

## 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 PELECANOIDIDAE diving-petrels

The family Pelecanoididae comprises a single genus *Pelecanoides* with 4–5 species, two of which occur in our region. The diving-petrels occupy the niche for small aquatic species feeding on plankton left unoccupied by the penguins, perhaps because a small penguin would have difficulty in getting ashore to breed. They show a remarkable convergence in form and behaviour with the smallest northern Alcidae, especially with the small Atlantic representative of that group, the Little Auk or Dovekie *Alle alle* (Murphy & Harper 1921). They are characterized by having gular pouches for storing food; short wings adapted for use under water rather than for flight, some at least becoming flightless during moult; legs set well back and adapted for swimming; no hind toe; counter-shaded plumage; crepuscular hole-breeding habits; and twittering voices. The main difference from alcids is that they retain the tubular nostrils characteristic of procellariiforms.

Two closely related groups, each representing a superspecies, appear to have developed round the main s. land masses, with an overlapping distribution in subantarctic islands. The group in s. American areas, with a pointed arch to the lower jaw and rounded nostrils, has three species: large *garnotii* in Peru; medium-sized *magellani* in the Chilean channels; small *georgicus* in subantarctic islands. The Common Diving-Petrel *P. urinatrix* of A'asia has a rounded arch to the lower jaw and elongated nostrils, and a much smaller reduction in size southwards, where it overlaps with *georgicus*. Their biology at S. Georgia has been compared by Payne & Prince (1979), who report that among various differences *georgicus* fed mainly on euphausiids, *urinatrix* on copepods.

In general, diving-petrels are small, stocky, compact seabirds with short necks. Wings short, narrow; 11 primaries, p10 longest, p11 minute; 12 secondaries. Tail, short, square; 12 feathers. Bill, short, stubby, hooked; distensible pouch between mandibular rami; nasal tube, about one-quarter of length of bill, pointing upwards, rounded or oval opening with lateral septum. Legs short; tarsus compressed.

Plumage black above, white below. In at least one species, remiges moulted simultaneously with flightless period as a consequence (Watson 1968). Flight whirring, direct, rarely gliding and quite unlike that of other procellariiforms; can dive straight into water from flight without settling first. Gait on land, crawling; unable to stand or walk properly. Feed mostly on crustaceans but may take small fish, by pursuit-diving; use wings under water. Little knowledge of movements but some claimed to be essentially sedentary, others migratory. Social behaviour little known. Breed colonially, in burrows. Eggs, ovate, mat, white. Clutch-size invariably one. Incubation by both adults in alternate shifts. Incubation period, 45–50 days. Young, semi-altricial, nidicolous; hatched in down. Brooded by both parents for a few days. Fed by both parents by incomplete regurgitation. Nestling period, 50–55 days.

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*Pelecanoides urinatrix* **Common Diving-Petrel**

COLOUR PLATE FACING PAGE 688

*Procellaria urinatrix* Gmelin, 1789, *Syst. Nat* 1: 560 — Queen Charlotte Sound, South Island, New Zealand.

*Pelecanoides* is the diminutive from the Greek πελεκάν (pelican) 'having the form, or after the sort, of a pelican' in reference to the loose skin or incipient pouch below the lower mandible. The specific name is Latin for 'diver', in the female form, though this seems not to have been recognized in Latin.

**OTHER ENGLISH NAMES** Diving Petrel, Smaller Diving Petrel.

It is best to avoid vague qualifiers for English names; though common in one place, a species may be rare in another. However without a complete innovation, which is not obvious, **Common** is preferred as the most widely used epithet.

POLYTYPIC Nominate *urinatrix* breeds on islands of se. Aust, NI, NZ, and Cook Str.; *chathamensis* Murphy & Harper, 1916, on Solander, Snares, Chatham Is, and islets round Stewart I; *exsul* Salvin, 1896, on South Georgia, Marion, Crozet, Kerguelen, Heard, Macquarie, Auckland and Antipodes Is; three extralimital subspecies (*dacunhae* Nicoll, 1906; *berard* (Gaimard, 1823) and *coppingeri* Mathews, 1912).

**FIELD IDENTIFICATION** Length 20–25 cm; wing-span 33–38 cm; weight 110–150 g. Small stocky petrel with neckless and short-tailed appearance resembling small auks (Alcidae) of n. hemisphere; very similar to South Georgian Diving-Petrel *P. georgicus* which is very rare in A'sian region; the two species probably indistinguishable at sea. Wings, short and rounded; bill, stubby and black. Feet and legs, short and cobalt blue. Body, black above and white below. Has characteristic whirring flight, close to sea. Dives well, using wings to fly through water. Sexes alike. Juveniles and adults in fresh plumage have pale tips to scapular feathers; feet and legs of adults become brighter cobalt blue during breeding season.

**DESCRIPTION ADULT.** Upperparts, glossy black, becoming browner with wear. Sides of face and neck, mottled grey, often with darker patch on lores and below eye, shading into pale-grey throat. Inner webs of primaries, brownish. Scapular feathers have white tips in fresh plumage. Underparts, white with partial grey collar extending onto sides of breast. Flanks and under tail-coverts have greyish wash. Under wing-coverts vary from heavily smudged brown-grey to pale grey. Bill, black. Iris, brown. Feet and legs, cobalt blue to lavender, brighter during breeding season. **JUVENILE.** Recently fledged young have large white tips to scapulars forming white stripe across base of upperwing; otherwise as adults.

**SIMILAR SPECIES** Cannot be separated reliably from **South Georgian Diving-Petrel** at sea; Common Diving-Petrel averages larger and has darker plumage; under wing-coverts pale grey to dark grey in Common, white to very pale grey in South Georgian Diving-Petrel; however, colour of underwing hard to see in field because whirring wing-action is so rapid. Sides of face, area behind ear and scapulars also darker on Common. In the hand, inner webs of outer primaries, brown (c.f. white to very pale grey in South Georgian Diving-Petrel). Viewed from above, the paraseptal processes in nostrils of Common Diving-Petrels are situated posteriorly, whereas those of South Georgian are near centre of nostril. Viewed from below, rami of Common Diving-Petrels more or less parallel, curving inwards just before joining with mandibular unguis; rami of South Georgian straight and converge evenly. Flight-action of diving-petrels is distinctive and cannot be mistaken for other seabirds in s. oceans.

A bird of waters of continental-shelf but also frequent open ocean. Flight is fast and direct, close to sea, with tail-down aspect and rapid quail-like beats of short rounded wings. Disappear into waves in full flight and dive deeply. Swim very well, resembling tiny penguins; dive from surface; patter along on take-off or emerge from waves in full flight. Usually found in small, loose flocks, particularly near breeding colonies. When nesting, fly straight to mouth of burrow or nearby without circling.

**HABITAT** Circumpolar, usually between 35° and 55°S, from subtropical waters N of Subtropical Convergence to

subantarctic waters N of Antarctic Convergence (Bourne 1968). Identification at sea so difficult that little is known about distribution. Feed in inshore waters round breeding islands; on windy days, feed in thousands near Whero I. (Richdale 1965); hundreds feed over rips N of The Brothers Is (Thoresen 1969); in Iles Crozet, feed in offshore waters up to 300 m deep (H. Weimerskirch). Off NI, NZ, not noted outside inshore zone (Norris 1965). Large numbers in Derwent Estuary, Tas., may have been moulting (Aust. Atlas).

Breed on islands round s. Aust., NZ, South America, and subantarctic islands, with peat or stable soil under vegetation on slopes with direct access to sea; concentrating round coasts, but some burrows may occur far inland (Imber 1983). Terrain generally of coastal slopes, cliffs and ridges but also on flat ground (Downes *et al.* 1959), which may be snow-covered at start of breeding. Vegetational cover may be dense on good soil to sparse on rocky areas; often among tussock grass (Downes *et al.* 1959; Richdale 1965; Thoresen 1967; Brothers 1983, 1984; Cooper *et al.* 1986).

On Heard I., roost on ledges and crannies in cliffs. Fly just above or through waves; avoid flying over land in daylight (Downes *et al.* 1959).

**DISTRIBUTION AND POPULATION** Circumpolar, usually between 35° and 55°S. Breed on islands round s. Aust., NZ and South America and on subantarctic islands. Distributed through s. Indian, Pacific and Atlantic Oceans, mostly between 35° and 55°S. Round Aust., *urinatrix* most common.

**AUST.** Qld: one, beachcast, N. Stradbroke I., Aug. 1961 (Hines 1962). NSW: a few records S of Sydney (Marchant 1977; Fullagar 1989), perhaps more common than records show. Vic.: rarely seen E of Wilson's Prom. and Corner Inlet; common westward to SA border (Vic. Atlas). Tas.: common round coast and in Bass Str. (Aust. Atlas). SA: seven beachcast records from SA-Vic. border to Adelaide (Parker *et al.* 1979). WA: recorded at Albany and Cervantes I., N of Perth (Aust. Atlas).

**NZ** Inshore waters from off Three Kings Is in N, southwards off all coasts but especially N. Cape to E. Cape, Cook Str., Foveaux Str., off Chatham, Stewart and Snares Is (M.J. Imber).

#### BREEDING

**AUST** (from *Seabird Islands Series*, *Corella* 3,4,7,8 unless indicated)

#### Vic.:

Seal Is Grp: Seal I.

Notch I.

Cliffy I.: formerly (Campbell), now probably extinct.

Rag I.: probable.

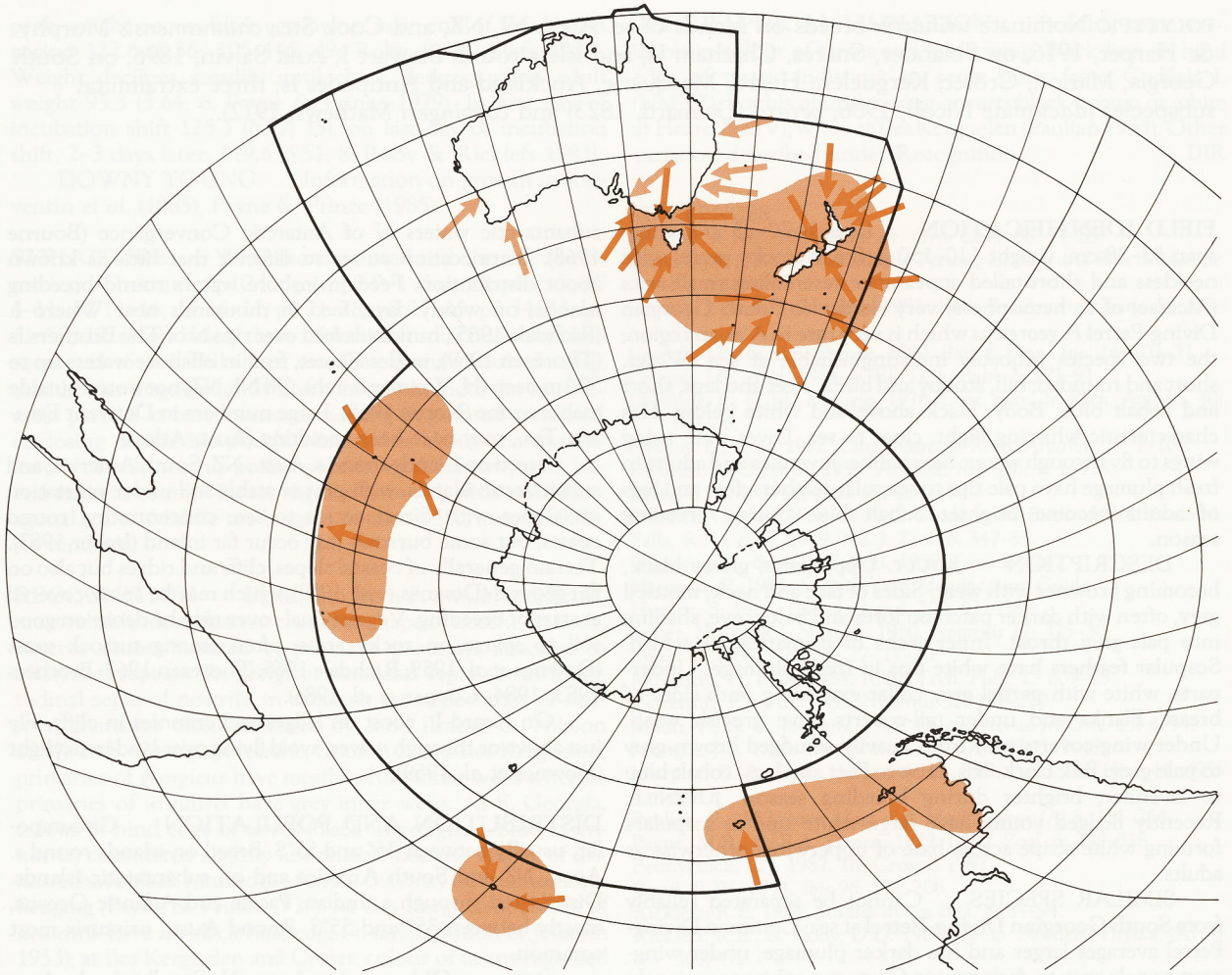
Glennie Grp: Citadel I.: possible.

Dannevig I.: 1978 (Lane 1979).

McHugh I.: formerly (Gillham 1961, 1962); now possibly extinct.

Wilson's Prom.: Norman I. (Lane & Battam 1980).

Wattle I.: possible (Lane & Battam 1980).



Anser Grp: Kanowna I.: possible.  
Shellback.

Lady Julia Percy I. (Pescott 1976).  
Lawrence Rocks.

Tas.: islands of Tas. are breeding stronghold in Aust. (N.P. Brothers).

Craggy I.: (Whinray 1975).

Bird I.: Georges Rock: 1977, c. 50 pairs.

The Nuggets: probable.

The Thumbs 1980: <20 pairs.

Maatsuyker I.: 1975, c. 400 pairs.

East Pyramids.

Councillor I.: before 1972, c. 20 pairs.

NZ

NI

Three Kings Is: Great King I. (Turbott & Buddle 1948).

Moturoa Is: Moturoa, Green, Sugarloaf, Whale Is and stacks (Adams 1971).

Cavalli Is: Motukawanui, Motuharakeke (R.A. Anderson).

Poor Knights Is: Aorangi and stacks and lesser islets: possibly (Harper 1983; M.J. Imber).

Hen & Chickens Is: Hen I.: scarce; North-western Chicken I.: common; Coppermine, Lady Alice (Marotiri) Is: possibly (Merton & Atkinson 1968; M.J. Imber).

Mokohinau Is (Oliver).

Little Barrier I.: Lot's Wife: (P.C. Bull).

Noises Is: Maria: scarce; David Rocks: 1962, possibly, now extinct (Cunningham & Moors 1985).

Mercury Is: Green, Middle Is: abundant (Skegg 1963); Korapuki, scarce (Hicks *et al.* 1975).

Oheua Is: Little Oheua: common (Blackburn 1970).

Aldermen Is (Falla 1934).

Karewa I. (Falla 1934).

Slipper I. and nearby islets (Falla 1934).

Motunau (Plate) I. (Falla 1934).

Motumahunga, New Plymouth: abundant (CSN 19).

Trios Is (B.D. Bell).

The Brothers (B.D. Bell).

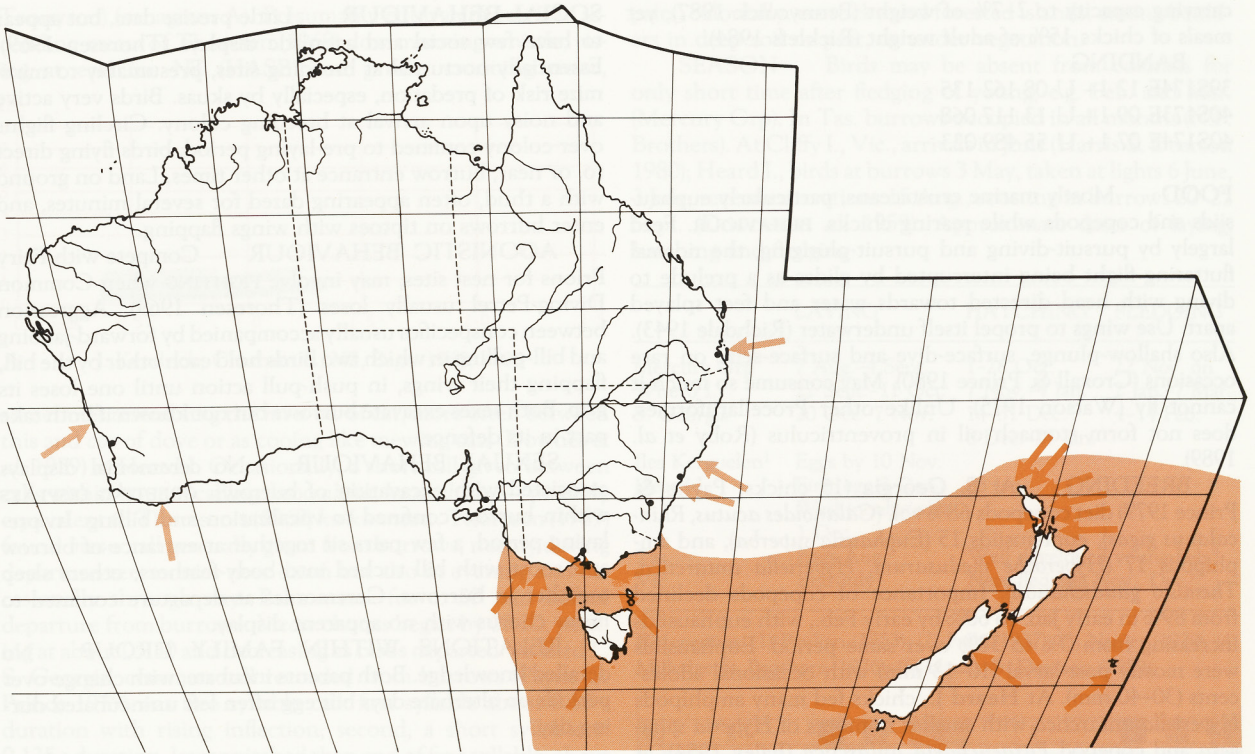
CHATHAM IS: Chatham I.: nearly extinct; Houruakopara I.: rare; Rabbit I.: scarce; Mangere I.; Star Keys: rare (M.J. Imber);

South East I.: abundant (Fleming 1939; M.J. Imber); Murumurus: scarce (A.J.D. Tennyson).

SOLANDER IS: Solander I.: rare; Little Solander I.: abundant (Falla 1948; Wilson 1973; Cooper *et al.* 1986).

CODFISH I.: rare (Imber & Nilsson 1980); nearby islets and stacks: probably (M.J. Imber).

STEWART I.: many nearby islands and islands (NZCL). Jacques Lee I.: formerly abundant, now rare (Wilson 1959); Whero I.: 1938-57: breeding (Richdale 1965), now doubtful due to invasion of Stewart Shags *Phalacrocorax chalconotus* (Watt 1975).



**SNARES IS:** Main I.: common (Warham 1967); Western Chain (Tahi, Rua, Toru islets), possibly (Miskelly 1984).

**ANTIPODES I.** (Imber 1983; Warham & Bell 1979).

**AUCKLAND I.** (Warham & Bell 1979); adults found in burrows on Enderby, Ocean and Ewing Is; dead chick outside burrow on Disappointment I. (G.A. Taylor).

**CAMPBELL I.** nearby Lion Rock, two chicks, 11 Feb. 1985 (G.A. Taylor).

**MACQUARIE I.:** 1979, 20 pairs (Jones 1980; Brothers 1984; Rounsevell & Brothers 1984).

**HEARD I.** (Williams 1984).

**PRINCE EDWARD IS:** Marion I.: formerly, now apparently extinct; Prince Edward I. (Williams 1984).

**ILES CROZET:** Ile de l'Est: millions; Ile des Pingouins:  $> 10^5$ ; Ile des Apôtres:  $10^4$  (Jouventin *et al.* 1984).

**ILES KERGUELEN:** abundant (Weimerskirch *et al.* 1989).

**S. GEORGIA:**  $3.8 \times 10^6$  (Prince & Croxall 1983).

Extraliminally, breed Gough I., Tristan da Cunha (Williams 1984), Falkland Is (Croxall *et al.* 1984) and Diego Ramirez and islands off s. Chile (Schlatter 1984). Formerly bred Ile St Paul (Jouventin *et al.* 1984). In NZ, total population *urinatrix* possibly  $10^{5-6}$  pairs or more.

Populations mostly stable, some declining. At Falkland Is and S. Georgia, nesting habitat grazed and trampled (Croxall *et al.* 1984). At Falkland Is and a few NZ islands feral cats take birds; have exterminated population on Marion I. Black Rats *Rattus rattus* cause problems on Macquarie I. (Rounsevell & Brothers 1984) and Iles Crozet (Jouventin *et al.* 1984); and *Rattus* spp on some NZ islands (Robertson & Bell 1984). Declining at Macquarie I. (Rounsevell & Brothers 1984) and now probably confined to offshore stacks (Jones 1980; Brothers 1984). Polynesian Rats *R. exulans* limit populations in NZ (Thoresen 1967, 1969). At Chatham I. nearly annihilated by feral cats and rats and grazing and trampling by

livestock (M.J. Imber). At Whero I., population displaced by shags (Watt 1975).

**MOVEMENTS** Virtually unknown away from breeding sites. May have more pelagic and migratory dispersal pattern than sympatric South Georgian Diving-Petrel (Payne & Prince 1979) but little information.

**DEPARTURE** Whero I., 2 Jan.–7 Mar. (60% 17–31 Jan.; Richdale 1965); Iles Crozet, 7 Feb. (10 days; 25 Jan.–2 Mar.; 11; Jouventin *et al.* 1985); Bird I., S. Georgia, 10 Feb. (Croxall & Prince 1980, 1987); Snares Is, 23 Apr. 1972 (Horning & Horning 1974); Tristan da Cunha late May (Richardson 1984), but some recorded roosting ashore on Heard I. (Downes *et al.* 1959) and Chatham Is (M.J. Imber) in every month.

**NON-BREEDING** Movements away from breeding sites unknown but possibly only to waters near breeding sites (Downes *et al.* 1959; M.J. Imber). Although rarely seen Bay of Plenty, NZ, Dec.–Apr. (Vooren 1972) and from NZ coastal waters Jan.–Mar. (Falla 1934), may be inconspicuous because moulting and flightless (Vooren 1972). No records of seasonal increases of pelagic populations.

**RETURN** Tristan da Cunha, mid-July (Richardson 1984); Snares Is, 25 Aug. (Horning & Horning 1974); Mercury I., before 2 Sept. (Edgar 1962); Iles Crozet, before 19 Sept. (Jouventin *et al.* 1985); S. Georgia, 4 Oct. (Croxall & Prince 1980, 1987). Pre-laying exodus, probably of females, about 5 days on Iles Crozet but movements then unknown (Jouventin *et al.* 1985). On basis of unexpectedly low retrapping rate of yearlings at banding sites, Richdale (1965) suggested that many may visit other sites in their first year.

**BREEDING** Maximum foraging range while breeding about 360 km (Croxall & Prince 1980) but probably does not travel so far because high wing-loading reduces sustained

carrying capacity to 2–7% of weight (Pennycuik 1987), yet meals of chicks 15% of adult weight (Ricklefs 1984).

#### BANDING

39S174E 12 1+ U 08 162 135  
40S173E 09 1+ U 13 117 068  
40S174E 07 1+ U 55 489 023

**FOOD** Mostly marine crustaceans, particularly euphausiids and copepods while rearing chicks. **BEHAVIOUR**. Feed largely by pursuit-diving and pursuit-plunging, the normal fluttering flight being interrupted by glides as a prelude to diving with head directed towards water and feet splayed apart. Use wings to propel itself underwater (Richdale 1943). Also shallow-plunge, surface-dive and surface-seize on rare occasions (Croxall & Prince 1980). May consume so much it cannot fly (Watson 1975). Unlike other Procellariiformes, does not form stomach oil in proventriculus (Roby *et al.* 1989).

**BREEDING** At S. Georgia (15 chicks; Payne & Prince 1979) diet copepods 68% vol. (*Calanoides acutus*, *Rhincalanus gigas*), euphausiids 15 (*Euphausia superba*), and amphipods 17 (*Hyperoche medusarum*, *Hyperliella antarctica*, *Themisto gaudichaudii*). Importance of copepods declined from 89% in early Jan. to 60% by early Feb., with euphausiids increasing from 0% to 38% over same period. Euphausiids were mostly post-larval (10–13 mm) with occasional adolescents (30–40 mm). At Heard I., chicks fed many amphipods *Hyperliella antarctica* with smaller numbers of *Hyperia spinigera* and copepod *Paraeuchaeta antarctica* (Ealey 1954); at Mercury I., NZ, chicks fed mostly euphausiids (Thoresen 1969) and one stomach from Prince Edward I. contained 13 euphausiids and one amphipod Hyperiididae (Williams & Imber 1982). Also reported to take isopods (HASB). Diet estimated to contain 10.8% protein, 4.5% lipid, 1.5% chitin and carbohydrate and 79.3% water (Roby & Ricklefs 1986).

**INTAKE** At S. Georgia, Ricklefs (1983) recorded 1.88 visits/day to nest with mean meal weight of 26.0 g ( $\pm 0.4$  SE; 10–31; 146). At Ile de l'Est, Iles Crozet, interval between meals while chick being brooded 0.91 days (0.23; 0.50–1.41; 105 weighings of 11 chicks) with weight increase during 24-h feeding period 5.3 g (4.8; 0–32; 84); after brooding stopped, interval 1.14 days (0.11; 1.00–1.36; 249) with weight increase 8.9 g (6.7; 0–29; 170; Jouventin *et al.* 1985).

**SOCIAL ORGANIZATION** Gregarious when breeding. No information on behaviour at sea.

**BONDS** Monogamous. Duration of pair-bonds correlated closely with mortality rate. Sixty-five per cent of pair-bonds (n=125) lasted only one season, 25% two seasons, 10% three seasons, 12% four seasons and 5% five seasons. Of 94 broken pair-bonds, 97% resulted from loss of at least one partner (37% one partner, 63% both), only 3% from divorce (Richdale 1965). Nearly all birds probably recruited into breeding population by 3 years of age; some one-year-olds keep close company with others; seven of ten 2-year-olds and six of seven 3-year-olds found in burrows were breeding (Richdale 1965). This is the youngest age of first breeding known in Procellariiformes (Croxall 1982). Equal sex ratios. Both parents incubate and tend young until fledging.

**BREEDING DISPERSION** Colonial, nesting in underground burrows. Strongly territorial.

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

**SOCIAL BEHAVIOUR** Little precise data, but appear to have few social and agonistic displays (Thoresen 1969). Essentially nocturnal at breeding sites, presumably to minimize risk of predation, especially by skuas. Birds very active and noisy upon arrival at breeding colony. Circling flights over colony confined to pre-laying period, birds flying direct to, or near, burrow entrance at other times. Land on ground with a thud, often appearing dazed for several minutes, and enter burrows on tiptoes with wings flapping.

**AGONISTIC BEHAVIOUR** Compete with Fairy Prions for nest sites; may involve FIGHTING when Common Diving-Petrel usually loses (Thoresen 1969). Aggression between conspecifics usually accompanied by forward-jabbing and bill-pulling in which two birds hold each other by the bill, flapping their wings, in push-pull action until one loses its grip. Both sexes excavate burrows but not known if both take part in its defence.

**SEXUAL BEHAVIOUR** No ceremonial displays associated with excavation of burrows. **GREETING DISPLAYS** within burrow confined to vocalization and billing. In pre-laying period, a few pairs sit together at entrance of burrow and roost with bill tucked into body-feathers; others sleep together in burrows. Ceremonies at departure confined to *meow* chorus with no apparent display.

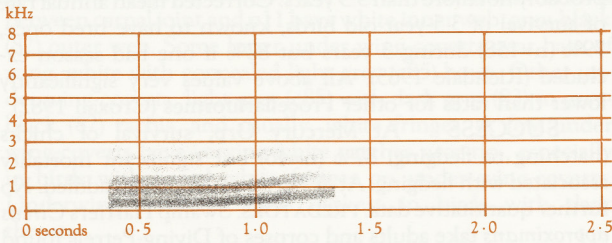
**RELATIONS WITHIN FAMILY GROUP** No detailed knowledge. Both parents incubate, with change-over periods on alternate days but egg often left unincubated during day.

**VOICE** No detailed studies. Account based on Richdale (1943, 1965), Thoresen (1969) and information supplied by A.J.D. Tennyson. Apparently silent at sea. Very noisy at breeding colonies at night, commonly calling in flight over colony, on ground and in burrows (Thoresen 1969; A.J.D. Tennyson); occasionally call during day (Thoresen 1969). On The Brothers, on Green I., and on stack off Stanley I., NZ, two main types of call and variations reported; loud resonant and harsh: *kooh-ah* and *kuaka-did-a-did* (Thoresen 1969; A.J.D. Tennyson); latter reflected in Maori name *Kuaka*. Both calls given in flight and from ground. Call throughout breeding season, peak of calling during pre-laying period; calling in flight over breeding colonies more frequent during early part of breeding season (Richdale 1943, 1965; Thoresen 1969). At breeding colonies, calling concentrated at time of arrival in evening (2 h) and before departure at dawn, though colonies generally noisy all night (Thoresen 1969). **SEXUAL DIFFERENCES** in calls apparent on stack N of Stanley I., Mercury Is (18 and 20 Aug. 1989; A.J.D. Tennyson). Sex was determined for seven pairs and one female and calls noted; unsexed pairs were heard to give equivalent calls: *kuaka* call (and variations) given by females; *kooh-ah* call by males. **GEOGRAPHICAL VARIATION** possibly occurs but not recorded or analysed; indication that variants of (female) call differ in frequency in different areas (Thoresen 1969): *ku-ku-did-did* predominant call at The Brothers, heard only occasionally at Green I., *kuaka* often heard at Green I., rarely heard at The Brothers. Several other variants, generally modifications of most common call, were only noted at The Brothers. Calls of both males and females usually repeated several times in a bout of calling; may function in territorial defence and advertisement. When regurgitating food for young, barely audible cough by parent (Richdale 1965).

**ADULT MALE** *Kooh-ah*. Call of male slow single-syllable *kooh-ah*, about 1 s long and rising in pitch (A.J.D.



Tennyson) (sonagram A). Presumably equivalent to clear ascending *meow* of Thoresen (1969), low moaning whistle, rising at end for NZ (HASB) and gentle, crooning noise,



A J. Kendrick; Chatham Is, NZ, Sept. 1968; P100

sometimes resembling the *mi-a-ow* of cat, more often between this and *coo* of dove or as cooing like mewing cats (Downes *et al.* 1959) at Heard I. Occasionally, a short call given between calls within bout of calling: *kooo-ah ka, kooo-ah ka, ---*; possibly equivalent to Thoresen's (1969) *ku-ku-meow*. Thoresen (1969) found *meow* call generally given from burrows, mainly during departure-ceremonies near dawn but also in evening and occasionally through day. Pairs *meow* for c. 30 min before departure from burrows. *Meow* chorus began by 03:30, peaking at about 05:30 and decreasing as birds departed. At Bird I., S. Georgia, common call recorded from burrows (Payne & Prince 1979) was two syllable call: first syllable about 0.65 s duration with rising inflection; second, a short syllable c. 0.125 s duration, lower pitched than end of first syllable; about 0.1 s between syllables. Call rate c. 1/s for minutes at a time. This call may be equivalent to *kooo-ah* of males (A.J.D. Tennyson).

**ADULT FEMALE** Call begins with syllable very similar to initial syllable of male call but rapidly rises in pitch (*kua*) then breaks into several shorter syllables; full call sounds like *kuaka-did-a-did* as described by Thoresen (1969) for birds of unknown sex. Full call slightly longer than call of male (A.J.D. Tennyson). Variation in number and form of final syllables. Occasionally notes slightly altered: *kuaka-kit-a-did*; and additional variants formed by adding or omitting notes (Thoresen 1969): *kuaka-did-a-did-a, kuaka-did-did, kua-kit-a-did, ku-ku-ku, kuaka-ku-ku, kuaka-ku, ku-ku-did-did* are probably all variations of female call.

At Nightingale and Inaccessible Is, Tristan da Cunha and Gough I., calls described as resonant nasal bleating *kerrraaa-ek, crrrrrooeek-ek* or *bee-aw-ek*, occasionally followed by repeated *ek ek ek* (Elliott 1957).

**YOUNG** Barely audible peeps when hatching (Thoresen 1969). Chick uttered little soft noises when unattended in burrow at night (Richdale 1965). Begging call of young when adults entered burrow or when adult reaches young (Richdale 1943): continuous, rasping *squeer* (Thoresen 1969), assumed equivalent to Richdale's incessant monotonous call. Chicks to c. 21 days do not call in alarm when captured. Chicks older than 21 days *squeer* call when handled (Richdale 1943). Richdale noted young calling on surface (continuous monotonous *squeak*) after leaving burrow but before leaving island.

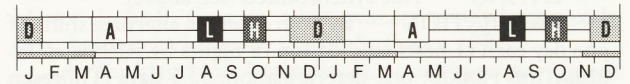
**BREEDING** Fairly well known. Detailed studies: Mercury Grp, NI, NZ (Thoresen 1969); Stewart (Whero) I. (Richdale 1965); S. Georgia (Payne & Prince 1979; Roby & Ricklefs 1983); Iles Crozet (Jouventin *et al.* 1985). Information supplied by J.P. Croxall, P.A. Prince and M.J. Imber. Breed in simple

pairs, colonially, on rocky and forested islands, among boulders in deep soil or peat, or under vegetation.

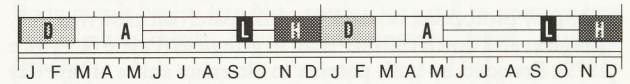
**SEASON** Birds may be absent from colonies for only short time after fledging of young, e.g. Feb. and Mar. (Mercury Grp). In Tas. burrows occupied in all months (N.P. Brothers). At Clifty I., Vic., arrivals in June (Harris & Deerson 1980); Heard I., birds at burrows 3 May, taken at lights 6 June, 3 July, recent excavations 15 Aug., roosting in burrows 20–22 Sept. (Downes *et al.* 1959). Approximate dates of laying, hatching and fledging:

	LAYING	HATCHING	FLEDGING
Mercury Grp	7 Aug.–4 Sept.	1–28 Oct.	22 Nov. on
Whero I.	22 Sept.–11 Oct.	7 Nov.–4 Jan.	2 Jan.–7 Mar.
S. Georgia	20 Oct.–7 Nov.	14–31 Dec.	4–14 Feb.
		8 Dec.–27 Jan.	
Iles Kerguelen <sup>1</sup>	Eggs by 10 Nov.		
Heard I.	First egg 3 Dec.	23 Jan.	
	Well incubated <sup>2</sup>		
	1 Dec.		
Tas.	Eggs Aug. <sup>3</sup>	Well developed young Feb. <sup>4</sup>	
Vic.	End July <sup>5</sup>	Near fledging Nov., Dec. <sup>5</sup>	

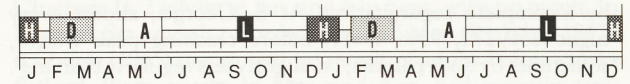
**References:** (1) Paulian (1953); (2) Falla (1937); (3) Napier (1979); (4) Milledge & Brothers (1976); (5) Harris & Deerson (1980).



a) Mercury Group



b) Whero I.



c) S. Georgia

**SITE** On coastal plains and slopes, among boulders and scree at base of cliffs, on summit ridges and plateaux, saddles, cliff edges, low headlands and behind stable dunes. On steep (50°) slopes to flat ground. In thin, continually saturated ground on Macquarie I. On Heard I. most burrows with n. aspect, perhaps snow-covered at start of breeding. Among sparse vegetation on rocky areas in some places; elsewhere among dense vegetation (tussock-grass and other plants) and among roots of *Olearia* trees. On Whero I., avoid areas of *Muehlenbeckia* and *Stilbocarpa* (Rand 1954; Skegg 1963; Pescott 1976; Imber & Nilsson 1980; Harris & Norman 1981; Brothers 1983, 1984; Imber 1983; Cooper *et al.* 1986).

**NEST, MATERIALS** In burrows or tunnels 25–150 cm long, to depths of 0.2–1.0 m or more below surface; entrance 5–8 cm in diameter. Pairs use same burrow in successive years: 93% (n=58) for 2 years, 81% (n=21) for 3 years, 50% (n=8) for 4 years; or move to nearby sites if partner is lost or burrow destroyed or both (Richdale 1965). Density: in Mercury Grp, estimated 15 000 pairs at average 50 or 60/100 m<sup>2</sup> (Skegg 1963) but Thoresen estimated 1000–1500 pairs in same area, confirming density only for optimum areas. At S.

Georgia, maximum 1.69 burrows/m<sup>2</sup>; optimum 0.29 occupied burrows/m<sup>2</sup>; total burrows 0.84/m<sup>2</sup>; in all, occupied burrows 0.23/m<sup>2</sup> and total burrows 0.59/m<sup>2</sup> (I. Hunter).

**EGGS** Rounded, ovate; more or less smooth, mat; white, often becoming stained.

**MEASUREMENTS AND WEIGHTS:**

WEIGHTS	MEASUREMENTS
16.6 (14.5–20.0; 14)	37.9 (35.9–41.8; 15) x 20.6 (28.0–30.7) (Thoresen 1969)
14.9 (1.8; 11.0–18.2; 27)	37.7 (1.7; 34.5–42.0; 39) x 29.4 (1.0; 27.2–31.5) (Richdale 1965)
18.8 (1.2; 15.5–21.5; 31)	40.2 (1.6; 37.0–44.0; 37) x 31.6 (1.7; 29.5–33.2) (Payne & Prince 1979) 39.9 (1.5; 38.1–43.0; 8) x 30.8 (1.5; 28.0–32.8) (Roby & Ricklefs 1983) 37.9 (2.7; 36.2–42.0; 4) x 31.0 (0.4; 30.5–31.54) (Paulian 1953)

Weights taken part way through incubation; at S. Georgia, calculated fresh weight 22.2.

**CLUTCH-SIZE** One. Pattern and duration of laying period suggest ability to re-lay if egg lost early in incubation (Richdale 1965; Roby & Ricklefs 1983).

**LAYING** Not synchronized (see above).

**INCUBATION** By both adults in alternate shifts of one day each (3 nests studied for 18 nights by Richdale). **INCUBATION PERIOD:** one determination, 53.5 days (Thoresen 1969). No further information.

**YOUNG** Semi-altricial, nidicolous. Hatched with pale-grey protoptile, no dark blackish patch on crown as in *P. georgicus* and down thinner than in *georgicus* (Payne & Prince 1979). Brooded by both parents in alternate shifts of one day in all studies. Duration of brooding: Mercury Grp, 10–15 days; Whero I., 10.8 days (2.0; 18); S. Georgia, 11–12 days. Fed by incomplete regurgitation. At S. Georgia, almost every night (259/271, 95%, n=11) before reaching peak weight, sometimes by both parents, i.e. slightly less regularly than in *P. georgicus* (*q.v.*) at same site. At Whero I., broadly similar but no allowance made in results for loss of weight by respiration and excretion; also smaller meals (c. 20 g) estimated and so greater frequency of feeding by both parents during one night. **NESTLING PERIOD:** at Mercury Grp, 50.5 days (45–56; 16); Whero I., 53.7 days (2.5; 47–59; 54); S. Georgia, 53.9 days (2.6; 50–58; 16).

**GROWTH** Rates of growth very similar in all studies and generally significantly slower than in *P. georgicus* (Payne & Prince 1979, Fig. 7). Weight at hatching: at Whero I., c. 13 g; S. Georgia, 15.7 g. Peak weights: at Mercury Grp, c. 115% of adult weight when 36 days old (n=10); Whero I., 119% of adult weight when c. 41 days old (n=30); S. Georgia, 122% of adult weight when 35–36 days old (n=11). Reach effective homoeothermy when 9 days old; maximum mass specific metabolism, when 5–6 days old (Roby & Ricklefs 1983). Weight at fledging: at Whero I., 125 g (roughly = adult weight); S. Georgia, 132 g (99% adult weight).

**FLEDGING TO MATURITY** Independent of parents on fledging. First breed at 2–3 years old. Corrected mean annual rate of survival for all breeding birds 61% (n=388) during 4 years but 70% (n=197) if only two typical seasons with good retrap results considered. Two-year-old breeders probably not stable members of population and may move to other

colonies or survival of birds breeding first when 2 years old is lower than that of those breeding first at 3 years old, which seems reasonable. Average life expectancy of breeding bird probably not more than 3.5 years. Corrected mean annual rate of survival of 3.5-year-old birds, known to have bred once, 79% (n=158) during 3 years but 82% if one bad season excluded (Richdale 1965). All above values very significantly lower than rates for other Procellariiformes (Croxall 1982).

**SUCCESS** At Mercury Grp, survival of chicks (hatching to fledging) 87% (n=46) but significant mortality associated with fledging. At Whero I., 10% of eggs added. No further quantitative data. **PREDATORS.** Swamp Harriers *Circus approximans* take adults and corpses of Diving-Petrels found in stomachs of Kelp Gulls *Larus dominicanus* and Snapper *Pagrosoma asuratus*; chicks killed by burrowing shearwaters (Thoresen 1969). On Chatham, Stewart and Snares Is, skuas *Catharacta* kill adults and young (Richdale 1965; Miskelly 1984; M.J. Imber). Remains found in stomachs of giant-petrels *Macronectes giganteus* and *halli* at S. Georgia (Hunter 1983) and of Leopard Seals *Hydrurga leptonyx* at Iles Kerguelen (Paulian 1953).

**PLUMAGES** *P. u. urinatrix* from Bass Str. colonies.

**ADULT** Definitive basic. **HEAD AND NECK.** Crown and hindneck, glossy black (c89). Lores and forehead, glossy black (c89), fading to dark brown (c121) with wear. Ear-coverts and sides of neck, grey (83–84), sometimes with fine white mottling; feathers, grey (84) with narrow white tips and concealed white bases. In some birds, feather shafts of ear-coverts, dark grey (brownish 83); these highlighted when dark tips lost through wear. As in *P. georgicus*, exposure of white bases can form well-defined white arc behind ear-coverts. Chin, white. Throat, white with highly varying amount of grey (84) to dark-grey (83) mottling; this mottling lightest in centre of throat and near chin. In palest birds, throat, white with grey mottling at sides of foreneck. In darkest birds, throat, dark grey (83) with white mottling strongest in centre; many intermediates occur. Feathers, grey-white with white tips and dark-grey sub-terminal band of varying thickness. Much individual variation partly related to wear; pale bases of feathers exposed as overlying feathers lose tips. Birds with throat of pale or intermediate colour similar to *P. georgicus*, but predominantly grey or dark grey throat only in *P. urinatrix*. **UPPERPARTS,** glossy black (89) when fresh; when worn, longest scapulars and feathers of mantle and back develop broad dark-brown (c21) fringes. One row of shorter scapulars, dark grey (83) to grey (84) with white tips, narrowest on outer web. This forms distinctive white stripe in some birds; smaller in birds with worn plumage and sometimes concealed by feathers of back. Though scapulars have fewer white tips than *P. georgicus*, amount of white exposed varies greatly and of little use in identification at sea. **TAIL,** glossy black (c89), becoming brown-black with extreme wear. **UPPERWING.** Remiges and primary coverts, black-brown (c119) when fresh, fading to dark brown (21) with wear. Secondaries have narrow white tips when fresh. All other feathers, glossy grey-black (c82), developing dark brown (21) fringes with wear. **UNDERPARTS,** mostly white. Uppermost breast as lower throat. In darkest birds, flanks and extreme sides of breast mottled dark (84–83) and light grey (85–86), with slight white scalloping. Feathers, dark grey (83) merging to pale grey (86) or white bases, with white fringes. Posterior flanks, almost totally white in palest birds, feathers with grey (84) to light-grey (85) shaft-streaks. Thighs, grey (84). **TAIL,** glossy black (c89), becoming brown-black with

extreme wear. **UNDERWING.** Remiges, grey (84) with grey-black (c82) outer edges to outer primaries. In some, grey inner webs of primaries grade to light-grey (85) inner edges. Marginal coverts, grey-black (82). Coverts on leading edge of wing between carpal joint and p11 have white inner web, grey-black (82) outer web. Some lesser under wing-coverts near base of wing, white with concealed light-grey (c85) bases. Other under wing-coverts, light grey (c85) with dark grey (83) to grey-black (82) rachis, and usually, white fringes. A few under wing-coverts have varying white patches near tip., especially in birds with broad white fringes on under wing-coverts. Underwing tends to look darkest in birds with dark throats.

**DOWNY YOUNG** (MV; Richdale 1965; Thoresen 1969; A.J.D. Tennyson). Protoptile, white, sometimes with pale-grey tinge to upperparts. Most, but not all, birds have light-grey (85) wedge in front of cloaca, tapering towards belly. Down short and thick, lost from most of head (but not crown) because adults rub chick while feeding. Mesoptile longer, brownish grey (between 79 and 119C). Chick has mottled appearance between time when mesoptile appears (about 1 week) and before protoptile wears off (about 3 weeks). Fleming (1939) described mesoptile at Chatham Is as dark silver-grey on upper surface, fading on belly to a much lighter shade.

**JUVENILE** Closely similar to adult. Only five examined; all as palest adults, with light-grey mottling on underside restricted to lower throat. Throat and breast may darken with age but Richdale (1965) suggested that fledgelings at Whero I. had more grey mottling than adults.

**BARE PARTS** Based on Richdale (1965), Payne & Prince (1979), Jouventin *et al.* (1985), MV and NMNZ labels, and photos in Lindsey (1986) and unpublished (A.J.D. Tennyson).

**ADULT** Iris, dark brown (219). Bill, grey-black (82), usually with pale-blue (168D) to light blue-grey (c88) mandibular rami. Tarsus and tops of toes, blue (168B) to light blue (168C), sometimes with blue-black (-) or black (-) patch above hind toe and smaller patches above joints of other toes. A bird, perhaps adult on basis of worn plumage, which landed on ship off Bruny I. (Tas.) in late Mar., had grey-black (82) hind-edge to tarsus (D.W. Eades), as did two adults, collected Dec. on Campbell I. (NMNZ). Webs, grey-black (c82) above; at Kerguelen, varying, often pink or whitish streaked grey (Falla 1937). Soles, blue-black (-) to black (-), somewhat darker on underside of toes. Claws, black (89).

**DOWNY YOUNG** Few data for *urinatrix*; based on photos from Snares (A.J.D. Tennyson) and Richdale (1965) at Whero I. Iris as adult; eyelid grey; exposed skin on throat, pink (Richdale 1965). On hatching, bill, dark grey (c83) with dull-pink (c5) base (not observed by Richdale); 5-day-old chick had grey-black (82) bill (A.J.D. Tennyson). Pouch, light grey, becoming black-grey before fledging. According to Richdale, tarsus blue all over, toes lighter blue, which inconsistent with Snares birds, which have grey (84) hind edge of tarsus, merging to pink or grey-pink at junction of toes; toes have dark-grey underside. Webs, pink. At 43 days, bare parts similar to fledgeling.

**JUVENILE** When freshly fledged, similar to adults, but tarsi, pale blue (168D), usually with blue-black (-) to black (-) hind edge. At Whero I., pale-blue markings on ramicorn of fledgeling tend to be smaller than in adults.

**MOULTS** From skins at MV and NMNZ except where stated.

**ADULT POST-BREEDING** Pre-basic. May include non-breeders. Complete. Primaries outwards at S. Georgia (Payne & Prince 1979) and within our area. Two birds beachcast in NZ said by Falla to be in synchronic primary moult (Stresemann & Stresemann 1966); specimens cannot be located, and possibility that they were fledgelings cannot be excluded. Geographical variation occurs in timing; effect, if any, on sequence unknown.

Subspecies *exsul*. At Heard I., primary moult of most birds occurs Jan. and Feb. (14 of 17 birds examined); all of unknown breeding status, but primary moult probably begins while chicks are being fed. as occurs on S. Georgia. Earliest records 8 Jan., when three birds had just started primary moult and two had worn wings. Bird collected 21 Feb. had completed primary moult; another collected 14 Feb. had primary moult N<sup>9</sup>4<sup>1</sup>. Two to five inner primaries may be growing at one time. Two birds, collected 13 and 14 Feb., had moult formulae N<sup>2</sup>4<sup>1</sup>1<sup>1</sup>0<sup>6</sup> and 4<sup>2</sup>2<sup>0</sup>6, which suggests primary moult of some birds may persist into Mar. No information on moult of other tracts.

Timing apparently similar at Iles Kerguelen, where moult well advanced in Feb.; moult complete in bird collected 23 Feb. 1930 (Falla 1937). One collected 10 Feb. (NMNZ), had primary moult N<sup>8</sup>4<sup>2</sup>, was beginning centrifugal tail-moult and had fresh body-plumage. No information for Iles Crozet or Marion I. At S. Georgia, adult primary moult begins early Feb., before chicks fledge (Payne & Prince 1979).

At Auckland and Antipodes Is, no active primary moult recorded between Nov. and Feb.; 11 skins have worn wings; bird collected 16 Feb. had recently completed primary moult. Body-moult begins late Nov.-early Dec.; still in progress late Feb., when birds have predominantly fresh plumage (NMNZ).

Subspecies *chathamensis*. Adult collected Chatham Is, 5 Feb., starting primary moult (2<sup>1</sup>1<sup>2</sup>0<sup>7</sup>) and body-moult. At Chatham Is, 2 adults in Jan. and 6 in Sept. with no moult. In Foveaux Str., moult recorded Feb. and Mar. (Richdale 1947); Richdale (1965) mentioned no moult of adults before chicks fledged. Birds caught in Mar. and Apr. had recently completed moult.

Nominate *urinatrix*. In se. Aust., birds collected from Apr. to Oct. show no moult. Bird collected 17 Apr. had fresh remiges; in incubating adults in Oct., primaries worn. In wreck in early Aug., 30% of birds had completed wing-moult, and were completing, or had recently completed, asymmetrical tail-moult (Norman & Brown 1987). In NZ, wing- and tail-moult occurs Jan.-Mar. when birds at sea (Falla 1934). Beachcast bird 23 Apr. had primary moult N<sup>6</sup>4<sup>1</sup>3<sup>1</sup>1<sup>2</sup> and strong body-moult. No sign of wing- or tail-moult before end of Nov. when chicks are leaving (Thoresen 1969). Some birds at Mercury Grp still moulting contour feathers 25 Apr.; all contour feathers fresh by May (Thoresen 1969).

**POST-JUVENILE** No direct information. Unemployed birds at Whero I., including year old juveniles, leave breeding grounds about 1 month earlier than adults (Richdale 1965), perhaps to moult.

**MEASUREMENTS** Nominate *urinatrix*, se. Aust. (1) SE. Aust. breeding locality, juveniles excluded, skins; bill width level with end of feathers on culmen (MV). (2) Vic. (ectoparasites, breeding condition and biometrics imply se. Aust.-provenance), freshly-dead beachcast in early Aug.;

slightly flattened wing chord, BD(N) = bill depth immediately anterior to nares (Norman & Brown 1987).

	MALES	FEMALES
WING	(1) 129.8 (4.53; 126-136; 6) (2) 130.1 (3.04; 123-138; 70)	121 129.2 (2.99; 122-135; 30)
8TH P	(1) 80.3 (3.10; 77-86; 7)	78.7 (1.89; 76-80; 3)
TAIL	(1) 42.4 (3.81; 37-48; 7) (2) 42.1 (1.67; 39.0-47.0; 70)	41.5 (3.20; 39-47; 4) 41.9 (1.42; 38.0-45.0; 30)
BILL	(1) 16.6 (0.90; 14.7-17.8; 7) (2) 16.8 (0.82; 15.0-18.9; 70)	16.2 (0.51; 15.6-17.0; 4) 16.3 (0.67; 15.1-18.1; 30) **
BILL W	(1) 7.93 (0.231; 7.7-8.3; 7)	7.38 (0.130; 7.2-7.5; 4) **
BD(N)	(2) 7.4 (0.38; 6.6-8.2; 70)	6.9 (0.45; 6.1-7.9; 30) **
THL	(2) 52.5 (1.47; 70)	51.6 (1.20; 30) **
TARSUS	(1) 26.4 (1.98; 22.3-28.4; 7) (2) 27.2 (0.87; 25.4-29.2; 70)	26.0 (0.93; 24.4-26.9; 4) 26.7 (1.13; 23.8-28.9; 30) *
TOE	(1) 34.5 (2.80; 31.7-40.0; 7)	31.7 (1.03; 30.5-33.0; 3)

NZ. (1) Breeding colonies in Cook Str. and Bay of Plenty, juveniles excluded, skins (NMNZ). (2) Mercury Gp, adults of unknown status, live; bill width from tomia to tomia at junction of feathering with culmen, BILL D = minimum bill depth at this point, BD(N) = bill depth immediately anterior to nares (A.J.D. Tennyson; G.A. Taylor).

	MALES	FEMALES
WING	(1) 127.0 (2.31; 124-131; 6)	131.8 (2.04; 129-134; 5) **
8TH P	(1) 78.6 (0.49; 78-79; 5)	81.0 (1.27; 79-82; 5) **
TAIL	(1) 41.0 (2.31; 38-45; 6)	42.8 (2.40; 40-47; 5)
BILL	(1) 16.5 (0.44; 15.8-16.9; 6)	16.6 (0.36; 16-17; 5)
BILL W	(1) 8.00 (0.32; 7.4-8.3; 6)	7.80 (0.30; 7.4-8.2; 5)
TARSUS	(1) 26.5 (0.83; 25.2-27.7; 6)	26.8 (1.12; 25.0-28.1; 5)
TOE	(1) 33.8 (0.89; 32.7-35.2; 5)	33.0 (1.85; 31.1-35.5; 4)

	UNSEXED
WING	(2) 130.8 (4.46; 117-137; 39)
TAIL	(2) 39.6 (2.11; 35.7-43.2; 26)
BILL	(2) 16.8 (0.62; 15.4-17.7; 36)
BILL D	(2) 9.30 (0.458; 8.5-10.6; 28)
BD(N)	(2) 7.25 (0.385; 6.6-8.3; 27)
BILL W	(2) 8.00 (0.409; 6.9-9.0; 24)
TARSUS	(2) 26.9 (1.05; 24.5-28.7; 29)
TOE	(2) 33.6 (1.60; 30.6-36.1; 25)

*P.u. chathamensis*. (1) Chatham Is, juveniles excluded, skins; ; bill width level with end of feathers on culmen (NMNZ). (2) Snares Is, adults (large gonads; breeding status unknown), recently dead; bill width from tomia to tomia at junction of feathering with culmen, BILL D = minimum bill depth at this point, BD(N) = bill depth immediately anterior to nares (A.J.D. Tennyson). (3) Snares I., breeding adults, live; methods as source (2) (A.J.D. Tennyson). (4) Whero I., Foveaux Str., mated pairs, live; methods unknown (Richdale 1965). (5) Whero I., fledgelings (wing taken on night of leaving burrow); methods unknown (Richdale 1965).

	MALES	FEMALES
WING	(1) 124.8 (1.09; 123-126; 4) (2) 121.7 (3.75; 116-131; 15)	122.8 (2.86; 118-125; 4) 118.8 (3.02; 113-123; 13) *
8TH P	(1) 77.0 (2.35; 75-81; 4)	77.8 (1.30; 76-79; 4)
TAIL	(1) 39.3 (1.25; 38-41; 3)	40.5 (1.80; 38-43; 4)

	(2) 39.1 (1.42; 37.2-41.8; 14)	38.8 (2.28; 34.2-41.9; 11)
BILL	(1) 16.1 (0.41; 15.4-16.5; 5) (2) 16.4 (0.60; 15.1-17.3; 15)	15.3 (0.40; 14.8-15.9; 4) ** 15.9 (0.41; 15.4-16.6; 12) **
BILL D	(2) 8.77 (0.538; 7.8-9.6; 6)	8.23 (0.366; 7.6-8.8; 12) **
BD(N)	(2) 6.63 (0.336; 6.0-7.1; 11)	6.28 (0.325; 5.7-6.8; 10) **
BILL W	(1) 7.46 (0.42; 7.0-8.1; 5) (2) 7.61 (0.41; 7.1-8.9; 15)	6.90 (0.430; 6.2-7.3; 4) 7.43 (0.30; 7.0-7.9; 13)
TARSUS	(1) 25.4 (0.61; 24.7-26.3; 5) (2) 25.7 (0.75; 24.2-27.2; 15)	24.9 (0.57; 23.7-26.0; 13) **
TOE	(1) 30.3, 31.4, 32.4 (2) 33.2 (1.07; 31.7-35.3; 15)	30.2, 30.7 32.6 (1.67; 30.5-37.7; 13)

	UNSEXED
WING	(3) 121.0 (3.46; 114-125; 14) (4) 122.6 (2.9; 115-130; 100) (5) 120.9 (3.3; 111-130; 48)
TAIL	(3) 38.2 (1.95; 34.7-41.5; 14) (4) 40.3 (1.4; 38-45; 100)
BILL	(3) 16.3 (0.55; 15.6-17.3; 14) (4) 16.6 (0.7; 15-18.5; 100) (5) 16.0 (0.55; 15-17.5; 62)
BILL D	(3) 9.09 (0.256; 8.6-9.4; 14) (4) 6.8 (0.5; 6-8; 100) (5) 6.6 (0.44; 5.8-7.5; 62)
BD(N)	(3) 6.28 (0.325; 5.7-6.8; 10)
BILL W	(3) 7.65 (0.316; 7.2-8.2; 14) (4) 8.1 (0.4; 7-9; 100) (5) 7.7 (0.29; 7-8.25; 62)
TARSUS	(3) 25.3 (0.97; 22.5-26.3; 14)
TOE	(3) 32.0 (1.17; 29.6-34.5; 14) (4) 33.5 (1.5; 30.5-37.5; 100) (5) 33.4 (n=20)

*P.u. exsul*, NZ offshore islands. (1) Auckland Is, juveniles excluded, skins (NMNZ). (2) Antipodes Is, probably breeding birds (from condition of gonads), live; flattened chord (Warham & Bell 1979). (3) Same sample and methods as source (2), skins (Warham & Bell 1979).

	MALES	FEMALES
WING	(1) 121.6 (1.59; 119-124; 7)	123.3 (2.21; 119-126; 6)
8TH P	(1) 74.7 (1.83; 72-77; 7)	75.2 (2.27; 72-79; 6)
TAIL	(1) 37.3 (1.49; 36-40; 7)	38.8 (1.94; 36-41; 5)
BILL	(1) 16.3 (0.39; 15.8-16.9; 7)	15.9 (0.41; 15.4-16.7; 6)
BILL W	(1) 8.06 (0.33; 7.4-8.5; 7)	7.78 (0.177; 7.6-8.1; 6)
TARSUS	(1) 26.3 (0.59; 25.6-27.3; 7)	25.8 (0.95; 24.3-26.9; 6)
TOE	(1) 32.7 (0.96; 31.1-33.8; 6)	32.4

	UNSEXED
WING	(2) 118.6 (3.2; 14) (3) 117.3 (2.6; 14)
TAIL	(2) 39.4 (2.4; 14) (3) 38.2 (1.3; 14)
BILL	(2) 16.1 (0.8; 14) (3) 15.8 (0.8; 14)
TARSUS	(2) 25.0 (1.3; 14) (3) 25.2 (1.1; 14)
TOE	(2) 33.3 (1.6; 14) (3) 32.2 (1.2; 14)

(1) Heard I., juveniles excluded, skins (MV). (2) Heard I., breeding adults, live; BW(B) bill width at base, bill width from tomia to tomia at junction of feathering with culmen, BILL D = minimum bill depth at this point, BD(N) = bill depth im-

mediately anterior to nares (E.J. Woehler).

	MALES	FEMALES
WING	(1) 119.6 (3.92; 112-126; 9)	123.9 (3.33; 118-132; 13) **
8TH P	(1) 73.2 (2.57; 69-77; 9)	75.3 (2.92; 71-81; 13)
TAIL	(1) 39.7 (1.63; 37-43; 9)	40.9 (2.65; 35-45; 13)
BILL	(1) 16.2 (0.69; 15.3-17.5; 9)	16.0 (0.48; 15-16.7; 13)
BILL D	(2) 9.45 (0.564; 8.4-10.7; 25)	
BILL W	(1) 8.42 (0.336; 7.9-8.8; 9)	8.15 (0.395; 7.1-8.7; 13)
TARSUS	(1) 26.2 (1.21; 23.6-28.2; 9)	26.7 (0.84; 25.3-28.4; 13)
TOE	(1) 32.9 (0.77; 31.7-34.3; 7)	33.5 (0.88; 31.7-35.4; 12)
UNSEXED		
WING	(2) 123.4 (3.91; 115.0-131.0; 25)	
TAIL	(2) 39.0 (1.78; 35.0-41.0; 25)	
BILL	(2) 16.2 (0.82; 14.3-18.2; 25)	
BD(N)	(2) 7.08 (0.391; 6.4-8.0; 25)	
BW(B)	(2) 8.87 (0.519; 7.9-10.0; 25)	
TARSUS	(2) 25.8 (1.17; 22.5-28.3; 25)	

Indian Ocean. (1) Iles Kerguelen, skins (Mougin 1985). (2) Iles Crozet, live; methods of Prévost (1970), and Despin *et al.* (1972) unknown; may have measured skins (Jouventin *et al.* 1985, derived partly from Prévost 1970 and Despin *et al.* 1972).

	UNSEXED
WING	(1) 128 (3; 122-136; 56) (2) 122 (4; 114-1129; 54)
BILL	(1) 17.5 (1.0; 14.0-19.5; 56) (2) 16.4 (0.7; 14.0-18.0; 54)
BILL W	(2) 9.3 (0.6; 8.5-10.5; 33)
TARSUS	(1) 27.8 (1.1; 23.8-29.8; 56) (2) 26.8 (1.0; 25.3-29.0; 54)

In largest sexed samples (Norman & Brown 1987), males larger, but in Cook Str. and in only sexed sample of *exsul* (Heard I.) females have longer wings. Fledgelings have significantly shorter wings and smaller bills than breeding adults (Richdale 1965). Unknown when adult size attained. Payne & Prince (1979) suggested non-breeders are smaller than adults, but this based on comparisons of their measurements of live breeders with published measurements of skins, which may have been affected by post-mortem shrinkage. Richdale (1965) presented measurements of 100 breeders from Whero I., and of 100 birds of unknown status from nearby Herekapore I., which probably included non-breeders. They do not differ significantly; nor do measurements from Snares Is (A.J.D. Tennyson) of 14 breeders and 25 birds of unknown status.

Other measurements of all races given by Bourne (1968), who used same methods as here; his small samples consistent with larger samples now available. Murphy & Harper (1921) also present small samples of all subspecies; Murphy's measurement methods similar to Bourne's, save for tendency to take slightly smaller tail measurements (W.R.P. Bourne). Measurements for *exsul* from Marion I. in Crawford (1952), Clancey (1981); from Macquarie I. in Brothers (1984); measurements for *dacunhae* in Fraser *et al.* (1988), Clancey (1981) and Swales (1965); tarsus measurements in latter anomalously small for all species, suggesting unusual measuring method.

**WEIGHTS** *P.u. urinatrix*. At Green I., Mercury Grp, adults gain weight during post-breeding season at sea, and lose weight during breeding season (Thoresen 1969). On 25 Apr., 153 (5.6; 20), on 9 May 146 (4.6; 20), 27 June 136 (4.2; 20), 16 July 136 (4.6; 20), 19 Oct. 136 (4.9; 14) (data from graph in Thoresen 1969). Beachcast birds in Vic. in early Aug.: males 110.3 (6.81; 96.0-126.0; 70); females 101.0 (8.81; 86.0-126.0; 30); birds had probably died of starvation, no desiccation had occurred after death (Norman & Brown 1987).

*P.u. chathamensis*. From Richdale (1965), except where stated. At Herekopare I., Foveaux Str., 27-29 Aug., adults of unknown status 121.1 (9.5; 100-143; 100). At Whero I., Foveaux Str., 50 mated pairs between 22 Dec. and 30 Jan. (over two seasons) 124.1 (10.3; 108-158; 100). Most of these probably weighed after feeding chicks; birds weighed as they landed during chick feeding period 136.2 (6.3; 125-152; 26). At Snares I., breeders 123.6 (7.71; 110-135; 14; A.J.D. Tennyson).

*P.u. exsul*. At Heard I., breeding adults returning to burrows 153.9 (10.26; 136.0-168.0; 25; E.J. Woehler). At Ile de Croy, Iles Kerguelen 164 (11; 133-185; 44; Mougin 1985). Payne & Prince (1979) give information on weight changes at S. Georgia.

**STRUCTURE** Wing short, pointed and narrow. Eleven primaries, p11 minute, p10 (usually longest) 0-1, p9 0-2, p8 1-5, p7 6-10, p6 11-18, p5 18-25, p4 25-32, p3 31-40, p2 40-47, p1 47-56. Twelve secondaries, including three tertials. Tail short and square; 12 feathers (occasionally 13; Norman & Brown 1987); t1-t6 = 0-4. Bill short, maxillary unguis hooked at tip, mandibular unguis slightly downcurved. Mandibular rami almost parallel, diverging at base in most *exsul* and some *urinatrix*; meeting in pointed arch and enclosing distensible pouch. Mandibular arch generally more rounded than in *P. georgicus*, but much overlap. Nasal tubes c. one-quarter bill length; nostrils point upwards; oval, narrow, with small lateral septa near forehead. Tarsus slightly compressed laterally; reticulate. Middle toe longest, outer c. 95%, inner c. 80%, no hind toe.

**AGEING** In juveniles before leaving colony, culminicorn has small central ridge; in adults, top of culminicorn rounded.

**GEOGRAPHICAL VARIATION** Six subspecies recognized (Peters). The species has been reviewed by Murphy & Harper (1921), and Bourne (1968); several authors have suggested lumping various subspecies (e.g. Clancey 1981; Norman & Brown 1987). Three occur in our area; nominate *urinatrix* from islets of se. Aust., NI and Cook Str., described above. *P.u. chathamensis* breeds Snares and Chatham Is, and islets off Stewart I. Closely similar to *urinatrix*; cannot be identified away from breeding grounds. Given subspecific status solely on basis of small size (Murphy & Harper 1921); in largest comparable samples (A.J.D. Tennyson biometrics presented above) all measurements of *chathamensis* except depth of bill, and tail significantly smaller than *urinatrix*.

Subspecies *exsul* known to breed S. Georgia, Marion, Iles Crozet, Iles Kerguelen, Heard, Macquarie, Auckland and Antipodes Is. Bill relatively broad; Heard I. birds have significantly broader bills than birds from Bass Str., Cook Str and Chatham Is breeding grounds (see Measurements). Bills of Auckland I. birds broader than those from Chathams, but width of bill similar to *urinatrix* from Bass and Cook Straits.

Mandibular rami tend to be less parallel than other races (Murphy & Harper 1921; Falla 1937) but this character varies; similar range of variation found in *urinatrix* (Falla 1937; D.I. Rogers).

Subspecies *exsul* said to have heavier grey mottling on throat and breast than other subspecies (Murphy & Harper 1921; Bourne 1968). This character varies; full range of variation seen in skins from breeding grounds in Cook Str. (Falla 1937), Bass Str., Heard, Macquarie and Auckland Is; darkness of breast also recorded systematically on a 5-point scale on skins from breeding grounds on Cook Str. and Chatham Is. Breast of Heard I. birds (n=21) tends to be darker than those from Cook Str. (n=11) and Chatham Is (n=9) (Mann-Whitney U-tests,  $P < 0.05$ ). Confusingly, this also applies to skins from Bass Str. (n=11), and birds from Auckland I. (n=14) apparently intermediate. Appearance of breast strongly affected by wear, making this character difficult to use in taxonomic studies.

Little information on downy young of *P.u. exsul*. At S. Georgia, chicks in first down said to lack dark wedge in front of cloaca (Payne & Prince 1979). At S. Georgia, black line on hind edge of tarsus usually disappears before fledging (Payne & Prince 1979); this probably the case at Iles Crozet, where lack of black hind edge to tarsus regarded as best character for separating from *P. georgicus* (Jouventin *et al.* 1985), and Iles Kerguelen (Milon & Jouanin 1953). Black line retained until fledging in *chathamensis* (Richdale 1965), in the only juvenile Vic. *urinatrix* for which there is information (MV), and probably in *dacunhae* from Tristan da Cunha, where tarsi with black hind-edge have been found in stomach of Sooty Albatross *Phoebetria fusca* (Hagen 1952). At Heard, Kerguelen and S. Georgia, adult *exsul* known to begin primary moult before chicks fledge; apparently not so in *urinatrix* or *chathamensis* (see Moulting section).

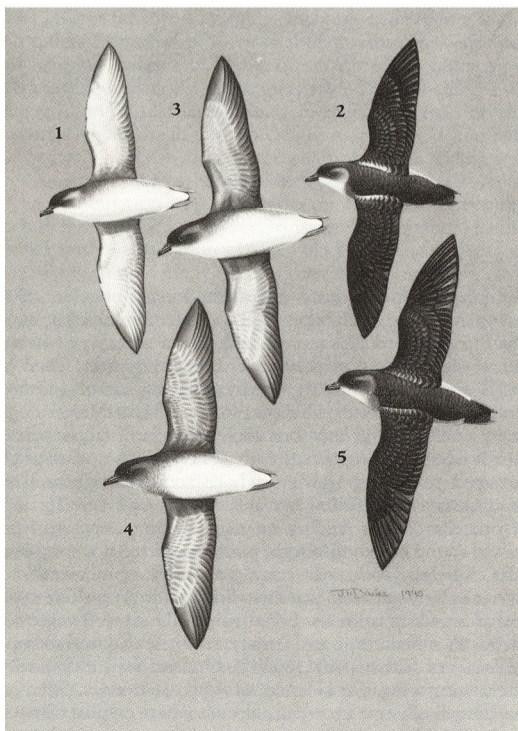
Size of *exsul* varies. Mougín (1985), who uses same measuring methods as here, presents measurements of Kerguelen skins that are significantly larger than skins from Heard I. (see Measurements). Kerguelen measurements also significantly larger than those available from Crozet. These differences in size at least as striking as those considered of taxonomic relevance in separating *urinatrix* and *chathamensis*.

DIR

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**Volume 1 (Part A), Plate 53**

South Georgian Diving-Petrel *Pelecanoides georgicus*

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

Common Diving-Petrel *Pelecanoides urinatrix*

- 3. Adult, pale form, ventral
- 4. Adult, dark form, ventral
- 5. Adult, dorsal

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