

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 HYDROBATIDAE (OCEANITIDAE) storm-petrels

Storm-petrels are the smallest seabirds, distinguished by having prominent united nostrils with a single opening, wings with a longer second functional primary, and often with a white rump, varying in closely related forms and assumed to serve as an important interspecific recognition-signal. They feed by picking small animals from the surface and fall into two groups.

(1) The sub-family Oceanitinae consists of seven fairly distinct species in five genera, of which five species occur in our region. Characterized by short wings with only ten secondaries, more or less square tails, elongated skulls, and tarsi longer than the toes. They progress by hopping and fluttering over the surface. Some species are said to have only one coat of nestling down. Adults are all polymorphic to some extent. Six species are usually white below; only one has an entirely black breast (Murphy & Snyder 1952). Most breed in the s. hemisphere and only the normally dark-breasted species, Wilson's Storm-Petrel *Oceanites oceanicus*, migrates far N of the equator, where an ancestor might have given rise to the second group (Palmer 1962).

(2) The sub-family Hydrobatinae consists of some 14 fairly closely related species in three genera; in our region only two of these species (in *Oceanodroma*) have been recorded, as accidentals. This group is characterized by having longer wings than the other, wedge-shaped or more usually forked tails, short skulls and bills, tarsi usually about equal in length to the toes, and a swooping flight, walking but not hopping along the surface. They have two coats of nestling down. Adults are usually dark and not polymorphic, though one species is grey and another southern one is white below. Most breed in the north but some breed, or migrate a short distance, south of the equator.

In general, plumage is black or grey above; the rump and underparts may be grey or white. Wing with 11 primaries, p9 longest, p11 minute; 10-11 secondaries, rather short, diastataxic. Tail quite long, forked, square or rounded; 12 feathers. Bill rather small, strongly hooked; nostrils fused with single opening, often upwards. Tarsus, rounded; three forward toes, webbed; hind toe, rudimentary; claws, sharp; flattened in some. Oil-gland feathered. Peculiar musky odour. Sexes similar and juveniles like adults.

Cosmopolitan in all oceans; strictly pelagic, coming to shore only to breed and then usually by night. Very little knowledge of distribution, behaviour and requirements of most species when at sea, because birds are so hard to find and identify. On land, crouch on tarsi and move with shuffling gait. Flight erratic, usually close to surface, characterized by bouncing, fluttering, swooping and skimming progress. Feed mostly on planktonic crustaceans, molluscs and small fish; some species habitually follow ships, scavenging in wake; obtain food mostly by flight-feeding while hovering, pattering or walking on water; seldom dive. Gregarious or solitary at sea. Long-term monogamous pair-bond, probably maintained only at nest-sites by reason of fidelity to site. Little knowledge of social behaviour but birds evidently not specialized for visual displays; sexual communications probably by tactile (allopreening), olfactory and vocal means. Churring or purring calls are a notable feature of breeding colonies. Nest colonially in holes or burrows. Eggs, ovate, mat, white. Clutch-size, invariably one. Single-brooded and probably no replacement laying or very seldom. Incubation by both sexes in alternate shifts of up to 6 days; single median brood-patch. Incubation period, 40-50 days. Eggshells usually left in nest. Young, semi-altricial, nidicolous; hatched in down. Guarded and brooded for 5-7 days before being left alone during day and fed at night, by incomplete regurgitation. Nestling period, 59-73 days; not deserted by parents in last days in nest. Maturity attained in some species at 4-5 years of age.

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Fregetta grallaria **White-bellied Storm-Petrel**

COLOUR PLATE FACING PAGE 681

Procellaria grallaria Vieillot, 1817, *Nouv. Dict. nat., nouv. éd.* 25: 418 — 'Nouvelle Hollande' = Australia.

Grallaria is a modern Latinized adjective from *grallae* (stilts) and no doubt refers to the habit of dangling the feet and treading the water shown by these birds.

OTHER ENGLISH NAMES Vieillot's or Broad-tailed Storm-Petrel.

White-bellied, now most widely used, is preferred to **Vieillot's** and makes a good descriptive contrast with **Black-bellied**.

POLYTYPIC Nominate *grallaria* breeds Admiralty Is (Roach), Lord Howe Grp and Macauley I., Kermadec Grp; *leucogaster* (Gould, 1844) breeds Tristan da Cunha Grp, on Ile St Paul, and perhaps Ile Amsterdam; *segethi* (Philippi & Landerk, 1860) breeds on Juan Fernandez Is; *titan* Murphy, 1928, breeds on Rapa I., Austral Grp in central Pacific Ocean.

FIELD IDENTIFICATION Length 18–22 cm; wing-span 46–48 cm; weight 45–62 g. Medium to large polymorphic storm-petrel; very similar in size, shape and flight to Black-bellied Storm-Petrel *F. tropica* (also polymorphic). Light morph: blackish above with white upper tail-coverts forming conspicuous patch; blackish hood sharply demarcated from white underbody across upper breast; white triangular-shaped patch on under wing-coverts. Intermediate morphs show increasing amounts of black along flanks, breast, vent, under tail-coverts, underwing and rump. Dark morph, wholly dark except for white mottling on centre of belly and lateral and distal upper tail-coverts. Sexes alike. No seasonal variation. Juveniles inseparable.

DESCRIPTION Nominate subspecies. **ADULT.** **Light morph.** Head and neck, blackish brown (appearing blackish at sea). Mantle, back, scapulars and rump, blackish brown with narrow white fringes; upper tail-coverts, white, showing as conspicuous white patch above blackish tail, extending down to join white of underparts. Upperwing, blackish with narrow white fringes to median secondary coverts; greater secondary coverts paler greyish brown with narrow white fringes showing as pronounced pale panel on innerwing, contrasting with darker blackish remiges and forewing; pale fringes and panels impart greyish cast to saddle and inner wing-coverts; greyish cast lost with wear, saddle appearing darker blackish brown; pale innerwing panels may become paler through wear and fading. From below, blackish brown of head and neck extends to upper breast forming blackish hood sharply demarcated in straight line across breast from clean white lower breast, belly, flanks and vent; under tail-coverts, white tipped blackish brown; undertail, blackish. On underwing, broad blackish brown leading-edge and wholly blackish remiges enclose triangular-shaped area of white on central coverts that joins white axillaries and central flanks. Bill, black; short, strongly downcurved at tip with prominent tubed nostrils, angled upwards. Iris, dark brown. Feet and long legs, black; in travelling flight tips of feet level with tip of tail (at least on those in A'asian waters *contra* Harrison 1985). Little known **Dark morph** (breeding Lord Howe I., Tasman Sea) differs from light morph by entirely dark blackish-brown plumage except for white mottling on centre of belly and on lateral and distal upper tail-coverts; on upperwing, greater secondary coverts, dark brown, and inner wing-panel darker (unknown if show narrow white fringing above or if inner wing-panel paler greyish-brown when fresh). Little known **Intermediate morphs**, also from Lord Howe I. (and possibly other populations) show continuous variation between light and dark morphs. On palest-bellied intermediates, border of hood and breast smudged, not sharply demarcated; dark on sides of breast extends narrowly along full length of flanks, combining with dark axillaries to form dark band separating white of wing-pit from white of belly; compared to light morph: less white on under wing-coverts and largely confined to wing-pit; more dark on under tail-coverts; dorsal pattern similar. Variation from light to dark intermediates shows progressive reduction in area of white on belly and

vent and increase in dark on breast, flanks and vent; boundary of white and dark, streaked and smudged; upper tail-coverts gradually darken leaving only narrow area of white mottling on lateral and distal coverts. Darker intermediates show much dark streaking and smudging over belly giving underbody mottled appearance but never pattern of irregular black stripe down centre of belly as on Black-bellied Storm-Petrel.

SIMILAR SPECIES Difficult to distinguish from *F. tropica* because plumages overlap by polymorphism (of both) and affected by wear. Both are same size and shape but always separable by position of feet in relation to tip of tail: in *grallaria*, feet level with tip of tail; in *tropica*, most of feet project beyond tip of tail. **Light-morph** *grallaria* differs from typical *tropica* by: (1) narrow white fringing to saddle and inner wing-coverts, with pronounced grey-brown panels on innerwing giving greyish cast to dorsum and paler appearance above (*tropica* has little or no pale fringing above and innerwing panels darker brown, appearing darker above); difference lost with wear; (2) demarcation between hood and white of underbody straighter, sometimes even gently concave (not forming V in centre of upperbelly) and across upper rather than lower breast; (3) Underbody (except tip of under tail-coverts), clean white (*tropica* has diagnostic irregular black stripe down centre of belly fusing with V-shaped lower border of hood and black feathering in centre of vent); (4) chin and throat, black (*tropica* has varying white patch on chin and throat though difficult to discern). Some *tropica* are white bellied: black stripe on belly much reduced or lacking; belly and flanks may be clean white or marked with small, isolated black smudges on rear flanks, sides of lower belly and vent, isolated from black on under tail-coverts and central vent; further, demarcation of hood and belly may appear straighter and across upper breast, recalling light-morph *grallaria*. Very difficult to separate **light-morph** *grallaria* from white-bellied *tropica*: differ by dorsal pattern, colour of chin and projection of feet; also, underbody from lower breast to vent clean white without isolated black smudges. **Palest intermediate-morph** *grallaria* differ from white-bellied *tropica* by dorsal pattern, colour of chin and projection of feet; also separable by (1) dark line down full length of flanks combining with dark axillaries to form dark band separating white in wing-pit from white belly (on *tropica*, flanks and axillaries always clean white and continuous with white of under wing-coverts); (2) area of white on underwing smaller, mostly confined to wing-pit (on *tropica*, larger, showing as triangular-shaped area extending from wing-pit onto primary coverts). **Darker intermediate-morph** *grallaria* differ from typical *tropica* by (1) extensive dark on flanks; (2) obvious dark smudging and streaking round white of belly, which on darkest birds covers much of belly but never forms pattern of black stripe down centre of belly; (3) little or no white in wing-pit; (4) varying amount of blackish on upper tail-coverts substantially reduces area of white patch (on all *tropica*, upper tail-coverts white, forming prominent white patch). **Dark-morph** *grallaria* differs from **Wilson's Storm-Petrel** *Oceanites oceanicus* as follows: (1) larger, fatter-bodied and broader-winged; (2) feet do not pro-

ject beyond tip of tail (on Wilson's, much of feet project beyond tip of tail); (3) white mottling down centre of dark underbody (uniform sooty brown on Wilson's); (4) upper tail-coverts dark except for white mottling on lateral and distal coverts (on Wilson's, upper tail-coverts wholly white); (5) on upperwing, innerwing panel darker brown (on Wilson's, innerwing panel, much paler, more pronounced); (6) characteristic erratic skipping progression in direct flight (see below; flight of Wilson's more direct, higher above sea, with bursts of rapid wing-beats broken by short glides). For differences from **Grey-backed Storm-Petrel** *Oceanites nereis*, see that account.

Circumpolar in Southern Ocean mostly in Subtropical Zone but ranging into Subantarctic; migrate N to Tropics during non-breeding season. Markedly pelagic; occasionally sighted in shelf-break and, rarely, inshore waters. Flight distinctive and varied: in windy conditions, glide rapidly forward into wind on gently upswept wings, body swinging wildly from side to side in characteristic contour-hugging action and, with one leg lowered and angled at 45° to body, pushing off surface every few seconds to give skipping progression recalling that of *tropica*; when feeding by contact-dipping, collide breast-first with surface between each skip; suddenly break off skipping progression and glide rapidly downwind keeping low to surface in level or gently undulating glide (on gently upswept wings) sometimes interspersed with brief series of shallow fluttering wing-beats; when feeding by pattering, maintain nearly stationary position facing into wind with legs dangling and pattering on surface, bird reaching forward to pick items deftly from surface with bill. When gliding, wings appear broad with proportionately short innerwing, strongly curved leading-edge to outerwing (tapering to pointed tip) and nearly straight trailing edge; tail appears gently notched at tip when held tightly folded, square-cut in most flight attitudes and rounded at tip when fanned. Feed by dipping and pattering; solitary or gregarious at sea, sometimes following in wake; more often seen ahead of or accompanying vessels. Breed on rocky or well-vegetated subtropical islands where

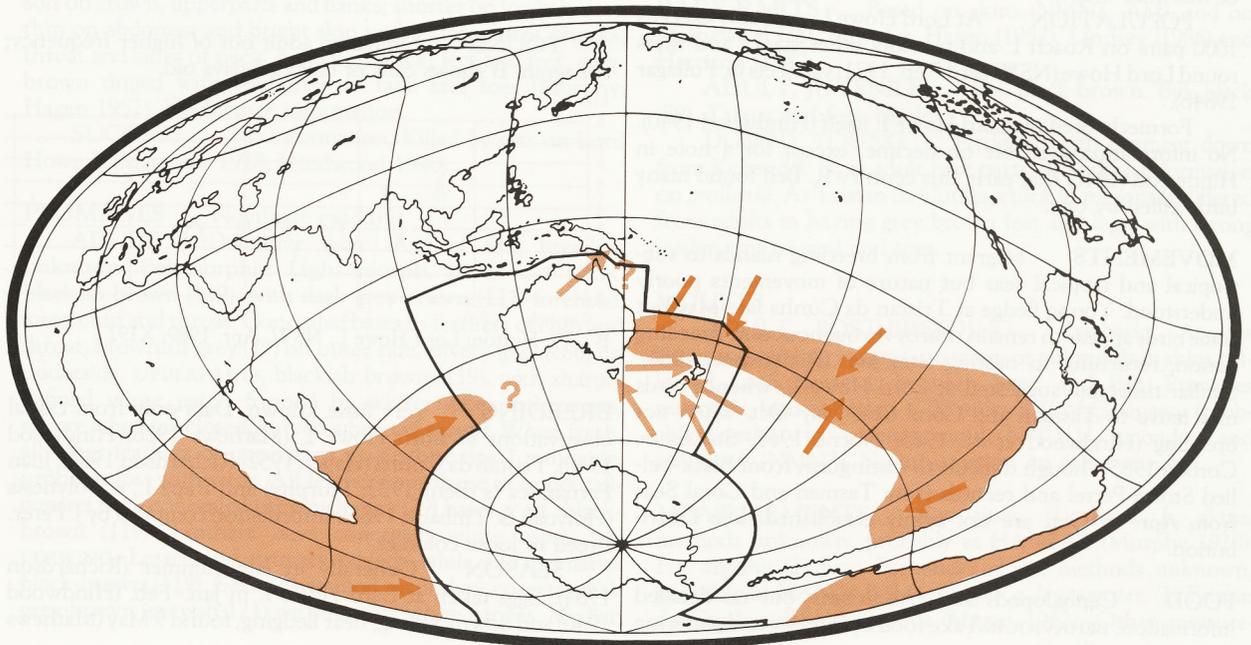
loosely colonial and strictly nocturnal. Silent at sea; repeated shrill monotonous whistle *huuuu* or high-pitched piping *pee-pee* (or *peu-peu*) at nest.

HABITAT Marine, pelagic; in subtropical and highly saline tropical waters of Pacific, Indian and Atlantic Oceans (Crossin 1974; Ainley & Boekelheide 1983); less common in subantarctic waters (Bierman & Voous 1950; Ryan *et al.* 1987). In non-breeding season, migrate to Tropics; recorded in Tasman Sea, as far S as 34°S where warm surface water present (Norris 1965). In Aust., recorded in non-breeding season near edge of continental shelf; seen feeding 25 km offshore in NSW, but not at 10 km; continental margin of n. and central NSW may be favoured feeding area of Lord Howe I. breeding birds (Holmes 1977). At Juan Fernandez Is, feed in pelagic waters, except in rough weather, when close inshore below cliffs (Murphy). At Tristan da Cunha, at sea always observed on seaward side of kelp (*Macrocystis*) zone, in waters where small crustaceans abundant (Hagen 1952).

Breed in s. Atlantic and Pacific Oceans, close to Subtropical Convergence; on rocky or vegetated islands and stacks; from close to sea-level to 450 m asl (Murphy; Hagen 1952); Holyoak & Thibault 1984; van Tets & Fullagar 1984a,b). Nest in caves, cliff and rock crevices (E. Polynesia; Holyoak & Thibault 1984); on boulder beaches, slopes and plateaux (Tristan da Cunha; Hagen 1952). Vegetation in some nesting areas: grass, tussock, *Scirpus* or tree-fern (Tristan da Cunha; Hagen 1952).

Fly immediately above surface when feeding.

DISTRIBUTION AND POPULATION Pelagic distribution poorly understood; found s. Pacific, Atlantic and Indian Oceans, S to 42°S (Crossin 1974; Ainley & Boekelheide 1983; Ryan *et al.* 1987; Rose & Rose 1989; N.G. Cheshire; D.W. Eades). In w. Pacific, nominate race found N and E of breeding islands to Tropics; recorded Tasman Sea (Norris 1965; N.G. Cheshire; D.W. Eades), Coral Sea (Hindwood *et al.* 1963; Norris 1967) and N of NZ (25°41'S,



176°00'E) (Lovegrove 1978). Extralimital races recorded at 7°S in Atlantic (Peters); in w. Pacific found between 2°N and 15°S and 85 and 117°W (R. Beck in Murphy; King 1974) and between 26° and 27°S, round breeding islands off coast of Chile (Peters).

AUST. No specimens (Aust. CL); difficult to distinguish from Black-bellied Storm-Petrel. Sight-records in Tasman and Coral Seas, May–Oct. (Hindwood *et al.* 1963; Norris 1967; Stokes & Corben 1985) are unsubstantiated, however likely they may be, and others claimed in Tasman Sea (33°S, 156°E, June; 33°S, 153°E and 32°S, 155°E, April) (N.G. Cheshire; D.W. Eades) have not been published. **Qld.** One seen near Flat Rock off Pt Lookout, 14 Apr. 1984 (Qld Bird Rep. 1984). **NSW.** Claimed sight-records: on continental shelf waters between Woolli and Nambucca Heads in 1975 (three, 23 May; three, 1 July; nine, 7 July; two, 15 Sept.; two, 30 Sept.) (Holmes 1977); two, at sea, 40 km off Coffs Harbour, 25 Sept. 1983 (NSW Bird Rep. 1983); off Wollongong, 1985 (NSW Bird Rep. 1985). **Tas.** One found dead, Eaglehawk Neck 'towards close of 1928' (Fletcher 1947). None of these records has been properly supported by published details, so that status, distribution and occurrence of species in e. Aust. waters cannot yet be assessed.

NZ 'One specimen taken in NZ seas' (Oliver). Three seen near coast 1969: two, 75 km W of C. Farewell in Nov. (Jenkins 1970) and one near Poor Knights Is., Dec. (Croxall 1970). Beachcasts: one, Waikawa Beach, July 1975 (CSN 22); one, Ninety Mile Beach, Apr. 1978 (CSN 1978); one Piha Beach, Auckland West, May 1985 (Powlesland 1987); one Hampden Beach, Otago, 12 June 1987 (Powlesland 1989; CSN 35).

Nominate race breeds Admiralty Is (Roach), Lord Howe Grp (possibly islets), and Kermadec Grp (Macauley and Curtis Is). Extraliminally, in Pacific Ocean, *segethi* breeds Juan Fernandez Is (Goat I. off Mas a Tierra), and *titan* breeds on Rapa I. and Austral Group; in Atlantic and Indian Oceans, *leucogaster* breeds Tristan da Cunha Grp (Inaccessible, Nightingale and perhaps, Tristan da Cunha) (Richardson 1984; Fraser *et al.* 1988), on Roche Quille, off Ile St. Paul (Tollu 1984; Roux & Martinez 1987).

POPULATION At Lord Howe I., probably exceeds 1000 pairs on Roach I. and possibly other stacks and islets round Lord Howe (NSW Bird Rep. 1971; van Tets & Fullagar 1984b).

Formerly bred on Lord Howe I. itself (Hindwood 1940). No information available on decline, except for a note in Hindwood (1940) that early this century R. Bell found many birds killed by cats.

MOVEMENTS Migrant from breeding islands to subtropical and tropical seas but nature of movements poorly understood. Young fledge at Tristan da Cunha late May but some birds appear to remain nearby throughout non-breeding season, returning to nesting sites Jan. (Richardson 1984). Similar timetable suggested at Lord Howe I., whence birds may move to Tasman and Coral Seas May–Oct. when not breeding (Hindwood *et al.* 1963; Norris 1967; Stokes & Corben 1985) though difficult to distinguish from Black-bellied Storm-Petrel and records from Tasman and Coral Seas from Apr. to Oct. are not firmly established. See Distribution.

FOOD Cephalopods and crustaceans, but no detailed information. **BEHAVIOUR.** Take food by dipping and pattering

(Harper *et al.* 1985). Observed skipping across surface with legs flipping from side to side (Jenkins 1970) and lifting wings high every third flap (Croxall 1970) while following ship (Jenkins 1970). Seen feeding in association with gadfly petrels *Pterodroma* spp, Buller's Shearwater *Puffinus bulleri* and Masked Booby *Sula dactylatra* (Ainley & Boekelheide 1983).

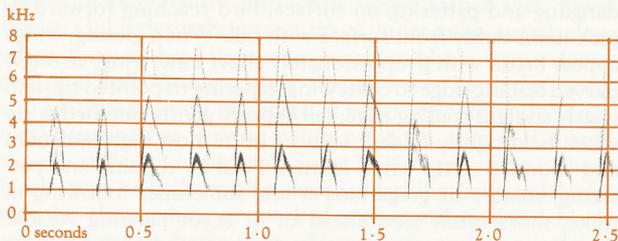
SOCIAL ORGANIZATION AND BEHAVIOUR

No information. Spend daylight at sea and do not come to land until it is quite dark (Hindwood 1940).

BREEDING DISPERSION Colonial. Not especially gregarious.

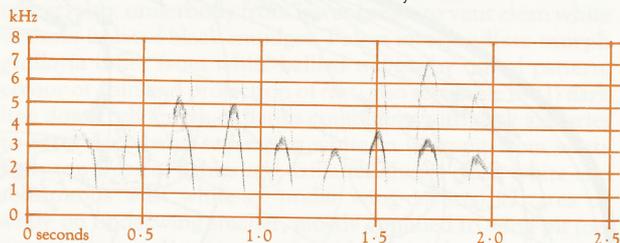
VOICE No detailed studies published. All information supplied by P.J. Fullagar from observations at Lord Howe I. Generally silent and little variety in calls; only high-pitched twittering call known. Call only from ground, usually, if not always, from within nesting cavity. Not noisy. Call best described as soft. Apparently silent in flight and at sea. Calls heard at breeding sites from Jan. to Mar. at least. Sexual, individual and geographical differences have not been investigated.

ADULTS High-pitched whistle *pee-pee-pee-pee* or *peu-peu-peu-peu*, often repeated 20 or more times in sequence (sonagram A). Presumably locating and advertising call. Calls probably similar to those of Black-bellied Storm-Petrel (*q.v.*).



A P.J. Fullagar; Lord Howe I., NSW, Aug. 1971; B792

YOUNG Similar to adult but of higher frequency; sonagram B shows calls of chicks 3-days old.



B I. Hutton; Lord Howe I., NSW, Apr. 1989; X192

BREEDING Very little known. Data only from casual observations at Lord Howe I. (Mathews 1928; Hindwood 1940), Tristan da Cunha (Hagen 1952; Richardson 1984), Juan Fernandez Is (Bent 1922; Murphy) and Rapa I., e. Polynesia (Holyoak & Thibault 1984). Information compiled by J. Peter. Breed in loose colonies.

SEASON Generally in late summer (Richardson 1984). Eggs taken at Lord Howe I. in Jan.–Feb. (Hindwood 1940) and downy young, near fledging, found 9 May (Mathews

1928). At Tristan da Cunha, nesting Jan.–Mar. At Juan Fernandez, most nests with chicks 19 Jan. (Bent 1922). Most leave Tristan da Cunha in May.

SITE In compact soil on flat ground or slopes up to 45° (Hagen 1952); among loose rocks (Richardson 1984); in rock piles under large rocks quite close to beach (Bent 1922) and on lee side of island (Murphy); also 15–20 m asl and on plateaux to 450 m asl (Hagen 1952). On grassy slopes, burrows under hanging tussocks, which may completely hide entrance, and on plateaux between tufts of *Scirpus* and tree-ferns (Hagen 1952). In grassy areas little soil left outside burrows, but some nests among rocks clearly visible (Murphy). On Tristan da Cunha, some shared burrows with Great Shearwaters *Puffinus gravis* (Hagen 1952).

NEST, MATERIALS In enlarged chamber at end of shallow burrow, which often has right-angled bend; however, on flat ground, tunnel straight, sloping gently. Entrance may resemble rat-hole (Hagen 1952; Hindwood 1940). Nests examined on Juan Fernandez Is lined with straw or few twigs from bushes (Bent 1922) and on Lord Howe I. lined with little dead grass (Hindwood 1940); on Tristan da Cunha, circular nest-cup of dry grass, fronds of tree-ferns, moss, leaves and plant stems, material being collected from close round entrance (Hagen 1952). Excavation and building probably at night, because birds absent during daylight. Measurement of burrows, 45–47 cm long; of chamber, 20x20 cm across and 8 cm high or about 12 cm in diameter. Depth below surface, 10 cm; nest-cup, 8–11 cm across, 2–4 cm from entrance (Hagen 1952; Hindwood 1940).

EGGS Almost symmetrically ellipsoid or elongate oval; smooth-shelled, lustreless; dull white, almost covered with very faint brown, red-brown or pink spots, becoming streaky at larger end where may unite into patch 14 mm in diameter (Murphy; Hagen 1952).

MEASUREMENTS: Tristan da Cunha, av. 36.3 x 26.4 (n=3) (Hagen 1952; Richardson 1984).

CLUTCH-SIZE One.

LAYING, INCUBATION No information.

NESTLING Semi-altricial, nidicolous. Hatched with lead-grey to bluish grey down, brighter on belly; long and soft on crown, upperparts and flanks; shorter on lower breast; thin on abdomen and bright skin visible; face, lores, cheeks, throat and sides of neck, bare; bill, black; legs and feet, grey-brown tinged with lead-grey on tarsi and toes (Murphy; Hagen 1952). No further information.

SUCCESS No information. Killed by cats on Lord Howe I. (Mathews 1928; Hindwood 1940).

PLUMAGES Nominate *grallaria*

ADULT Definitive basic. Age of first breeding unknown. Polymorphic. **Light morph.** **HEAD AND NECK,** blackish brown (119), with dark grey-brown (121) forehead, lores, chin and throat. Concealed bases to feathers of chin and throat, brownish grey (79) on outer side, silvery grey (c86) on underside. **UPPERPARTS,** blackish brown (119), with sharply defined white patch formed by white upper tail-coverts, square when tail closed; curved when tail spread. When fresh, all other feathers of upperparts have white tips 1 mm wide; probably lost with wear. All feathers but those of upper tail-coverts have concealed brownish grey (79) bases. **TAIL,** black-brown (119). Feathers have concealed white bases. **UPPERWING.** Lesser and primary coverts, alula and primaries black-brown (119). Secondaries and secondary coverts, dark grey-brown (greyish 121) with narrow white fringes. Median

coverts, black-brown (119) with narrow white tips. With wear, white fringes lost and rest of feather discolours to brown (119B). Marginal coverts, black-brown (119) with narrow grey-brown (119C) tips. **UNDERPARTS.** Upper breast and sometimes sides of central breast, dark brown (c121), feathers having concealed white bases and very narrow white tips, rapidly lost with wear. Central under tail-coverts, dark brown (c121) with narrow white tips and concealed white bases. Lateral under tail-coverts, white with dark brown subterminal band. Rest of underparts, white. **UNDERWING.** Remiges and outer four primary under wing-coverts, dark grey (c83) with light grey (85) gloss in some lights. Outer primaries have less reflective, narrow tegmen; secondaries have very narrow white fringes. Outer primary-median and primary-lesser under wing-coverts, black brown (119) with white tips. Remaining median and greater under wing-coverts, white. Lesser under wing-coverts, black-brown (119). **Dark morph:** only differences from light morph described. **UPPERPARTS.** Feathers lack white tips (unknown if present when very fresh). Upper tail-coverts, blackish brown (c121) with concealed white bases; those of lateral upper tail-coverts visible when ruffled. **UNDERPARTS,** dark brown (121). Lower breast, belly and flank-feathers have concealed white bases that can be exposed when ruffled, giving appearance of white mottling. **WING.** Secondaries and secondary coverts, dark brown (dark 121); unknown if greyer when fresh. Under wing-coverts, all black-brown (119). **Intermediate morph:** continuous variation from pale to dark morph. White tips to feathers of upperparts not recorded; unknown if present in fresh plumage. Position of junction of blackish brown breast and white belly varies, but closer to vent than in light morph. Belly has varying amount of dark brown (121) mottling formed by dark brown tips. No birds have dark stripe down centre of belly.

DOWNY YOUNG No information on protoptile. Mesoptile, grey (84–85). Said to be paler in *F.g. titan* (Holyoak & Thibault 1984).

JUVENILE Only one skin studied, plumage appears same as light-morph adult. Unknown if colour related to age.

BARE PARTS Based on skins (NMNZ; AM), and on Mathews (1928), Murphy, Hagen (1952), Lindsey (1986) and Harrison (1987).

ADULT, JUVENILE Iris, black-brown. Bill, black (89). Tarsus and feet, black.

DOWNY YOUNG Fledgling with remnant down from Kermadec Is, as adult bare parts. No other information on *grallaria*. At Tristan da Cunha, chick in mesoptile differed from adults in having grey brown feet and legs, with strong leaden tint to tarsi and toes.

MOULTS

ADULT POST-BREEDING Pre-basic. At sea between breeding seasons; no wing- or tail-moult in skins collected Lord Howe I. between Sept. and Feb. Primaries outwards; bird collected 1700 miles SW of Galápagos (probably *segethi*) with primary moult N⁷4¹3¹1¹, secondary and tail-moult (NMNZ). No information on other moults.

MEASUREMENTS *F.g. titan:* (1) Rapa I., skins; methods unknown, probably as HANZAB (Murphy 1928). *F.g. segethi:* (2) Juan Fernandez skins; methods unknown, probably as HANZAB (Murphy). *F.g. leucogaster:* (3) Tristan da Cunha, definitive skins (Hagen 1952). Other measure-

ments in Murphy & Snyder (1952). Reversed sexual dimorphism apparently marked at Tristan da Cunha (Hagen 1952) but negligible elsewhere; more information needed.

	MALES	FEMALES
WING	(1) 181 (17)	184.1 (10) (Combined range = 177-188)
	(2) 155.4 (51)	156.4 (12) (Combined range = 146-163)
TAIL	(3) 162.3 (5.77; 159-169; 3)	179.5 (2.65; 176-182; 4)
	(1) 82.4 (17)	83.8 (10) (Combined range = 78-89)
BILL	(2) 73.3 (51)	73.5 (12) (Combined range = 71-77)
	(3) 73.0 (1.00; 72-74; 3)	82.3 (5.25; 79-90; 4)
TARSUS	(1) 15.4 (17)	15.5 (10) (Combined range = 15-16.3)
	(2) 13.1 (51)	13.4 (12) (Combined range = 12.6-14)
TOE	(3) 14.6 (0.55; 14.2-15.3; 3)	14.6 (0.39; 14.4-15.2; 4)
	(1) 40.6 (17)	41.6 (10) (Combined range = 39-43)
BILL	(2) 35 (51)	35.6 (12) (Combined range = 33-37)
	(3) 39.3 (0.35; 39.1-39.7; 3)	38.5 (0.74; 37.7-39.2; 4)
TARSUS	(1) 25.1 (17)	25.8 (10) (Combined range = 23.6-27)
	(2) 21.6 (51)	21.5 (12) (Combined range = 20-22.6)
TOE	(3) 23.8 (1.45; 22.3-25.8; 3)	23.3 (0.73; 22.3-25.2; 4)

Unsexed birds. *F.g. grallaria*: (4) Lord Howe I., live adults; unflattened unstraightened wing measured from carpal joint to tip of longest primary with a soft tape stretched over top of wing, other methods as HANZAB (ABBBS; G.F. van Tets & P.J. Fullagar) (5) Lord Howe I., definitive skins (AM; ANWC; HLW). *F.g. leucogaster* (6) Tristan da Cunha, live (Fraser *et al.* 1988).

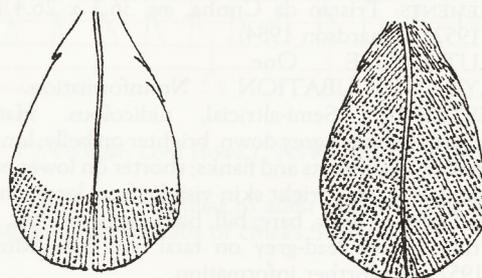
	UNSEXED
WING	(4) 168 (3.80; 159-176; 37)
	(5) 165 (2.98; 161-169; 8)
8TH P	(6) 168 (3.80; 158-174; 29)
	(5) 124 (2.59; 120-127; 8)
TAIL	(4) 75.6 (3.30; 66-82; 37)
	(5) 75.0 (2.50; 71-78; 8)
BILL	(6) 78.3 (3.8; 71.0-86.5; 25)
	(4) 14.1 (0.39; 13.2-15.0; 37)
TARSUS	(5) 14.0 (0.51; 13.0-14.7; 8)
	(6) 15.8 (0.6; 14.5-17.0; 25)
TOE	(4) 37.1 (1.02; 35.1-39.1; 37)
	(5) 37.6 (1.32; 35.6-39.6; 8)
BILL	(6) 40.7 (2.7; 37-43; 25)
	(5) 21.6 (1.10; 20.2-23.4; 8)
TARSUS	(6) 26.1 (2.7; 22-30; 24)

WEIGHTS *F.g. grallaria*: Lord Howe I., adults, late Feb. and early Mar., 52 (4.7; 45-65; 35) (ABBBS; G.F. van Tets & P.J. Fullagar); males 47 (2.0; 45-63; 5), females 52 (4.9; 46-60; 7) (combined data from AM, ANWC, ABBBS; G.F. van Tets & P.J. Fullagar); an adult female with much fat, late Feb., 60 g (ANWC). *F.g. titan*: Rapa I., Oct.-Dec., 69 (60-74; 9) (Holyoak & Thibault 1984). *F.g. leucogaster*: Tristan da Cunha in

Feb., males 47.9 (2.29; 45.3-49.5; 3), females 58.1 (5.66; 53-65; 4) (Hagen 1952); unsexed birds of unknown status, 52.6 (4.7; 45.5-62.5; 30) (Fraser *et al.* 1988). *F.g. segethi*: moulting at sea, 31 July, 30 g (NMNZ).

STRUCTURE Nominate *grallaria*. Eleven primaries; p11 minute, p9 longest, p10 8-11 shorter, p8 0-4, p7 12-15, p6 24-28, p5 35-41, p4 48-53, p3 57-66, p2 65-79, p1 75-90. Thirteen secondaries, five of tertial form. Tail, square to slightly rounded, 12 feathers; t1 2-5 longer than t6. Bill, short and slender; upper mandible hooked, lower mandible slightly decurved. Nasal tube tapers towards end, which points forwards and curves about 30° upwards; collapses when dried (Kinghorn & Cayley 1922). Reports that nasal tube less elevated than in Black-bellied Storm-Petrel (e.g. Tuck & Heinzel 1980) incorrect. Nostrils separated by narrow septum, which does not extend to opening of nasal tube. Feet do not stretch to tail tip. Tarsus, scutellate. Claws, flat; wedge-shaped when fresh, almost circular when blunt. Outer toe (excluding claw) longest, middle toe *c.* 90%, inner toe *c.* 97%.

RECOGNITION Based on nine *grallaria* and one *segethi* skins (no specimens of *titan* or *leucogaster* examined). Confusion possible with Black-bellied Storm-petrel. All morphs of *grallaria* lack black stripe down centre of belly characteristic of most Black-bellied Storm-petrels; along with *segethi* lack white bases to chin and throat feathers (Fig. 1), have scutellated tarsi, and feet do not extend beyond tip of tail when stretched. White-bellied forms of Black-bellied Storm-petrels have white bases to throat feathers, holothecal tarsi, and feet extend at least 1 cm beyond tail tip when stretched. Illustrations in Mathews (1933) suggest these characters may be less reliable in extralimital populations.



1a Black-bellied Storm-Petrel 1b White-bellied Storm-Petrel

Fig. 1 Throat-feathers

GEOGRAPHICAL VARIATION Four subspecies recognized (Peters). Nominate *grallaria* breeds Lord Howe and Kermadec Is; Lord Howe population only one known to be polymorphic; ratio of pale:intermediate:dark birds 1:4:5 (Bell *et al.* 1984). One specimen (light morph) known from Kermadecs. All other populations have only light morph, unless dark flecking in underparts of some *segethi* and *titan* (Murphy & Snyder 1952) related to polymorphism. Subspecies *titan* breeds Rapa I. and Austral Is (Murphy 1928) and considerably larger than other subspecies (see Measurements). Subspecies *segethi* breeds Juan Fernandez Is. Subspecies *leucogaster* breed Tristan da Cunha, Ile St. Paul, possibly Ile Amsterdam (Peters); probably also on Gough I., though status of white-bellied birds breeding there uncertain (see Black-bellied

Storm-Petrel); suggested that either *leucogaster* or light morph population of Black-bellied Storm-petrel (Bourne 1960; Peters; Clancey 1981).

Large variation in size at Tristan da Cunha and Gough I. unexplained, perhaps due to sexual dimorphism (Fraser *et al.* 1988). Clancey (1981) recorded 'markedly whitish' bases to chin and feathers on forethroat of specimen collected at Gough, but did not mention how specimen identified.

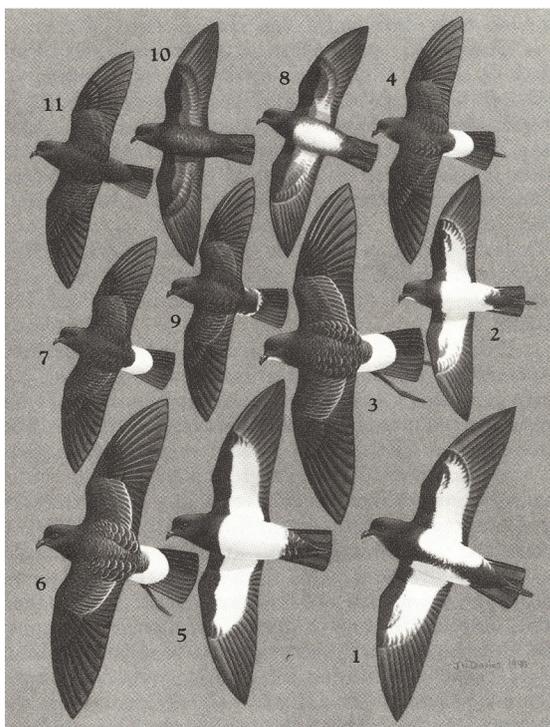
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Volume 1 (Part A), Plate 52

Black-bellied Storm-Petrel *Fregatta tropica*

1. Adult typical, ventral
2. Adult white-bellied, ventral
3. Adult, dorsal, fresh
4. Adult, dorsal, worn

White-bellied Storm-Petrel *Fregatta grallaria*

5. Adult, light morph, ventral, fresh
6. Adult, light morph, dorsal, fresh
7. Adult, light morph, dorsal, worn
8. Adult, intermediate morph, ventral
9. Adult, intermediate morph, dorsal
10. Adult, dark morph, ventral
11. Adult, dark morph, dorsal

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