

## Order PROCELLARIIFORMES

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

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

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

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

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

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

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

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## Family 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 georgicus* South Georgian Diving-Petrel

COLOUR PLATE FACING PAGE 688

*Pelecanoides georgica* Murphy and Harper, 1916, *Bull. Am. Mus. Nat. Hist.* 35: 66 — Cumberland Bay, South Georgia.

The specific name is geographical.

### MONOTYPIC

**FIELD IDENTIFICATION** The South Georgian Diving-Petrel cannot be separated from the Common Diving-Petrel *P. urinatrix* at sea and the two are so similar in all respects that there is no point in repeating a full Field Identification section here. Refer to Common Diving-Petrel.

**HABITAT** Marine, perhaps pelagic. Circumpolar, coastal and offshore waters round islands near Antarctic Conver-

gence and in Subantarctic Zone; possibly feed S of Convergence and farther out to sea than Common Diving-Petrel (Bourne 1968; Watson 1975). Birds so difficult to identify at sea that pelagic distribution little known. Stomach contents of birds from Codfish I. indicate feeding at some distance from island at edge of continental shelf (Imber & Nilsson 1980); in Iles Crozet, feed mostly in waters over edge of continental shelf, 300–1000 m deep (H. Weimerskirch).

All breeding islands, except Codfish I., in subantarctic seas S of Subtropical Convergence; Codfish I. in warmer water on Subtropical Convergence (Imber & Nilsson 1980). Commonly found at high altitudes inland, Marion I. (Rand 1954); less often at low altitude along coast (at 1–5 m asl in dunes, Codfish I.; Imber & Nilsson 1980). May be rare on subantarctic islands S of NZ because no scoria- or scree-covered islands (Imber & Nilsson 1980).

Fly just above waves; dive into them from flight.

Burrows in unstable ground susceptible to trampling (Imber & Nilsson 1980).

**DISTRIBUTION AND POPULATION** Antarctic, circumpolar species; breed on subantarctic islands in Atlantic, Indian and sw. Pacific Oceans and Codfish I., NZ. Accidental to Aust.

Distribution not well known because South Georgian and Common Diving-Petrels cannot be readily separated. At S. Georgia, may be largely sedentary (Payne & Prince 1979); at Iles Crozet, desert colonies completely during non-breeding period (Jouventin *et al.* 1985); in winter, possibly in Subantarctic Zone and waters N of breeding areas.

AUST. One record: single, beachcast, Bellambi Beach, NSW, 28 Dec. 1958 (Gibson & Sefton 1959).

#### BREEDING

##### NZ

Codfish I.: 1978, 30–35 pairs, total possibly 100 birds<sup>(1)</sup>. Auckland Is:

Enderby I.: 1840 (specimens in BMNH)<sup>(2)</sup>;

Dundas I.: 1943<sup>(3,4)</sup>; now possibly extinct<sup>(3,5)</sup>.

MARION and PRINCE EDWARD IS<sup>(6)</sup>.

ILES KERGUELEN 1–2x10<sup>6</sup> pairs<sup>(7)</sup>.

ILES CROZET

Ile de la Possession: 1981–82: 10s of 1000s<sup>(8)</sup>;

Ile de l'Est: 1981–82: millions<sup>(8)</sup>;

Ile aux Cochons; 1x10<sup>6</sup><sup>(8)</sup>;

Ile des Pingouins: 1981–82: 100s<sup>(8)</sup>;

HEARD I.<sup>(6)</sup>;

S. GEORGIA: 2x10<sup>6</sup> pairs<sup>(9)</sup>.

**References:** (1) Imber & Nilsson (1980); (2) Falla *et al.* (1966); (3) Falla *et al.* (1979); (4) NZCL; (5) Taylor (1971); (6) Williams (1984); (7) Weimerskirch *et al.* (1989); (8) Jouventin *et al.* (1984, 1985); (9) Croxall *et al.* (1984).

Macquarie I.: probably bred (Murphy & Harper 1921); no extant population (Jones 1980) and perhaps confused with Common Diving-Petrel; two specimens, collected 1899 (BMNH), said to be South Georgian Diving-Petrels (Aust CL; Harrison 1983).

Status, possibly stable but subject to predation by skuas *Catharacta* spp, rats *Rattus rattus* and *R. norvegicus*, feral cats and Wekas *Gallirallus australis* (Murphy; Jouventin *et al.* 1984; Robertson & Bell 1984; Williams 1984). Colony on Auckland I. wiped out by Hooker's Sea Lions *Phocarctos hookeri*; sheep and cattle may trample burrows (Taylor 1971; Jouventin *et al.* 1984).

**MOVEMENTS** Thought to be mostly sedentary (Payne & Prince 1979) but no information on movements at sea.

**DEPARTURE** Young fledge Iles Crozet, 31 Jan.–22 Mar. (Derenne & Mougin 1976; Jouventin *et al.* 1985) and

Bird I., S. Georgia 14.3 Mar. (10.2 days; 4 Mar.–2 Apr.; 18) (Payne & Prince 1979).

**NON-BREEDING** Winter movements at sea unknown.

**RETURN** Iles Kerguelen, mid-Sept. (Paulian 1953); Iles Crozet, 22 Sept. 1981 (Jouventin *et al.* 1985); Heard I., 27 Oct. 1951 and 1 Nov. 1953 (Downes *et al.* 1959); Bird I., S. Georgia, 27 Oct. (Payne & Prince 1979).

**BREEDING** Maximum foraging range during breeding season, 330 km has been estimated (Croxall & Prince 1980) but probably less as high wing-loading reduces sustained carrying capacity to 2–7% of weight (Pennycuik 1987), but meals of chick 20% of adult weight (Ricklefs 1984). Though it has been suggested that, where both South Georgian and Common Diving-Petrels occur together, the South Georgian feeds farther from shore (Watson 1975; Imber & Nilsson 1980), feeding frequency of the two species at S. Georgia (Croxall & Prince 1980) implies opposite.

**FOOD** Mostly marine crustaceans with some small fish and cephalopods. **BEHAVIOUR.** Most food by pursuit-diving, birds propelling themselves under water with wings and feet to depths of 10 m (perhaps 20) (Payne & Prince 1979), less frequently pursuit-plunging, surface-diving and surface-seizing (Croxall & Prince 1980). Unlike other procellariiformes, does not form stomach oil in proventriculus (Roby *et al.* 1989).

**BREEDING** At S. Georgia (17 chicks; Payne & Prince 1979) diet euphausiids 76% vol. (*Euphausia superba*), copepods 20 (*Calanoides acutus*, *Rhincalanus gigas*) and amphipods 4 (*Hyperoche medusarum*, *Hyperiella antarctica*, *Themisto gaudichaudii*, *Cylopus lucasii*). Euphausiids increased from 70% of diet late Feb. to 100% mid-Mar. Most were post-larval 10–13 mm long with few adolescents (30–40 mm). At Heard I., copepod *Paraeuchaeta antarctica* and amphipod *Themisto gaudichaudii* predominated with some amphipods *Hyperiella antarctica*, *Hyperia spinigera* and euphausiid *Thysanoessa vicina* (Ealey 1954). Remains of euphausiids, small fish and young cephalopods (*Histioteuthis atlantica*, *Teuthowenia*, *Chiroteuthis*, *Argonauta*) in two NZ specimens (Imber & Nilsson 1980). Diet estimated to contain 10.7% protein, 8.7% lipid, 1.4% chitin and carbohydrate and 75.8% water (Roby & Ricklefs 1986).

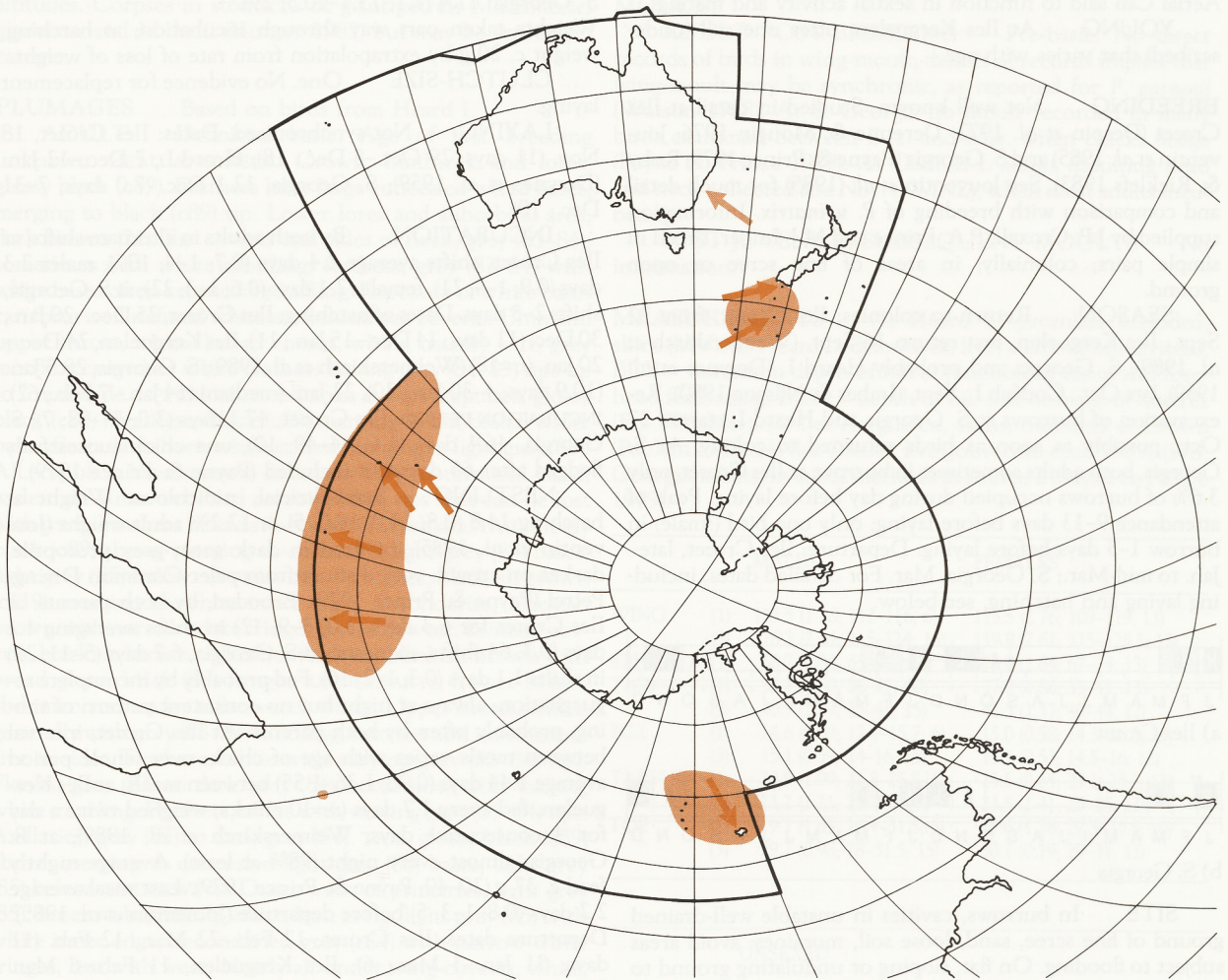
**INTAKE** Chicks at S. Georgia fed about 2 meals/day, mean weight of meals 18.6 g (n=9; Payne & Prince 1979), slightly less than mean weight of meal of 22.3 g (0.3 SE; 149) and 2.12 meals/day recorded there by Ricklefs (1984). At Ile de l'Est, Iles Crozet, interval between meals while chick being brooded 0.80 days (0.37; 0.50–1.45; 38 weighings of 8 chicks) with increase in weight during 24 h feeding period 4.8 g (4.5; 0–20; 31); after brooding has stopped, interval 1.33 days (0.15; 1.10–1.53; 167 weighings of 6 chicks) with increase in weight 11.2 g (8.7; 0–39; 102; Jouventin *et al.* 1985).

**SOCIAL ORGANIZATION** Virtually unknown. Breed colonially in simple pairs. No information on bonds.

**BREEDING DISPERSION** Colonial; for density see Breeding. No further information.

**ROOSTING** Before laying, only 3.6% of burrows occupied during day (Iles Crozet; Jouventin *et al.* 1985). No further information.

**SOCIAL BEHAVIOUR** Virtually unknown. Before laying at S. Georgia, two adults sometimes in same burrow but

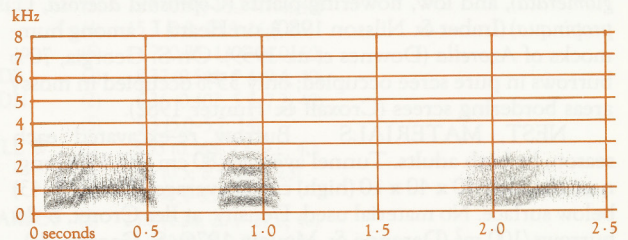


only one bird at nest in last 5 days before laying (Payne & Prince 1979). No information on agonistic and sexual behaviour.

**RELATIONS WITHIN FAMILY GROUP** Birds return to Iles Crozet, late Sept. Females usually returned to burrow on night before laying. Sexes share incubation equally; mean length of shifts 2.4 days (0.7; 1-4; 107); mean length of time at sea 2.3 days (0.7; 1-4; 43); desertions uncommon. Nestling fed by both parents. Independent after fledging.

**VOICE** Virtually no information; some observations from Bird I, S. Georgia (Payne & Prince 1979), Iles Kerguelen (H. Weimerskirch) and Codfish I, NZ (M.J. Imber). No reports of calling at sea; birds call at night at breeding colonies; at Iles Kerguelen and Codfish I., in flight over colony and from burrows; at S. Georgia, only reported to call from burrows. Not heard to call during day (M.J. Imber). At Iles Kerguelen, birds utter two calls, one in flight, the other from ground; at S. Georgia, common call, a varying series of *squeaks* (Payne & Prince 1979); probably similar at Codfish I. Calls noticeably different from those of Common Diving-Petrel. Period of calling, unknown. At Iles Kerguelen, both calls show distinct sexual dimorphism. No information on geographical variation.

**ADULT** At S. Georgia, common call from burrows consists of 5-10 varying *squeaks* (Payne & Prince 1979). Sonagram A shows 3 *squeaks*. Length of individual notes and interval between notes varying; pause of several seconds



A D. Turner; Bird I, S. Georgia, Dec. 1973; C129

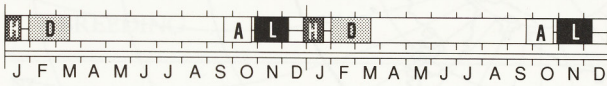
between calls; at Iles Kerguelen, call of male consists of one syllable, usually repeated four (1-4) times per call; call of female composed of 3-6 syllables, each syllable repeated once; said to function for territorial defence and individual recognition. **Aerial Call.** Reported at Iles Kerguelen and Codfish I., at night, in flight over colony; at Codfish I., between Sept. and Oct.; a repeated *ku-eek*, with interval of several seconds between calls; at Iles Kerguelen said to be sexual differences;

Aerial Call said to function in sexual activity and mating.

**YOUNG** At Iles Kerguelen, utter one call (undescribed) that varies with age.

**BREEDING** Not well known. Studied in detail at Iles Crozet (Despin *et al.* 1972; Derenne & Mougin 1976; Jouventin *et al.* 1985) and S. Georgia (Payne & Prince 1979; Roby & Ricklefs 1983). See Jouventin *et al.* (1985) for much detail and comparison with breeding of *P. urinatrix*. Information supplied by J.P. Croxall, P.A. Prince and M.J. Imber. Breed in simple pairs; colonially; in areas of fine scree or open ground.

**SEASON** Return to colonies: Iles Crozet, from 22 Sept.; Iles Kerguelen, first return 16 Sept. (Weimerskirch *et al.* 1989); S. Georgia and probably Heard I. (Downes *et al.* 1959), late Oct.; Codfish I., Sept. (Imber & Nilsson 1980). Re-excavation of burrows at S. Georgia and Heard I. started 27 Oct., possibly as soon as birds returned to colony. At S. Georgia, both adults sometimes in burrow; at Iles Crozet, only 3.6% of burrows occupied during day before laying. Peak of attendance 9–13 days before laying; only one bird (?male) in burrow 1–5 days before laying. Departure: Iles Crozet, late-Jan. to mid-Mar.; S. Georgia, Mar. For detailed dates, including laying and hatching, see below.



a) Iles Crozet



b) S. Georgia

**SITE** In burrows, cavities in unstable well-drained ground of fine scree, sand, loose soil, moraines; avoid areas subject to flooding. On flat, sloping or undulating ground to steep slopes ( $46^\circ+$ ); at high altitudes on Marion I. or less often near sea-level (1–5 m) on Codfish I. (Rand 1954; Downes *et al.* 1959; Imber & Nilsson 1980). Generally little vegetation in nesting areas; on Codfish I., sparse cover of sedges (*Scirpus nodosus*, *Demoschoenus spiralis*), introduced grasses (*Dactylis glomerata*), and low, flowering plants (*Coprosma acerosa*, *C. propinqua*) (Imber & Nilsson 1980); on Heard I., among hummocks of *Azorella* (Downes *et al.* 1959). On S. Georgia, 70% burrows in pure scree occupied; only 35% occupied in mossy areas bordering screes (Croxall & Hunter 1982).

**NEST, MATERIALS** Burrow re-excavated each season, by both adults. Tunnel averages 80 cm (30–170) long; nest-chamber 40 x 40 x 10 (high) cm, at average 28 cm (13–43) below surface. No material used. Density: at Iles Crozet, 8–26 burrows/100 m<sup>2</sup> (Derenne & Mougin 1976); S. Georgia, 10–300/100 m<sup>2</sup> (Croxall & Hunter 1982).

**EGGS** Rounded ovate; more or less smooth, mat; white, sometimes becoming discoloured.

**MEASUREMENTS:**

S. Georgia: 37.7 (1.6; 34.5–41.3; 32) x 30.6 (0.9; 29.0–32.0); 38.4 (1.8; 35.4–43.3; 51) x 30.9 (1.0; 28.8–33.5).

Iles Crozet: 38.8 (1.5; 36.2–41.7; 32) x 31.6 (1.0; 29.0–33.0).

Iles Kerguelen: 39.0 (1.2; 38.0–41.0; 5) x 32.5 (1.0; 30.1–33.5) (Paulian 1953).

**WEIGHTS:**

Iles Crozet: 21.1 (1.7; 19–24; 19).

S. Georgia: 17.4 (2.1; 13.1–20.5; 29).

Weights taken part way through incubation; at hatching, weight c. 20 g by extrapolation from rate of loss of weight.

**CLUTCH-SIZE** One. No evidence for replacement laying.

**LAYING** Not synchronized. Dates: Iles Crozet, 18 Nov. (11 days; 29 Oct.–8 Dec.; 18); Heard I., 7 Dec.–12 Jan. (Downes *et al.* 1959); S. Georgia, 12.1 Dec. (7.0 days; 7–31 Dec.; 10).

**INCUBATION** By both adults in alternate shifts; at Iles Crozet, shifts average 2.4 days (0.7; 1–4; 107), males 2.3 days (0.9; 1–4; 21), females 2.1 days (0.6; 1–3; 22); at S. Georgia, shifts 2–3 days. Dates of hatching: Iles Crozet, 25 Dec.–20 Jan., 30 Dec. (11 days; 14 Dec.–15 Jan.; 11); Iles Kerguelen, 24 Dec.–20 Jan. (n=18) (Weimerskirch *et al.* 1989); S. Georgia, 28.5 Jan. (10.9 days; 4–30 Jan.; 20), 22 Jan. (median) (14 Jan.–7 Feb.; 62). **INCUBATION PERIOD:** Iles Crozet, 47.1 days (3.0; 44–52; 7); S. Georgia, 46.4 days (1.6; 44–49; 10), one chick successfully fledged after 65 days not included (Payne & Prince 1979).

**NESTLING** Semi-altricial, nidicolous. Weight at hatching 14.8 (0.8; 14.0–16.0; 5) or 12.2% adult weight (Jouventin *et al.* 1985); covered in dark sooty-grey protopile, darker on crown, very distinct from paler Common Diving-Petrel (Payne & Prince 1979). Brooded, by both parents: at Iles Crozet for 6.3 days (2.0; 3–9; 12) in shifts averaging 1.1 days (0.3; 64 shifts, six nests); at S. Georgia, 6.7 days (5–11; 22) in shifts 1.1 days (0.3; 1–2; 16). Fed probably by incomplete regurgitation; always at night but no consistent pattern of timing, probably often by both parents. At Iles Crozet, interval between meals varies with age of chick: over whole period average 1.44 days (0.08; 1.36–1.55) between meals; at Iles Kerguelen, fed every 1.7 days (n=10 chicks, weighed twice a day for 4 consecutive days; Weimerskirch *et al.* 1989); at S. Georgia, almost every night (98% at least). Average nightly feed c. 37 g (20–40; Payne & Prince 1979). Last meal average 2.2 days (0.8; 1–3; 5) before departure (Jouventin *et al.* 1985). Departure dates: Iles Crozet, 17 Feb.–22 Mar., 12 Feb. (11 days; 31 Jan.–3 Mar.; 6); Iles Kerguelen, 11 Feb.–6 Mar. (Weimerskirch *et al.* 1989); S. Georgia, 14.3 Mar. (10.2 days; 4 Mar.–2 Apr.; 18). **NESTLING PERIOD:** Iles Crozet, 50.3 days (2.7; 47–54; 8); Iles Kerguelen, average 55 days (3.4; 49–60; 9) (Weimerskirch *et al.* 1989); S. Georgia, 45.5 days (1.5; 43–48; 18).

**GROWTH** For growth curves see Payne & Prince (1979) and Jouventin *et al.* (1985). Maximum weight: at Iles Crozet, 145.4 (21.7; 122–175; 8), 120.2% adult weight, at 37.9 days old (5.4; 30–47; 8); at S. Georgia, c. 152, 141% mean adult weight, at 33 days old. Weight at fledging: at Iles Crozet, 103.5 (23.5; 82–155; 8), 85.5% adult weight; at S. Georgia, c. 104, 97% mean adult weight. Achieve effective homoeothermy when 5–6 days old and maximum mass specific metabolism when 3+ days old (Ricklefs & Roby 1983).

**SUCCESS** Hatching: S. Georgia (inferred from status of burrows), c. 36% (n=51) in mossy areas, 67–71% (n=177) in scree (Croxall & Hunter 1982); Iles Crozet, 78% (n=9). Fledging: Iles Crozet, 29% (n=7) (Despin *et al.* 1972) but these birds were handled regularly. Thus, total success doubtfully 22%. **PREDATORS.** Skuas *Catharacta* take adults arriving at colonies at night and chicks from shallow burrows often during day (M.J. Imber) by trenching back along burrows (E.J. Woehler); without great care, burrows used for study are particularly vulnerable. Brown Rats *Rattus norvegicus* take eggs and small chicks on S. Georgia; feral cats take chicks and adults; both may be particularly serious as predators at low

altitudes. Corpses in stomachs of giant-petrels *Macronectes giganteus* and *M. halli* (Hunter 1983) but may be scavenged carrion.

**PLUMAGES** Based on birds from Heard I.

**ADULT** Definitive basic. Age of first breeding unknown. **HEAD AND NECK.** Crown, hindneck and lores, glossy black (c89). Feathers have large concealed white bases, merging to black (c89) tip. Lower lores and suborbital area, dark brown (21). Ear coverts and sides of neck, grey (83-84), sometimes with white mottling; feathers, grey (83-84) with white bases often exposed by ruffling. Exposure of white bases can form well-defined white arc behind ear-coverts. Chin and upper throat, white. Lower throat, white, usually with grey mottling caused by white feathers having grey (84-83) tips up to 2 mm wide. **UPPERPARTS.** All areas except scapulars, glossy black (c89). Feathers, black (c89) merging to concealed white bases. Scapulars short; white at base merging to light grey (85). All scapulars have narrow dark-grey (83) subterminal band, widest on outer web, and narrow white tips that can be lost with wear. Feathers have dark-brown (119) shafts. **TAIL,** glossy black (c89) above, merging to concealed light-grey (85) bases; light grey (85) below. **UPPERWING.** Primaries, blackish brown (c119) merging to white inner edge. Secondaries, blackish brown with narrow white fringes lost with wear. Primary coverts, blackish brown. All other feathers, blackish brown with broad glossy black (89) fringes. **UNDERPARTS.** Lower breast, abdomen and under tail-coverts, white. Upper breast, white, generally with grey (83-84) mottling, heaviest and most extensive at sides. Feathers, white with varying grey (83-84) tips. Flanks, grey (83) to dark grey (84), sometimes with varying white mottling. Feathers, white with varying grey (83-84) tips. Axillaries, grey (83) to dark grey (84). **TAIL,** glossy black (c89) above, merging to concealed light-grey (85) bases; light grey (85) below. **UNDERWING.** Outer webs of primaries, light grey (85); inner webs, mainly white, but, at tip, light grey (85) with white inner edge. Secondaries, grey (c84) with narrow white fringes, lost with wear. Nearly all under wing-coverts, white, with dark-brown (119), occasionally white, rachis. Feathers have greyish (85) bases, occasionally exposed at junction of humerus and ulna. Some small coverts at carpal joint, grey (85) with black (c82) shafts. Marginal coverts, grey (85). Outermost coverts between carpal joint and p10, grey (85) with black (c82) shafts. Primary under wing-coverts, light grey (85) with broad white shaft-streak and fringes. At Iles Crozet, small proportion of birds have grey (-) under wing-coverts (Jouventin *et al.* 1985).

**DOWNY YOUNG** Protoptile, sooty grey (Payne & Prince 1979). Mesoptile, dark brown-grey above, light brown-grey on breast and belly.

**BARE PARTS** Based on Payne & Prince (1979), NMNZ, MV, and photos in NZDOC library.

**ADULT, JUVENILE** Iris, black-brown (119). Bill, black (89) with pale-blue (168D) mandibular rami and base of ramicorn. Soles and hind edge of tarsus, black (-); black-brown also reported (Mougin 1985). Rest of tarsus and toes, blue (168B), sometimes slightly lighter at joints. Webs, blue-grey (dark 88) to blackish (82), sometimes with slight mauve tinge.

**DOWNY YOUNG** No black line on hind edge of tarsus on hatching, this attained before fledging (Payne & Prince 1979). No other information.

**MOULTS**

**ADULT POST-BREEDING** Pre-basic. No direct records of birds in wing-moult; dearth of records implies that wing-moult may be synchronic, as reported for *P. garnotii* (Watson 1968). At S. Georgia no moult recorded in many birds examined between Dec. and Mar. when chicks fledge (Payne & Prince 1979). At Codfish I. adults moulting head and neck collected late Nov. (NMNZ), when most adults incubating.

**POST-JUVENILE, SUBSEQUENT MOULTS** No information.

**MEASUREMENTS** (1) Heard I., juveniles excluded, skins (MV). (2) Heard I., definitives, live; width of bill at rictus, BDB = minimum depth of bill at junction of nares and forehead feathering, BDN = depth of bill just in front of nostrils (E.J. Woehler). (3) Iles Kerguelen, skins; methods unknown (Paulian 1953). (4) Iles Crozet, live (Jouventin *et al.* 1985). (5) S. Georgia, adults, live; bill methods as source 2 (Payne & Prince 1979).

		MALES	FEMALES
WING	(1)	113.5 (1.26; 112-116; 6)	115.5 (2.76; 109-119; 13)
	(3)	118.3 (2.44; 115-124; 15)	119.8 (2.61; 115-125.5; 12)
	(5)	118.2 (3.21; 112-124; 50)	
8TH P	(1)	68.7 (2.06; 65-71; 6)	70.0 (1.84; 67-74; 13)
TAIL	(1)	38.7 (1.60; 36-41; 40)	37.9 (1.86; 33-41; 13)
	(3)	40.9 (2.09; 35-45; 15)	41.3 (1.37; 40-44; 12)
BILL	(1)	14.6 (0.69; 13.4-15.7; 6)	15.0 (0.58; 14.3-16.2; 13)
	(3)	15.1 (0.59; 14-16; 15)	15.1 (0.53; 14.5-16; 12)
TARSUS	(1)	23.9 (1.09; 22.8-25.8; 6)	25.5 (0.64; 23.1-25.5; 13) **
	(3)	23.2 (1.21; 21-25; 15)	23.5 (1.41; 20-25; 12)
TOE	(1)	29.1 (1.63; 26.4-31.5; 5)	29.6 (1.28; 27.5-31.8; 10)
	(3)	29.7 (0.98; 28-31.5; 15)	30.1 (0.79; 29-31; 12)
UNSEXED			
WING	(2)	115.1 (3.73; 108.0-124.0; 40)	
	(4)	119 (5; 106-129; 35)	
	(5)	118.2 (3.21; 112-124; 50)	
TAIL	(2)	37.4 (1.81; 34.0-41.0; 40)	
	(5)	39.7 (2.26; 34.0-44.0; 50)	
BILL	(2)	15.1 (0.91; 13.1-17.4; 40)	
	(4)	15.3 (0.8; 13.8-16.8; 35)	
	(5)	14.7 (0.83; 13.4-16.0; 50)	
BDB	(2)	8.37 (0.541; 7.4-9.4; 40)	
BDN	(2)	6.26 (0.402; 5.3-7.2; 40)	
	(5)	5.3 (5.0-5.7; 14)	
BILL W	(2)	8.53 (0.368; 7.6-9.2; 40)	
	(4)	9.3 (0.5; 8.5-10.5; 23)	
	(5)	8.3 (7.4-9.0; 14)	
TARSUS	(2)	23.6 (1.26; 20.7-27.0; 40)	
	(4)	25.0 (0.9; 23.0-26.5; 35)	
	(5)	23.8 (0.83; 22.0-26.3; 50)	

Non-breeding birds at colony in S. Georgia smaller than breeding adults; females probably slightly larger than males (Payne & Prince 1979). Information on chick growth in Payne and Prince (1979), Jouventin *et al.* (1985).

**WEIGHTS**

**ADULT** At Heard I. 1987-88, 117.9 (7.34; 104.0-130.0; 40; E.J. Woehler). At Iles Crozet 121 (13; 90-150; 71; Jouventin *et al.* 1985). At S. Georgia during breeding season,

peak weight occurs after egg laying; near end of incubation period 122.6 (8.36; 105–146; 49; Roby & Ricklefs 1983). Weight declines steadily until chick fledges, when adult weight 93.3 (3.64; 6; Payne & Prince 1979). In first day of incubation shift 125.3 (6.97; 15), on last day of incubation shift, 2–3 days later, 119.6 (6.51; 8; Roby & Ricklefs 1983).

**DOWNY YOUNG** Information on growth in Jouventin *et al.* (1985), Payne & Prince (1985).

**STRUCTURE** Wing short, pointed and narrow; 11 primaries, p11 minute, p10 longest, p9 0–1 shorter, p8 2–5, p7 6–11, p6 11–16, p5 16–21, p4 21–28, p3 27–35, p2 34–42, p1 41–50; 12 secondaries, three of tertial form. Tail short and square, t1–t6 1–4. Bill short; maxillary unguis hooked at tip, mandibular unguis slightly downcurved. Mandibular rami almost parallel at base; concave, meeting in pointed arch, and enclosing distensible pouch. Nasal tubes about one quarter length of bill; nostrils point upwards; oval, narrow, with lateral septa in centre. Tarsus slightly flattened, with small hexagonal scales. Middle toe longest, outer c. 95%, inner c. 80%, no hind toe.

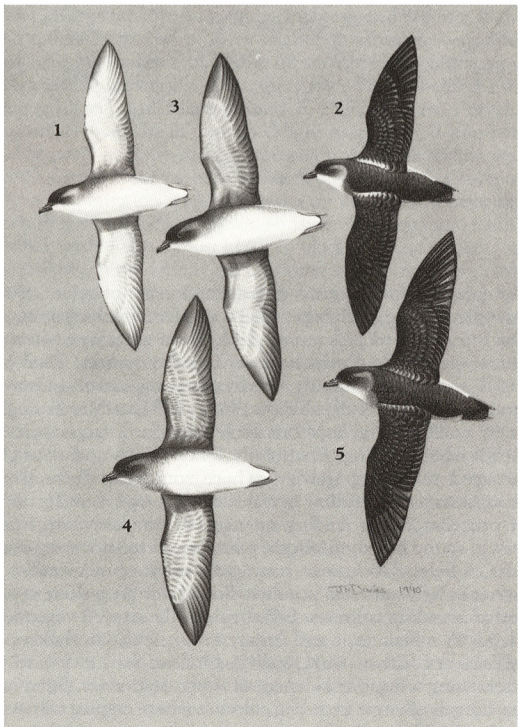
**RECOGNITION** Separation from *P. urinatrix* difficult, most reliable identification character shape of nostril. In both, nostrils almost bisected by paranasal processes attached to internasal septum. In *georgicus* paranasal septa set in longitudinal septa of nostrils, in *urinatrix* set at posterior of nostrils; character often obscured by sand (Imber & Nilsson 1980). In S. Georgia, Heard I., Codfish I. and Iles Kerguelen, primaries of *georgicus* have mostly white inner webs whereas primaries of *urinatrix* have grey inner webs. At S. Georgia, colour of hind edge of tarsus (black in *georgicus*, blue in *urinatrix*) considered slightly less reliable because chicks of *urinatrix* have black hind edge of tarsus that may be retained after fledging (Payne & Prince 1979). At Iles Kerguelen, chicks of *urinatrix* have no black hind edge on tarsus (Milon & Jouanin 1953); at Iles Kerguelen and Crozet, colour of tarsus regarded as most reliable character for identification (Milon & Jouanin 1953; Jouventin *et al.* 1985; J-C. Stahl). Measurements, especially width and depth of bill, useful for identification, *georgicus* being smaller than *P. u. exsul*. Other characters for identification discussed by Murphy & Harper (1921), Paulian (1953), Payne & Prince (1979): all vary too much to be used as basis of identity of all beachcast individuals. Extralimital *P. garnotii* and *P. magellani* described in Murphy and Harper (1921), Harrison (1983) and Murphy.

**GEOGRAPHICAL VARIATION** Possibly some variation in colour of tarsus and underwing. Black line on hind edge of tarsus indistinct in some birds from Codfish I. (NMNZ). Rachis of under wing-coverts black-brown or white at Heard I. (MV), white at Iles Kerguelen (Paulian 1953). Other variation described under Recognition. 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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