh. naturwiss. Vereins Hamburg NF* 8, Suppl. 1-249.

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.

REFERENCES

- Brodkorb, P. 1963. *Bull. Flor. St. Mus. biol. Sci.* 7: 179-293.
- Cox, J.B. 1980. *Rec. S. Aust. Mus.* 10: 91-121.
- Fleming, C.A. 1941. *Emu* 41: 134-55.
- Harper, P.C. 1980. *Notornis* 27: 235-86.
- Imber, M.J. 1985. *Ibis* 127: 197-229.
- Kuroda, N. 1954. *On the classification and phylogeny of the order Tubinares, particularly the shearwaters (Puffinus), with special consideration on their osteology and habit differentiation.* Tokyo.
- Murphy, R.C., & J.M. Pennoyer. 1952. *Am. Mus. Novit.* 1580.
- Olson, S.L. 1975. *Smithson. Contr. Paleobiol.* 23.
- Voous, K.H. 1949. *Ardea* 37: 113-22.

Pachyptila belcheri **Slender-billed Prion**

COLOUR PLATE FACING PAGE 528

Heteroprion belcheri Mathews, 1912, *Birds Aust.* 2: 215, text figs 224 — coast of Victoria, 13 miles south of Geelong (= Torquay).

Named in honour of Sir C.F. Belcher (1876–1970), born in Victoria, Australia; judge in Nyasaland and West Indies, 1920–37.

OTHER ENGLISH NAMES Thin-billed or Narrow-billed Prion.

Slender-billed seems somewhat more widely used in modern literature than the other terms but there is little to choose between them.

MONOTYPIC

FIELD IDENTIFICATION Length 26 cm; wingspan 56 cm; weight c. 150 g. Small, pale prion of subantarctic and Antarctic waters; head small and body slender, with slender bluish bill; mostly or wholly white lores and broad white

supercilium give striking pale-faced appearance; pale bluish-grey upperparts with indistinct open M-marking across wings and narrow black tip to tail. Sexes alike; no seasonal variation in plumage. Juveniles inseparable.

DESCRIPTION ADULT. Forehead and crown, pale blue-grey, uniform with hindneck and saddle; dark bluish-grey sub-orbital stripe extends from in front of eye to rear of ear-coverts; lores, usually white (on some, narrowly interrupted with grey between eye and forehead); combine with long broad white supercilium, extending to above rear of ear-coverts, to give striking pale-faced appearance. Blue-grey of hindneck extends onto sides of neck and upper breast forming rounded half-collar; collar appears richer blue on bottom half. Forehead and crown become darker with wear, contrasting slightly with grey of hindneck and saddle. Upperparts, pale blue-grey except for narrow ill-defined blackish open M-marking across wings (joining across rump); thin white trailing-edge to secondaries; scapulars, narrowly tipped white; narrow black terminal tail-band not extending onto outer two rectrices. On upperwing, area behind M-marking, especially remiges, appears paler than blue-grey of inner forewing and translucent when backlit; with wear, upperparts become smoky grey and M-mark noticeably brownish. Underparts, white except for pale blue-grey half-collar, blackish streak on centre of undertail (formed by blackish central rectrices and central under tail-coverts) and faint greyish trailing-edge to underwing. Bill, slender, not deep at base in profile (*c.f.* most Antarctic Prions *P. desolata*); pale blue except for blackish nostrils, culminicorn and sulcus. Iris, dark brown. Feet, lavender-blue; webs, creamy yellow.

SIMILAR SPECIES Combination of striking white-faced appearance (supercilium broadest and most extensive of all prions; Harper 1972), pale plumage, narrow indistinct M-mark, narrow tail-band and slender bill distinguish Slender-billed from all other prions. For distinctions from **Broad-billed** *P. vittata*, **Antarctic** and **Salvin's** *P. salvini* Prions, see those accounts. **Fairy** *P. turtur* and **Fulmar** *P. crassirostris* Prions are similar in size and shape but appear slightly smaller-headed, with broader, blacker more distinct M-mark, broader black tail-bands, richer blue plumage, shorter collar and paler head with indistinct facial pattern and less well defined supercilium; bill, shorter and stouter; black area on undertail,

shorter and broader. For distinctions from **Blue Petrel** *Halo-baena caerulea*, see that text.

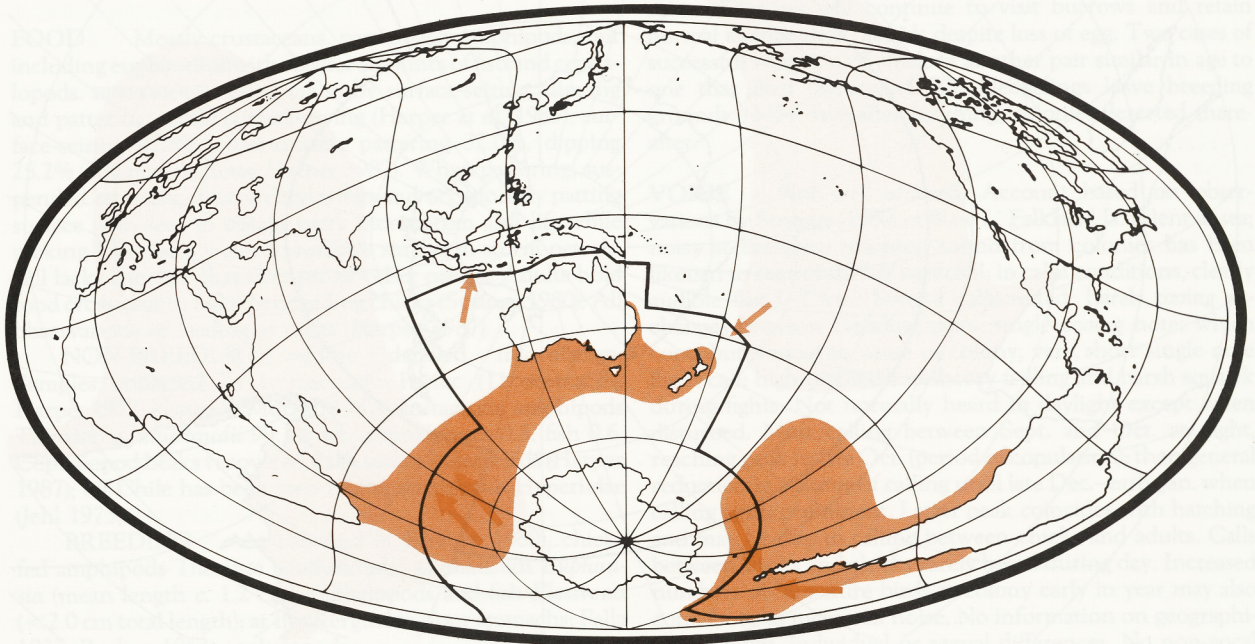
Pelagic, in Antarctic and subantarctic waters, ranging into subtropical waters. Sometimes seen from land during onshore gales. Flight, fast, buoyant and erratic in all weather, low to water, with brief bursts of shallow rapid wing-beats between twisting glides. Head and neck appear small and slim (not usually tucked into body as in Antarctic Prion), and often, projection of body appears about equal in front of and behind wings (though can appear longer-tailed when tail tightly folded). Feed by surface-seizing, dipping and pattering, rarely surface-diving; mostly at night. Solitary or gregarious at sea; often form large feeding flocks and often seen with Antarctic Prions. Do not usually follow ships though flocks will circle stationary ships and feed on food brought to surface by propeller. Breed colonially on islands in South Atlantic and s. Indian Oceans. Silent at sea; utter harsh cooing and squawking notes at colonies.

HABITAT Marine, pelagic; in subantarctic and Antarctic waters, S to limit of pack-ice. In Antarctic Zone, regular in open waters with sea surface-temperatures from -2 to 3.6 °C, but do not penetrate edge of pack (Harper 1972); observed feeding near icebergs (Falla 1937). Feed close inshore when breeding or in shallow waters offshore (Imber 1981). However, in Falkland Is do not feed inshore at breeding islands, but near islands 30–50 km away, where Falkland Is current causes upwelling and tidal streams (Strange 1980).

Breed on subantarctic islands in Indian and Atlantic Oceans; on sheltered coasts, islets, plateaux. Burrow in stony soils or volcanic ash, up to 300 m asl (Despin *et al.* 1972; Weimerskirch *et al.* 1989). At Falkland Is, nest in valleys and sand dunes, in soft soil or under rocks; nests placed among low vegetation (*Empetrum*, *Poa*, *Bolax*) (Cawkell & Hamilton 1961; Strange 1980).

Fly usually within few metres of sea surface, from which they feed (Strange 1980; Harper 1987).

Little published information, but areas of *Poa* used for



nesting may be degraded by grazing by introduced mammals or by fire (Falkland Is; Strange 1980).

DISTRIBUTION AND POPULATION Pelagic distribution generally circumpolar, ranging from Antarctic to subtropical waters N to 30°S during winter and spring. Indian Ocean populations range E to Aust. and NZ.

AUST. Common s. Aust. waters, especially SW; less common off e. coast. **Qld.** Six records: one beachcast, Fraser I., Sept. 1973 (Vernon & Martin 1974); singles beachcast, Aug., Burleigh Heads and North Stradbroke I. (no dates; Roberts 1979). Sightings off Pt Lookout: three, 11 July 1983; one, 17 July 1983; three, Aug. 1986 (Qld Bird Reps 1983, 1986). **NSW.** Uncommon to scarce July–Oct., with moderate numbers occasionally found beachcast (Morris *et al.* 1981). Twenty beachcast specimens from entire coastline between 1972 and 1975. Before 1973, only known as far N as Newcastle (Morris 1974). **Vic.** Winter visitor; mainly beachcast. All from w. and central coasts. Occasionally large numbers beachcast: 171 collected between Wilson's Prom. and Discovery Bay, Aug. 1985 (Vic. Bird Rep. 1985). **Tas.** Common winter visitor; often beachcast (Green 1977). Specimens collected from all coasts and King and Flinders Is. **SA.** Regular and often beachcast between May and Aug (Cox 1976; Parker *et al.* 1979). Usually singly or in small numbers. From w. Eyre Pen. to e.

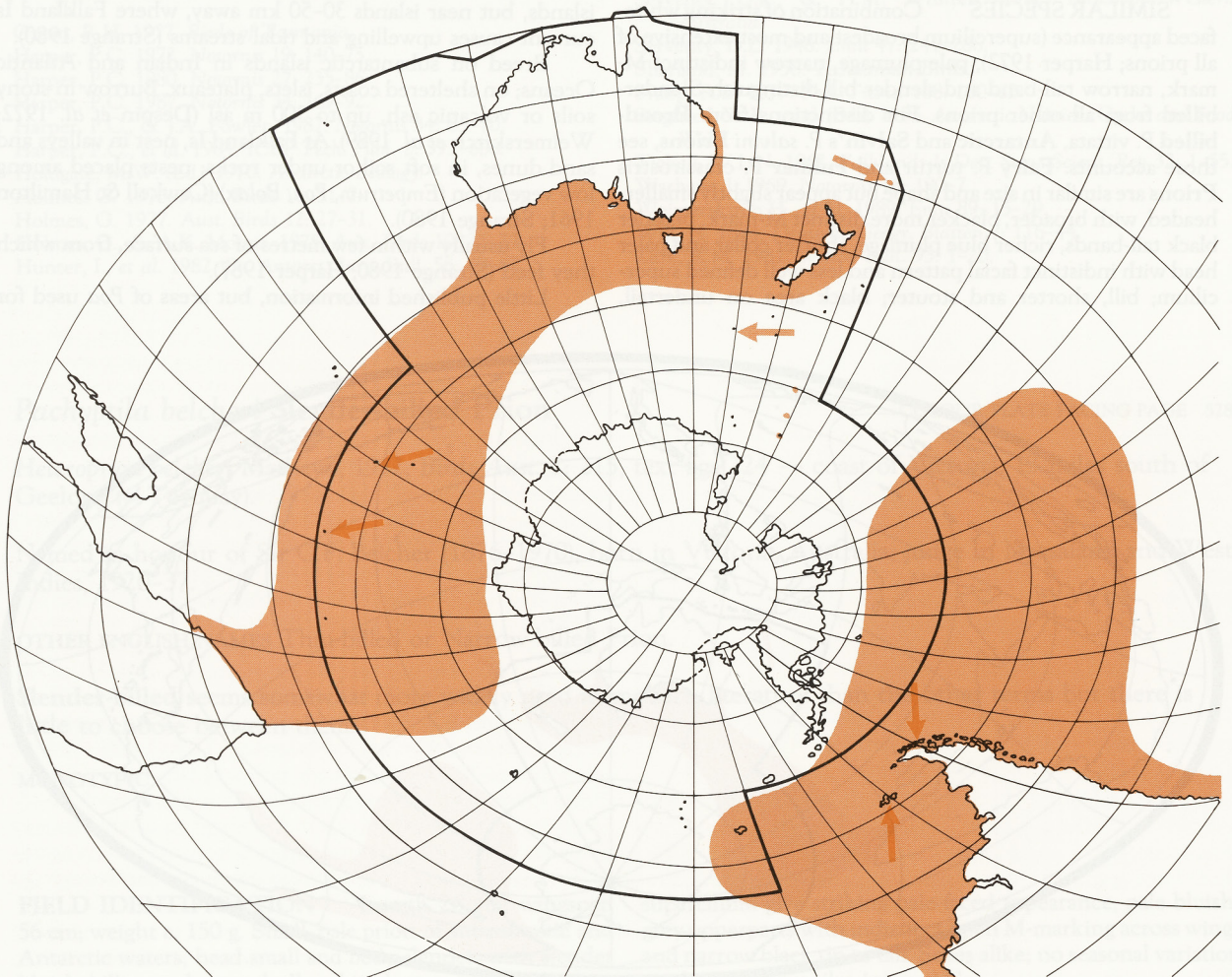
Gulf St Vincent and Encounter Bay. Also Kangaroo I. (Parker *et al.* 1979). **WA.** Frequent visitor to sw. coast (Serventy & Whittell 1976), where not beachcast as often as Antarctic Prion (Serventy 1948). Also recorded from Great Australian Bight (Dymond 1988).

NZ Immatures commonly beachcast winter (Harper 1980; Powlesland 1989). **NI.** Beachcast birds mostly collected from w. coast: between 1976 and 1986, 2396 on Auckland West beaches at rate of 13.9 birds/100 km (Powlesland 1989); 222 found Wellington West beaches in same period. Relatively scarce e. coast. **SI.** Less common than NI. Most often recovered e. coast between Canterbury North and Southland. Only two picked up on w. coast, 1976–86.

Extralimital: rare vagrant to s. African coast, from False Bay to Zululand (MacLean 1985). Regular winter visitor off Chilean coast, and central and s. Peru (Hughes 1970; Jehl 1973; Plenge 1974). Winters off Argentina, possibly as far N as Sao Paulo, Brazil (de Schauensee 1970). Recorded Java (Harper 1980).

Wrecks in NSW in July 1954 (Hindwood & McGill 1955); Vic. in 1985 (Vic. Bird Rep. 1985); Auckland West, NZ in 1974 and 1986 (Powlesland 1989).

BREEDING On islands between Subantarctic and Subtropical Convergences in s. Indian, Atlantic and Pacific Oceans:



Ile de l'Est, Iles Crozet: 10s (Jouventin *et al.* 1984)
 Iles Kerguelen: 7×10^5 - 1×10^6 pairs (Weimerskirch *et al.* 1989).

Possibly breed Macquarie I. (Brothers 1984; Rounsevell & Brothers 1984) and remains of birds found at S. Georgia (Tickell 1960) suggest breeding population but confirmation needed. Extraliminally, breed Falkland Is ($> 1 \times 10^6$ pairs; Croxall *et al.* 1984) and Isla Noir (s. Chile; Clark *et al.* 1984); possibly Staten I. and offshore islets of Tierra del Fuego (Harper 1972; Cox 1980).

Cats prey on Prions on Iles Kerguelen, but Ile de l'Est is free of both cats and rats. Falkland Is population has history of depredation and exploitation. Eradication of introduced predators and revegetation have recently been started (Croxall *et al.* 1984) and population appears to be increasing and occupying new sites (Lindsey 1986).

MOVEMENTS Dispersive or migratory, W from Falkland Is, E from Indian Ocean.

DEPARTURE Falkland Is, mid-Mar. (Strange 1980); assumed to leave breeding grounds in Indian Ocean at a similar time.

NON-BREEDING From Falkland Is apparently travels W into South Pacific but not as far as NZ; movements from Kermadec Is and Ile de l'Est, Iles Crozet, largely E (Harper 1972). Post-fledging movement more extensive than that of adults with immatures predominating among birds beachcast NZ. All age groups recorded from s. Aust. and mostly adults off WA, May-Sept. (Harper 1980). Of 1385 immatures beachcast on NZ beaches, 56.8% male (Harper 1980), peak mortality occurring winter with major wrecks 1974 and 1986 (Powlesland 1989).

RETURN Arrive breeding grounds Falkland Is (Strange 1980) and Iles Crozet (Jouventin *et al.* 1985) early Sept.

BREEDING Indian Ocean breeders may feed as far E as Macquarie I. unless they do, in fact, breed there (P.C. Harper).

FOOD Mostly crustaceans, particularly amphipods, but including euphausiids with smaller amounts of fish and cephalopods. **BEHAVIOUR** Food taken by surface-seizing, dipping and pattering, rarely surface-diving (Harper *et al.* 1985); surface-seizing 42.8% observations, pattering 32.0%, dipping 25.2% (306 observations; Harper 1987). When pattering, suspended on stiffly outstretched wings and occasionally patting surface with feet to obtain extra momentum and lift while picking food from water in manner similar to storm-petrels. Bill lacks lamellae characteristic of other prions. Adults hold food crossways in bill when feeding chicks (Strange 1980). All observations of feeding at night (Harper 1987).

NON-BREEDING Little detailed information. Samples collected in subantarctic Pacific (11 stomachs; Harper 1972; Prince & Morgan 1987) crustaceans, amphipods *Themisto gaudichaudii* 99.1% wt., cephalopods 0.3, fish 0.6. Cephalopod beaks recovered from storm-killed birds (Harper 1987); off Chile has been seen taking amphipods Hyperiidæ (Jehl 1973).

BREEDING At Falkland Is (Strange 1980), chicks fed amphipods *Themisto gaudichaudii*, euphausiids *Euphausia* (mean length c. 1.2 cm), cephalopods and fish *Electrona* (<2.0 cm total length); at Iles Kerguelen (four stomachs; Falla 1937; Paulian 1953) cephalopods.

SOCIAL ORGANIZATION Gregarious when feeding at sea and when breeding. Feeding flocks may number a few dozen to low hundreds. In non-breeding season (Sept.-Mar.) single birds scattered over a wide area of South Pacific (Harper 1972). Little information on behaviour at sea.

BONDS Monogamous. No information on length of pair-bonds; probably long lasting. Both parents incubate and tend young until fledging.

BREEDING DISPERSION Not truly colonial; nest in burrows in open sites. Strongly territorial; details of densities of nests not recorded.

ROOSTING At nest-sites in breeding season; on sea at other times.

SOCIAL BEHAVIOUR Generally silent, without communication at sea. On land, aggressive to conspecifics, uttering harsh squawks. Most noise in colony due to cooing exchanges between mates. On arrival at colonies, spend much of day roosting at nest-site, becoming active at night.

AGONISTIC BEHAVIOUR Ownership of nest-site advertised by holding wings high over back and neck outstretched. **FIGHTS** common; often between three birds; only brief contact made, accompanied by high-pitched screams (Strange 1980). Chicks sometimes killed by trampling during disputes between breeders and unemployed birds that are present during courtship, building and excavation of burrows.

SEXUAL BEHAVIOUR Copulation observed c. 6 weeks after arrival of first birds at breeding ground (Strange 1980). First bird of pair to arrive sits at entrance of burrow and occasionally emits high-pitched trill. Duetting follows arrival of mate with rapid chattering calls and allopreening c. 20 min before coition; trilling becomes more intensive at coition.

RELATIONS WITHIN FAMILY GROUP No detailed knowledge. Chick brooded continuously and alternately by parents for 46-47 days ($n=25$ pairs; Strange 1980). Shifts during incubation 4-7 days, rarely 8-9 days; male takes first shift, female the last and is always present when egg hatches. Chick begins calling 2-3 days before hatching. Unsuccessful pairs will continue to visit burrows and retain normal change-over periods despite loss of egg. Two cases of successful adoption of chick of another pair similar in age to one that died (Strange 1980). Fledgelings leave breeding grounds 43-54 days after hatching; colonies deserted thereafter.

VOICE Not well studied. Account based on observations by Strange (1980) at New I., Falkland Is. Silent at sea; noisy at breeding colonies, sound from colonies has been likened to roar of surf or waterfall; in calm conditions, clearly audible for 1-2 km. Several calls noted: harsh cooing exchanges between breeding pairs; single cooing note, which contributes most to noise of colony; very short single note flight-call; high-pitched copulatory trilling and harsh squawk during fights. Not normally heard in daylight except when disturbed. Most calling between Sept. and Oct. at night, reaching peak in late Oct. (period of copulation); then general reduction in volume of calling until late Dec.-early Jan. when calling again prominent. Latter peak coincides with hatching and may be due to calling between chicks and adults. Calls between adults and chicks rarely heard during day. Increased numbers of immature birds at colony early in year may also contribute to increased noise. No information on geographical variation, individual or sexual differences. No non-vocal

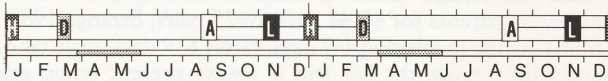
sounds reported.

ADULT Five calls identified (Strange 1980). (1) **Cooing**. Two forms: repeated harsh *cooing* made of four notes at one pitch with higher fifth note, sequence being repeated several times; appears to be given by only one member of pair; succession of single *cooing* notes usually in lower key, which most common and create most sound in colony for much of season; appears to be exchange between members of pair when meeting. (2) **Flight Call**. Short single-note call (undescribed) occasionally given by birds flying over colony or during flight into island at night. (3) **Squawk**. Brief harsh *squawks* given during fights. (4) **Copulation Call**. Very high-pitched trilling sound that may continue for several seconds; characteristic of courtship period, uttered by one bird of pair during copulation. (5) Rapid succession of fairly high-pitched single notes; often continued without interruption for 2.5 min and bouts repeated after short pauses; call has only been noted in Oct. and seems to be confined to one member of pair.

YOUNG Up to 30 days old, beg with cheeping call; as calling becomes stronger, sounds similar to adult Copulation Call. Older chicks have call similar to adults but not so strong.

BREEDING Not well known. Studied only in Falkland Is outside our limits (Strange 1980). Information supplied by P.C. Harper. Breed colonially, often in large numbers (thousands).

SEASON Birds return to colonies from mid-Aug. but generally in early Sept.; colonies fully occupied by 18 Sept. Copulation from mid-Oct., followed by prelaying exodus of 21–22 days. Laying in middle 2 weeks of Nov. Hatching 27 Dec.–12 Jan., mostly before 6 Jan. Departure early to mid-Mar. (Cawkell & Hamilton 1961; Strange 1980 for two seasons).



SITE Burrows in peat, sand, under rocks, tussock-grass; sometimes simply under cover of dense *Empetrum rubrum*. In open pastures, often in such density that pastures damaged and horses sink into soil when crossing; from c. 15 to 200 m asl (Cawkell & Hamilton 1961). Burrows usually oval in cross-section, 25–30 cm in circumference; turn to the side under ground, may anastomose and branch into more than one nesting chamber; as many as 12 birds have been found to use one tunnel system. Where loose rock covered by thin soil, birds excavate between rocks to produce intricate system of burrows and nest-chambers. Tunnels usually 0.6–1.5, even up to 3.5 m long. Nests under tussock-grass always at end of tunnels that slope down gently and then turn (Cawkell & Hamilton 1961).

NEST, MATERIALS Nesting chamber contains a little dry grass and feathers (Cawkell & Hamilton 1961; Harper 1980) or coarse leaves and twigs, sometimes goose droppings (Strange 1980).

EGGS Large, almost elliptical; chalky coated, mat; white, becoming stained light brown with peat (Strange 1980).

MEASUREMENTS:

Iles Kerguelen: 50, 49.5, 46, 47.7 x 36, 35.5, 34, 34.2 respectively (four eggs, Falla 1937); Ile de l'Est: 46, 51.1 x 33, 36.2 respectively (two eggs, Despin et

al. 1972);

Falkland Is: 46–50 x 34–37 (n=20; Strange 1980).

WEIGHTS: Falkland Is: 30.64 (28.6–32.7; 10 fresh) (Strange 1980).

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

LAYING Well synchronized. In Falkland Is, laying started 8 Nov., peaked 16–17 Nov., last egg 22 Nov. (Strange 1980).

INCUBATION By both sexes equally. Females leave soon after laying and then sexes alternate in shifts of 4–7 days, rarely 8–9, but egg may be deserted for c. 24 h at times within last 12 days of incubation (n=7); female usually incubating when egg hatches. **INCUBATION PERIOD:** 46–47 days (n=25) with pipping of shell and calling by chick from 43–44 days (Strange 1980). A single bird has been known to incubate for 32 days in all, repeatedly deserting egg for 1–6 day periods and at last abandoning egg after normal incubation period had been exceeded. Unsuccessful pairs continue to use burrows after losing egg, with change-overs as expected (Strange 1980).

NESTLING Semi-altricial, nidicolous. Hatched in grey or lavender-coloured protoptile; bill as in adult but with egg-tooth; feet and legs, light blue-grey; webs, flesh coloured. **NESTLING PERIOD:** 49–50 days (43–54; 10) (Strange 1980). Fed by incomplete regurgitation in cross-billed method from 24 h after hatching. On female's return just before hatching, her crop and stomach full of oily food in preparation for feeding young. Departure 13 Feb.–4 Mar. (Strange 1980).

GROWTH Weight at hatching 10–15 g; maximum, c. 270 g, reached at c. 34 days old; decreases to 155–160 g at fledging (Strange 1980, where also further details of gain of mass and development of plumage).

FLEDGING TO MATURITY, SUCCESS No data. Chicks may be trampled to death and may succumb to heat stress; adult may become entangled in tussock-grass. At Falkland Is, skuas *Catharacta* most important predator, in soft peat digging out incubating birds with great accuracy and catching fledgelings and adults. Peregrine Falcons *Falco peregrinus*, Kelp Gulls *Larus dominicanus*, Striated Caracaras *Phaloboenus australis*, and Short-eared Owls *Asio flammeus* also take adults and fledgelings. Feral cats and dogs do some damage but Prions are or were so numerous that heavy predation by cats made little difference. Some eggs taken for food by humans (Cawkell & Hamilton 1961; Strange 1980).

PLUMAGES Based on birds from Kerguelen Is. Age of first breeding unknown.

ADULT In fresh plumage: **HEAD AND NECK.** Crown, grey (87); concealed bases of feathers, pale grey (86); rachis, dark brown (119A). Forehead, narrowly fringed white; fringes broader at lores and at margins of lower mandible. Sub-orbital patch, dark grey (83); anterior margin, grey-black (82). White supercilium connects with lores, terminates above ear-coverts. Side of neck, blue-grey (c88), forming incomplete collar, which varies and most often absent. Rest of head and neck, white; demarcation at sides of neck, sharp. Feathers at demarcation from malar region to collar, varyingly mottled light grey (85). Interramal space, bare. **UPPERPARTS.** Mantle, back and rump, blue-grey (c88); concealed bases of feathers, dull white; rachis, dark brown (121) and fine. Mantle, back and rump, fringed light grey (85). On lower back, fringes, dark grey (83); distal tip of rachis, black-brown (119); feathers form central part of M-shaped marking when wings spread. Scapu-

lars, basally pale grey (86), with broad sub-terminal black-brown (119) band; scapulars broadly tipped white, particularly on outer web; innermost scapulars, mostly dark brown (121); some very narrow white tips. Rachis of scapulars, basally brown-grey (80) merging to darker brown-grey (-) distally. TAIL, dull blue-grey (88); rachis, dark olive-brown (129); distal tip of tail, black-brown (119). Black-brown (119) tip on t1, t2 and t3 prominent; tips progressively narrower from t1 to 3; t4-6, light grey (85). UPPERWING. Marginal coverts at humeral joint, white. Marginal, lesser and tertial coverts, dark brown (121); feathers narrowly fringed light grey (85); rachis, dark brown (121); feathers form part of M-shaped marking when wing spread. Median and greater coverts, grey (87), fringed light grey (85). Greater coverts and secondaries tipped pale grey (86). Tertials similar, but outer web suffused dark brown (121). Alula, marginal coverts near alula, and greater primary coverts, dark brown (121); marginal coverts near alula, narrowly fringed grey (84); greater primary coverts have narrow white tips. P10-7, black-brown (119) on outer web; inner web, mottled grey (84), merging to white; rachis, grey-black (82); p8-p1 P6-1, grey (87); rachis, basally grey-brown (91), merging to grey-black (82) distally. All primaries, narrowly tipped white. UNDERPARTS, almost entirely white. Feathers on outer breast, tipped grey (87); beneath closed wing, some have mottled paler-grey (c87) tips. Flanks, white, with varying mottled light-grey (85) tips. Lowermost flank feathers, next to abdomen, have broad light-grey (85) sub-terminal tips, narrowly tipped pale grey (86). Axillaries, white, varying mottled light blue-grey (88) on webs. Two longer outermost under tail-coverts, tipped black-brown (119); next innermost, varying mottled grey (84) and white; rachis, white. Rest of under tail-coverts similar to lower flank feathers. UNDERWING, almost entirely white. Marginal coverts from base of p11 to carpal joint, have outer webs dark brown (121) and inner, white, or dark brown (121) fringed white.

In worn plumage: white fringes on forehead and at margins of lower mandible, and white tips on primaries, lost. Similarly, white tips to scapulars mostly lost. With wear, plumage becomes darker. M-shaped marking occasionally worn but still visible (photo in Harper 1972).

DOWNY YOUNG Protophyle, grey-brown. Mesophyle, longer, smoky-grey (NZRD). Most down lost at 48-52 days; down lost last on back of head, neck and underparts; birds often leave nest with small amounts of down on back of head and under tail (Strange 1980). See Strange (1980) for full details of plumage changes in chicks. Fledge mid Feb.-early Mar. (Harper 1980).

JUVENILE Similar to adult in fresh plumage; few plumage characters present to distinguish from adult; Strange (1980) states that alula is less well defined and dark grey rather than slaty brown; also distinguished on bare parts.

ABERRANT PLUMAGES Albinos recorded (Falla 1933; MV).

BARE PARTS Based on photos in Lindsey (1986).

ADULT, JUVENILE Iris, dark brown (219). Bill, light blue-grey (88); culminicorn, sulcus and nostrils, grey-black (82). Maxillary unguis, light grey (85). Interramal space, no information; probably similar to other prions. Tarsus and toes, light blue (88); webs, pink-brown (219B). Claws, pale grey (86), tipped grey-black (82). Legs and toes also described as vivid blue to slate- or violet-blue; webs, pink, grey, whitish or cream (Strange 1980). Juvenile stated as having bill and feet slightly duller than adults (Strange 1980).

DOWNY YOUNG Few data; bill, grey-black (82). Bill very similar to adult, but egg-tooth white, lost at 14 days (Strange 1980).

MOULTS

ADULT POST-BREEDING Complete; body-moult begins near end of breeding season, in Mar.; new plumage by May (Harper 1980). Moult completed by May or June at sea (Harper 1972). Primaries moult outwards, with few adjacent inner primaries lost simultaneously (photo in Harper 1972). Duration and sequence require further study.

POST-JUVENILE Sub-mature birds from Falkland Is, moult in Antarctic South Pacific waters in Dec. (Harper 1972); those from South American quadrant often do not enter Pacific (e.g. de Schauensee 1966).

MEASUREMENTS (1) Beachcast birds, status unknown; methods unknown (Condon 1944).

	MALES	FEMALES
WING	(1) 180.3 (2.86; 177-184; 3)	183.3 (3.68; 179-188; 3)
TAIL	(1) 91.6 (2.35; 90-95; 3)	97.0 (4.08; 92-102; 3)
BILL D	(1) 5.6 (0.47; 5-6; 3)	4.8 (0.23; 4.5-5; 3)
BILL W	(1) 9.6 (0.47; 9-10; 3)	9.6 (0.23; 9.5-10; 3)
TOE	(1) 38.1 (1.31; 37-40; 3)	38.0 (0.81; 37-39; 3)

Unsexed birds. (2) Iles Kerguelen, live adults; methods unknown (Weimerskirch *et al.* 1989). (3) NZ, fresh birds, juveniles; methods unknown (Harper 1980). (4) Iles Kerguelen, adult skins; methods unknown (Harper 1980). (5) Falkland Is, adult skins; methods unknown (Harper 1980).

	UNSEXED
WING	(2) 181 (4.4; 172-190; 66) (3) 177 (4.69; 166-190; 45) (4) 181 (4.11; 175-187; 14) (5) 183 (3.37; 175-191; 71)
TAIL	(3) 82 (4.69; 74-93; 45) (4) 89 (4.86; 82-95; 14) (5) 87 (3.37; 81-96; 71)
BILL	(2) 25.3 (0.9; 23.0-27.3; 66) (3) 24.6 (0.67; 23-26; 45) (4) 25.2 (0.74; 24.6-27.0; 14) (5) 25.0 (0.84; 23.4-27.6; 71)
BILL W	(2) 11.4 (0.4; 10.2-12.5; 66) (3) 10.4 (0.67; 9.3-11.5; 45) (4) 11.1 (0.37; 10.5-12; 14) (5) 10.3 (0.84; 9.0-11.5; 71)
TARSUS	(2) 34 (1.1; 31-36; 66)

Additional measurements in HASB, Oliver, Harper (1972), Despin *et al.* (1972), Mouglin (1975), Cox (1980), Strange (1980) and Jouventin *et al.* (1985). In immature skins, bill width shrinks c. 8.4%; when fresh, 10.4 (9.3-11.5; 20); after drying, 9.5 (8-11) (Harper 1980). Kinsky & Harper (1968) found shrinkage: in adults, 13% (4.0; 5-16; 5); immatures 12% (2.0; 8-15; 8).

WEIGHTS At Iles Kerguelen: 145.1 (12.5; 118-180; 66) (Weimerskirch *et al.* 1989). Additional adult weights in Harper (1972). Details of changes of weight of chicks in Strange (1980).

STRUCTURE Wing, short and narrow. Eleven primaries, p9 usually longest, p10 0.5 mm shorter, p8 3–6, p7 18–22, p6 30–34, p5 43–46, p4 57–59, p3 70–73, p2 80–85, p1 96–100, p11 minute. No emarginations. Eighteen secondaries, four of tertial form. Twelve rectrices, t1 longest, t6 20–23 mm shorter. Maxillary latericorns, straight sided; unguis, weakly developed. Bill lamellae absent. Interramal space, bare and slightly distensible. Outer toe c. 108% of middle, inner c. 88%, hind, claw only.

SEXING, AGEING Females sexed on distension of abdomen during breeding season (Strange 1980). Juveniles have high culmen, greater bill-depth and soft latericorn, which distinguishes them from adults (Harper 1980).

RECOGNITION Bill measurements: average 26.5 mm long, 14 mm wide. Juveniles have weak bill. Adult *P. belcheri* distinguished from *P. turtur* by having culminicorn measuring no less than 8.3 mm, usually c. 9.2 mm; in *P. turtur*, this is an average of 5.1 (4.2–6.0 mm) (Harper 1980). Bill measurements of allopatric populations of *P. belcheri* and *P. desolata* sometime overlap, but populations from Iles Kerguelen and Ile de l'Est, Iles Crozet, indistinguishable (Cox 1980). Iles Kerguelen *P. desolata* (= *P.d. desolata*) like adult *P. belcheri*; dried specimens not like adult *P. belcheri* however (Harper 1980). Falla (1937) stated that both forms could be recognized only by compression of maxillae and consequent slight concavity of outline when viewed dorsally. Bill shapes of *P. belcheri* and *P. desolata* from Iles Kerguelen vary (see illustrations in Cox 1980). Some *P. desolata* have bowed outlines to bills but others have straight outlines. Some *P. belcheri* do not show slight concavity in dorsal outline. Live and fresh beach-cast specimens however show no indication of concavity (Cox 1980). Concavity of bill outline can be caused by shrinkage and consequent inward contraction of latericorns on drying specimens. Smallest *P. belcheri* has very slight concave outlines. Bill-width between largest *P. belcheri* and smallest *P. desolata* only 0.7 mm (Cox 1980). Some *P. belcheri* have shortest wings, but their measurements overlap widely with those of *P. desolata*. However, *P. belcheri* usually have longer tarsus than those *P. desolata* that have only slightly larger bills. At Falkland Is, where *P. belcheri* is only breeding form, distinct from *P. desolata* by bill-width, which not known to exceed 11.5 mm. Most *P. desolata* can be distinguished by having wider bill and shorter tarsus.

GEOGRAPHICAL VARIATION No subspecies recognized (Aust. CL; Peters). The crown of Iles Kerguelen birds are pale; however, 61% of Falkland Is birds have varying dark crown-feathering (Harper 1980). Iles Kerguelen *belcheri* have slightly shorter bill, with less variance about mean. Falkland Is birds vary more; largest bill 27.6 mm; smallest 23.4

(Harper 1980). Cox (1980) suggests that *belcheri* and *desolata* at Iles Kerguelen are hybridizing on basis of morphological characters (see recognition); this colony may comprise parental and hybrid birds; characters used to distinguish hybrids are unknown. RMO

REFERENCES

- Brothers, N.P. 1984. *Aust. Wildl. Res.* 11: 113–31.
 Cawkell, E.M., & J.E. Hamilton. 1961. *Ibis* 103a: 1–27.
 Clark, G.S., et al. 1984. *Notornis* 31: 320–4.
 Condon, H.T. 1944. *S. Aust. Orn.* 17: 38–42.
 Cox, J.B. 1976. *S. Aust. Orn.* 27: 28–82.
 Cox, J.B. 1980. *Rec. S. Aust. Mus.* 18: 91–121.
 Croxall, J.P. (Ed.) 1987. *Seabirds: Feeding Ecology and Role in Marine Ecosystems*.
 Croxall, J.P., et al. 1984. *ICBP Tech. Publ.* 2: 271–91.
 de Schauensee, R.M. 1966. *The Species of Birds of South America and Their Distribution*.
 de Schauensee, R.M. 1970. *A Guide to the Birds of South America*.
 Despin, B., et al. 1972. *Com. natn. fr. Rech. Antarct.* 31: 1–106.
 Dymond, N. 1988. *RAOU Rep.* 38.
 Falla, R.A. 1933. *Rec. Auck. Inst. Mus.* 1: 137.
 Falla, R.A. 1937. *Rep. B.A.N.Z. antarct. Res. Exped. Ser. B, II*.
 Green, R.H. 1977. *Birds of Tasmania*.
 Harper, P.C. 1972. *Notornis* 19: 140–75.
 Harper, P.C. 1980. *Notornis* 27: 235–86.
 Harper, P.C. 1987. *Notornis* 34: 169–92.
 Harper, P.C., et al. 1985. *BIOMASS Handbook* 24.
 Hindwood, K.A., & A.R. McGill. 1955. *Emu* 55: 148–56.
 Hughes, R.A. 1970. *Ibis* 112: 229–41.
 Imber, M.J. 1981. *Proc. Symp. Birds Sea Shore*: 63–88.
 Jehl, J.R. 1973. *Auk* 90: 114–135.
 Jouventin, P., et al. 1984. *ICBP Tech. Publ.* 2: 609–25.
 Jouventin, P., et al. 1985. *Notornis* 32: 157–220.
 Kinsky, F.C., & P.C. Harper. 1968. *Ibis* 110: 100–102.
 Lindsey, T.R. 1986. *The Seabirds of Australia*.
 MacLean, G.L. 1985. *Roberts' Birds of Southern Africa*.
 Morris, A.K. 1974. *Aust. Birds* 9: 1–11.
 Morris, A.K., et al. 1981. *Handlist of Birds in New South Wales*.
 Mougou, J.-L. 1975. *Com. natn. fr. Rech. Antarct.* 36: 1–195.
 Parker, S.A., et al. 1979. *An Annotated Checklist of the Birds of South Australia*. 1.
 Paulian, P. 1953. *Mem. Inst. Sci. Madagascar* 8A: 111–234.
 Plenge, M.A. 1974. *Condor* 76: 326–30.
 Powlesland, R.G. 1989. *Notornis* 36: 125–40.
 Prince, P.A., & R.A. Morgan. 1987. Pp 135–71. In: Croxall 1987.
 Roberts, G.J. 1979. *The Birds of South-east Queensland*.
 Rounsevell, D.E., & N.P. Brothers. 1984. *ICBP Tech. Publ.* 2: 587–92.
 Serventy, D.L. 1948. *Emu* 47: 241–86.
 Serventy, D.L., & H.M. Whittell. 1976. *Birds of Western Australia*.
 Strange, I.J. 1980. *Gerfaut* 70: 411–45.
 Tickell, W.L.N. 1960. *Ibis* 102: 612–14.
 Vernon, D.P., & J.H.D. Martin. 1974. *Sunbird* 5: 73.
 Weimerskirch, H., et al. 1989. *Emu* 89: 15–29.



Volume 1 (Part A), Plate 39

Blue Petrel *Halobaena caerulea*

- 1. Adult, ventral
- 2. Adult, dorsal

Slender-billed Prion *Pachyptila belcheri*

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

Fairy Prion *Pachyptila turtur*

- 7. Adult, ventral
- 8. Adult, dorsal
- 9. Adult, head

Fulmar Prion *Pachyptila crassirostris*

- 10. Adult, dorsal
- 11. Adult, head

© Jeff Davies