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.

References

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

Family PROCELLARIIDAE fulmars, petrels, prions, shearwaters

The family Procellariidae represents the main radiation of medium-sized 'true petrels', characterized by having united nostrils with a median septum and the outer functional primary at least as long as the next. It tends to be dominant among the birds of the Southern Ocean, though in the n. hemisphere the Charadriiformes are more numerous. The giant-petrels *Macronectes* have also developed as large scavengers and predators, showing some convergence in appearance and behaviour with the Diomedeidae. The Procellariidae may be divided into four main groups with some intermediate species, which makes it hard to draw distinctions between them.

(1) The fulmars *Macronectes, Fulmarus, Thalassoica, Daption* and *Pagodroma* consist of seven species of surface predators and filter-feeders of rather varying structure and appearance (Voous 1949) that breed in high latitudes but may migrate along cool currents into much lower ones. *Fulmarus* appears to have colonized the n. hemisphere in the Tertiary. Six of the seven species are essentially confined to our region.

(2) The gadfly-petrels *Pterodroma* are a large series of some 30 agile species; 16 breed in our region and another six occur rarely or rather rarely. Their short sturdy bills are adapted for seizing soft prey at the surface, and their twisted intestines, for digesting marine animals with an unusual biochemistry, which are also found throughout the warmer oceans (Imber 1985). They show complex markings of face and wings that must serve as interspecific recognition-marks (Murphy & Pennoyer 1952). Some species placed in this group have an intermediate structure and intergrade with all other groups distinguished here: *Pterodroma* (*Lugensa*) *brevirostris*, which moves S in winter, has distinctly big eyes like *Pagodroma*; *Halobaena caerulea* has a plumage similar to that of prions; *Bulweria* has some structural resemblance to shearwaters. At present it is difficult to determine their precise relationships.

(3) The prions *Pachyptila* are a specialized group of six (perhaps five) very numerous species, all in our region, that show a progressive adaptation of a small, agile, cryptically coloured, fulmarine form for filter-feeding on zooplankton. There has been dispute over their classification (Cox 1980; Harper 1980) but the arrangement discussed by Fleming (1941) seems best except that the Broad-billed Prion *P. vittata* appears to intergrade with Salvin's Prion *P. salvini* through *macgillivrayi* of Ile St Paul; so they may be better treated as subspecies of the same species.

(4) The shearwaters *Procellaria, Calonectris* and *Puffinus* include some 20 agile species with long bills adapted to catch prey more or less under water throughout the warmer seas (Kuroda 1954); 13 species breed in our region, some migrating into the n. hemisphere; six others are chance or perhaps regular visitors. From the fossil record (Brodkorb 1963; Olson 1975); they seem to have been particularly common in the great Tethys Ocean of the middle latitudes of the n. hemisphere in the Tertiary, so this development of aquatic habits may have occurred there without competition from penguins with a subsequent return S by the more successful forms.

General features of the family are: body, ovate, or elongate in shearwaters; wings, long and narrow, 11 primaries, p10 longest, p11 minute; 20–29 secondaries, short, diastataxic; tail, short, 12 feathers; bill, heavy (*Macronectes*), slender (shearwaters), broad (prions) or stubby (gadfly-petrels), hooked, formed of several horny plates; nostrils in dorsal tube of varying length; legs set far back, laterally flattened but round in gadfly-petrels; three toes, webbed, hind toe vestigial, raised. Oil-gland feathered. Peculiar musky odour. Sexes similar, male usually larger than female. Plumage, black or grey above, white below, or all dark; light and dark morphs in some species. Juveniles and immatures usually like adults.

Cosmopolitan throughout the oceans, essentially pelagic; more abundant in cool or cold waters rich in plankton and mostly away from ice. Swim well but usually aerial except when feeding or resting. Fly with alternate swooping and flapping action close to the surface but often arcing high in some gadfly-petrels. Gait on land, a shuffling crouch, being unable to walk properly with feet set so far back; generally avoid open areas on land, being thus vulnerable to predators. Nest colonially; for the most part in burrows and cavities in all sorts of terrain, sometimes far from the sea and in mountainous areas but some species, e.g. *Macronectes*, nest on open ground. Hole-nesters usually nocturnal at colonies, when often extremely vocal, though generally silent at sea. Migratory and dispersive. Some species divide the year between s. and n. hemisphere, often migrating in large flocks that may settle on the sea in huge dense rafts. Feed mostly on fish, cephalopods and crustaceans obtained by flight-feeding, plunge-diving, surface feeding, surface-diving and underwater pursuit; hydroplaning (Murphy) is a characteristic method used particularly by prions.

Probably all defend small nesting territories to which they return regularly while undisturbed; certainly so in some hole- and burrow-nesting forms. Agonistic and sexual behaviour of nocturnal, hole-nesting species very poorly known but generally seem to have little specialization for visual displays. Tactile actions such as allopreening and billing used but olfactory and vocal communication is probably important. Breeding is usually seasonal, generally with synchronized laying, often after a pre-laying exodus but some may not nest annually; some have shorter

cycles or nest continually. For the most part, little attempt to make substantial nests. Eggs, ovate, mat, white. Clutch-size, invariably one; single-brooded; no replacement laying. Incubation by both sexes in alternate spells of 1–11 days. Single median brood-patch. Incubation period, 45–55 days. Eggshells probably always trampled in nest. Young, semi-altricial, nidicolous; hatched in down. Rarely left alone in nest for first 1–2 weeks. Cared for and fed by incomplete regurgitation by both parents. Nestling period generally shorter in cliff- and ledge-nesting species than in hole-nesters. Young attain greatest weight, often well above that of adult, some days before fledging, by which time weight has been reduced to about the same as an adult, but no clear evidence that young are totally deserted for last few days in nest. Adults and young of most species liable to eject stomach-oil in defence. Young independent at fledging. Maturity reached at minimum of 3–4 years, in some 6–12 years.

REFERENCES

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

Bulweria bulwerii **Bulwer's Petrel**

COLOUR PLATE FACING PAGE 560

Procellaria bulwerii Jardine and Selby, 1828, *Ills. Ornith.* 2: Pl. 65 — Madeira.

Named in honour of Rev. James Bulwer (1794–1879), Norfolk clergyman and amateur naturalist who had little interest in birds but who collected the type-specimen, probably on the Desertas in 1828. It was fortuitously acquired by BMNH when Sir Williams Jardine's collection of 8500 skins was auctioned publicly some years after Jardine's death in 1874, realizing only £217 2s 6d (Mearns & Mearns, *Biogr. Birdwatch.*, 1988).

MONOTYPIC

FIELD IDENTIFICATION Length 26–28 cm; wingspan 68–73 cm. Small all-dark petrel, except for conspicuous pale diagonal bar across proximal part of upperwing; similar in size to small gadfly petrels *Pterodroma* spp and prions *Pachyptila* spp, with strikingly long wings and long wedge-shaped tail, usually held folded in long narrow point; wedge-shape apparent only when tail spread briefly while manoeuvring. In good light, pale wing-bar usually visible to *c.* 250 m; beyond, appears wholly dark. Head and bill rather small in relation to size of body, resulting in rather short projection in front of wings relative to long narrow tail behind. Wings, long narrow and pointed, appearing set well forward on body, and carpals held well forward. Sexes alike. No seasonal differences in plumage. Juveniles inseparable from adults.

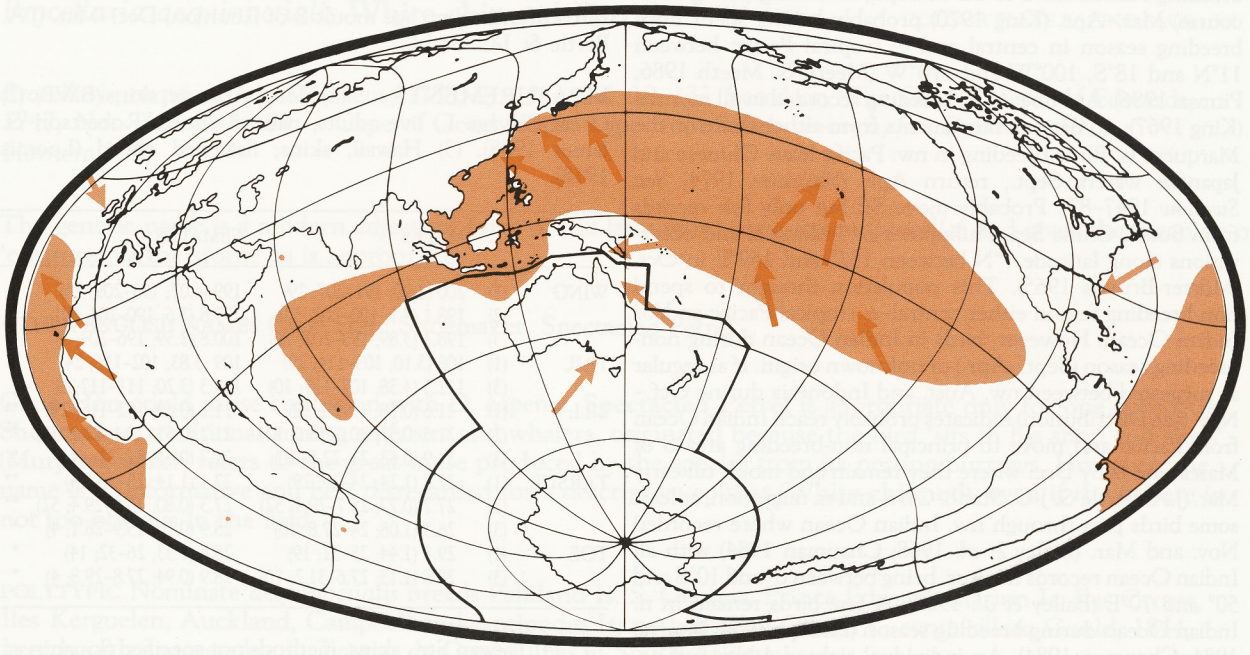
DESCRIPTION ADULT. Body plumage wholly sooty brown, showing slightly paler and greyer on chin, upper throat, lores and cheeks in some birds; whole plumage wears browner. Underwing and tail, sooty brown as body. Upperwing, uniform sooty brown apart from pale diagonal bar across proximal part, formed by median and greater secondary coverts. Pale bar, greyish brown when fresh, wearing and fading to pale buff; broadens outwards and extends forwards almost to carpals. Bill, black. Iris, dark brown. Legs rather short; tarsi, pink with outer sides sometimes darker; feet, usually greyish flesh with some pink on webs; outer toe tending to be darker than rest of foot.

SIMILAR SPECIES Can be confused with several dark petrels and shearwaters. **Matsudaira's Storm-Petrel** *Oceanodroma matsudairae* 10% smaller, with deeply forked tail and conspicuous pale patch on forewing formed by white

basal shafts of outer primaries; in calm conditions usually flies more slowly and sluggishly with shorter glides, though sometimes erratically like Bulwer's (see Bailey *et al.* 1968). **Swinhoe's Storm-Petrel** *O. monorhis* unrecorded in our region, distinctly smaller than Bulwer's, with shorter, forked tail, and closely resembles Leach's Storm-Petrel *O. leucorhoa* in size, jizz and flight. Dark morph **Wedge-tailed Shearwater** *Puffinus pacificus*, especially juveniles in fresh plumage, can cause greatest difficulty in identification of Bulwer's Petrel; some juveniles have pronounced silvery bar across inner part of upper wing, formed by pale bloom on greater secondary coverts but 50% larger and more broad-winged; also with long slender bill and longer finer head, resulting in greater body projection in front of wings. Adults lack pale upper wing-bar. At close range, Wedge-tailed Shearwaters of all ages show narrow pale fringes to scapulars, which form subtle scaly aspect to saddle (not in Bulwer's); also differ by lazier flap-and-glide and less erratic flight. **Christmas Shearwater** *P. nativitatis* between Bulwer's Petrel and Wedge-tailed Shearwater in size, with broader wings, shorter fuller tail, and long slender bill. Other distinguishing features are uniformly dark plumage, no pale wing-bar, black legs and feet, stiffer faster wing-beats and less erratic flight. **Jouanin's Petrel** *B. fallax*, of nw. Indian Ocean, and not recorded in our region, distinctly larger and heavier; at close range, longer and much heavier bill may distinguish it; in fresh plumage, pale wing-bar usually not noticeable but develops with wear. Some Jouanin's Petrels have lighter throat and forehead (*c.f.* subspecies *gouldi* of Great-winged Petrel *Pterodroma macroptera*); appearance of pale face never matched in Bulwer's. Tail of Jouanin's shorter and broader with mid-way step formed by shorter tail-feathers (Harrison 1987) but this may be caused by moult. Possibly best distinguished by combination of short broad tail and less erratic zig-zagging flight with roller-coaster progress, recalling that of *Pterodroma* spp but, like Bulwer's, may keep close to waves (below 5 m) more than previously realized (Bundy 1986). **Fiji Petrel** *Pterodroma macgillivrayi* extralimital in tropical sw. Pacific Ocean and known from only two records (Watling & Lewanavanua 1985); slightly larger than Bulwer's, wings more rounded, head larger, bill thicker and tail *c.* 20% shorter, feet mostly black with tarsi and spot on basal inner web pale blue; apparently without pale wing-bar; underwing, uniformly dark though, according to lighting and reflection, can appear silvery grey with dark leading-edge in contrast to uniform sooty brown in Bulwer's. Great-winged Petrel, Sooty Shearwater *P. griseus* and Short-tailed Shearwater *P. tenuirostris* are larger than Bulwer's Petrel with markedly different flight and jizz.

Flight buoyant and erratic; keeps close to water, rarely higher than 2–3 m above waves, alternating short series of strong rapid wing-beats in moderate to strong winds (slower in calms) with longer weaving glides. Main flight characteristic is frequent and irregular changes of direction, sometimes developing into bat-like zig-zagging, especially while foraging or feeding. Does not normally pay close attention to ships, except for short periods of 'bow-riding' when happening to be close enough. Surface feeder, not reported to plunge or dive. Feed by surface-seizing and dipping. Rest on surface in calm weather (Cheshire 1989). Silent and generally solitary or in pairs at sea; occasionally loose groups recorded.

HABITAT Marine; mainly in tropical and subtropical waters of three major oceans. Pelagic, occurring at sea up to 1600 km from breeding areas; pelagic distribution poorly known (King 1967). In Indian Ocean, recorded over warm waters (27.5–30 °C), of intermediate salinity (34–35‰) (Pocklington 1979); in e. Indian Ocean off Aust., widespread in waters of 24.69–27.04 °C and 34.27–34.82‰, including those of South Equatorial Current (Dunlop *et al.* 1988b). Only sighting off e. Aust. in waters of similar surface-temperature and salinity (28.78 °C, 34.66‰) (Cheshire 1989). Breed on islands, rocky islets and atolls in subtropical and tropical Pacific and Atlantic Oceans; breeding locations close to abundant food supplies in nutrient-rich upwellings and currents; nesting coincides with period of greatest food abundance and most favourable climate (Jouanin *et al.* 1979). Nest in rocky



sites, including cliffs, boulder slides, screes, shingle beaches (Bannerman & Bannerman 1963–68; Jouanin *et al.* 1979; Holyoak & Thibault 1984); apparently do not burrow, but will use burrows excavated by other birds (Jouanin *et al.* 1979). Restricted to holes too small for Cory's Shearwaters where two species sympatric (Lockley 1952).

Introduced mammalian predators on breeding islands are main conservation problem (Harrison *et al.* 1984).

DISTRIBUTION Tropical and subtropical zones of Atlantic, Indian and Pacific Oceans and East China Sea. Breed in two distinct areas: ne. Atlantic (Azores, Canaries and C. Verde Is); and nw. and central Pacific (off China, Taiwan [perhaps extinct], Ryukyu and Bonin Is, Hawaii, Phoenix and Marquesa Is). No records NZ.

AUST. Two acceptable (published with adequate details) sight records, each of a single bird: 31.5 km NE of Pith Reef lighthouse, just outside Great Barrier Reef at 18°01'S, 147°15'E on 4 Nov. 1985 (Cheshire 1989) and exceptionally far S, 5 km SE of C. Nelson, Vic., 14 Sept. 1986 (Carter & Reid 1989). However, since 1978 there have been increasing reports of birds off nw. Aust. and towards Christmas I. (Ind.) (Harrison 1979; Dunlop *et al.* 1988a; N.G. Cheshire) which strongly suggest that the species is quite usual or even common in nw. Aust. waters, at least between Sept. and Apr. These records have not been published with acceptable evidence recorded at sea and cannot be accepted officially.

MOVEMENTS Migratory from breeding localities but movements in non-breeding season poorly understood. Most Atlantic populations absent from breeding grounds Oct.–Mar. except those from Cape Verde Is, which leave Aug., return Jan. (Bannerman & Bannerman 1963–68). Non-breeding season spent in w. tropical and s. subtropical Atlantic between 10°N and 39°S and 20°W and 50°W, and some occur there all year (Bourne & Curtis 1985; BWP). A few records off s. Africa in non-breeding season (Brooke & Sinclair 1978) but Atlantic birds unlikely to penetrate Indian Ocean. Population breeding Hawaii leave to SE in Sept., returning (along same course) Mar.–Apr. (King 1970) probably having spent non-breeding season in central and e. tropical Pacific between 11°N and 18°S, 100°W and 170°W (Meeth & Meeth 1986; Pitman 1986). At Phoenix Is, breeding recorded in all months (King 1967); no data on movements from either there or the Marquesa Is. Birds breeding in nw. Pacific leave Chinese and Japanese waters Sept., return Apr. (Shuntov 1974; *Sea Swallow* 1947–87). Probably move SE but only few records from South China Sea, Philippines or Indonesia and observations along latitude 7°N between 152° and 169°E in Oct. (Mörzer-Bruyns 1965). This population thought to spend non-breeding season either central–e. tropical Pacific and/or Indian Ocean. However, birds in Indian Ocean during non-breeding season (Sept.–Apr.) of unknown origin. If as regular as suggested between nw. Aust. and Indonesia during Oct.–Nov. (see Distribution) indicates probably reach Indian Ocean from Pacific and move to principal non-breeding area S of Mascarene Is by Dec. where they remain and moult till early Mar. (J.A. Bartle & J-C. Stahl). On s. and n. migration, at least some birds pass through nw. Indian Ocean where recorded Nov. and Mar. (Bailey *et al.* 1968; Chapman 1984) with all Indian Ocean records for Apr. being between 0° and 10°S and 50° and 70°E (Bailey *et al.* 1968). A few birds remain in n. Indian Ocean during breeding season (Phillips 1959; Bourne 1984; Chapman 1984). An individual sighted 4 Nov. off ne. Qld (Cheshire 1989) fits none of the above patterns and is of uncertain origin.

PLUMAGES

ADULT Definitive basic. HEAD AND NECK, sooty brown above, slightly duller below. UPPERPARTS, sooty brown, marginally paler than crown, with faintly ashy tinge to rump. TAIL, sooty brown. UPPERWING. Secondary and median secondary coverts, grey (83–84) when fresh, becoming light grey-brown (c119C) with wear. Other coverts and alula, brown grey-black (brownish 82). Remiges, brown grey-black (brownish 82), palest on inner edges and base, with grey black (82) to brown (119B) shafts; colour of shafts perhaps related to wear. UNDERPARTS, sooty brown, slightly paler than upperparts. UNDERWING. Coverts, sooty grey; remiges as upperwing, but with grey gloss when viewed in some lights; shafts, grey-black (82).

DOWNY YOUNG Mesoptile, long and dense. First down, sooty (-), slightly paler below. Protoptile, dark, slightly brownish-grey (c79), a little paler below.

JUVENILE At breeding grounds, as fresh adult.

BARE PARTS Based on Zonfrillo (1988), BWP, NMNZ and photographs.

ADULT Iris, blackish brown. Bill, polished black (89); birds photographed with light grey-brown (119c) base to mandibular unguis may be dirty. Tarsus, pink (-). Feet vary from grey (-) to pink (-); usually greyish flesh (-) with some pink (-) on webs. Outer toe tends to be darker than rest of foot.

JUVENILE Feet, grey (-) to pink; bill of newly fledged birds with waxy texture; otherwise as adult.

MOULTS

ADULT POST-BREEDING Pre-basic. No information on body-moult. In North Atlantic, moult of flight-feathers presumably between Oct. and Apr., because it does not occur on breeding grounds. Little information for Pacific; a probable adult with fresh body-plumage and primary moult $N^{2}4^{1}2^{1}0^{6}$ collected N of Society Is, 20 Feb. 1956 (NMNZ). Birds of unknown age moult S of Reunion, Dec.–Mar. (J.A. Bartle & J-C. Stahl).

MEASUREMENTS (1) North Atlantic, skins (BWP). (2) Great Salvage I., live adults; natural chord (Robertson & James 1988). (3) Hawaii, skins; flattened chord (Loomis 1918).

		MALES	FEMALES	
WING	(1)	200 (3.90; 191–207; 29)	199 (4.07; 193–209; 24)	*
	(2)	198.1 (4.1; 190–208; 52)	197.8 (3.6; 190–204; 52)	*
	(3)	198.3 (3.89; 193–202; 10)	200.8 (3.59; 196–204; 4)	*
TAIL	(1)	108 (3.10; 103–114; 29)	109 (3.83; 102–116; 24)	*
	(3)	112.5 (4.38; 107–117; 10)	114.3 (3.20; 111–117; 4)	*
BILL	(1)	21.6 (0.78; 19–23; 29)	21.2 (0.69; 102–116; 24)	**
	(2)	21.6 (0.57; 20.6–23.0; 52)	21.2 (0.53; 20.1–22.3; 52)	**
	(3)	21.9 (0.63; 21–22.8; 10)	21.7 (0.61; 21–22; 4)	*
TARSUS	(1)	27.8 (1.24; 24–29; 29)	27.1 (1.14; 25–30; 24)	**
	(2)	27.7 (0.77; 25.7–29.4; 52)	27.3 (0.80; 25.8–29.4; 52)	**
	(3)	26.3 (1.08; 24–27.8; 10)	25.9 (0.26; 25.9–26.1; 4)	*
TOE	(1)	29.1 (1.44; 25–32; 19)	28.6 (1.33; 26–32; 14)	*
	(3)	29.8 (1.13; 27.6–31.2; 10)	28.9 (0.94; 27.8–29.8; 4)	*

(4) Taiwan Str., skins; methods not specified (Jouanin *et.*

al. 1979). (5) Marquesa Is, skins; methods not specified (Jouanin *et. al.* 1979). (6) Skins of mixed location (NMNZ).

	UNSEXED
WING	(4) 212.7 (5.3; 206–216; 3)
	(5) 191.3 (2.8; 187–194; 6)
8TH P	(6) — (129–136; 4)
BILL	(4) 21.9 (0.3; 21.5–22.2; 3)
	(5) 21.4 (0.4; 20.8–22.0; 6)
TARSUS	(4) 26.7 (0.3; 26.2–27.0; 3)
	(5) 26.2 (0.8; 25.0–27.0; 6)
TOE	(4) 31.7 (1.9; 29.0–33.2; 3)
	(5) 29.3 (0.6; 28.2–30.2; 6)

WEIGHTS Laysan I., Apr.–Aug., unsexed, 99 (13.8; 78–130; 191) (Harrison *et al.* 1983). Great Salvage I., June–July: males 107.1 (11.8; 87–131; 52), females 99.9 (10.0; 75–116; 52); daily weight loss during incubation shifts at Great Salvage: 2.50 g/day (0.50; 1.38–3.29; 21) (Robertson & James 1988).

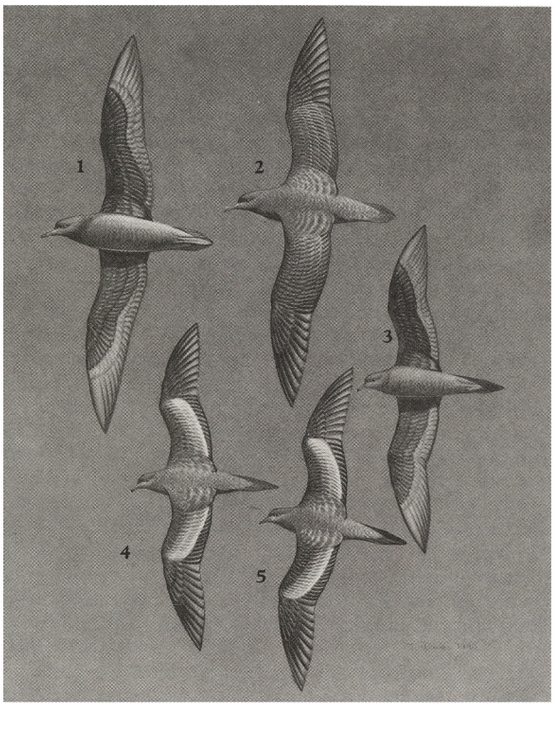
STRUCTURE Wing, long and narrow. Eleven primaries: p10 longest, p9 0–4 shorter, p8 6–10, p7 17–22, p6 32–39, p5 40–55, p4 63–72, p3 79–89, p2 92–101, p1 106–119. Tail, long and wedge-shaped; t1-t6 40–45. Bill stout, nasal tubes one-quarter to one-third of length; nostrils, small, circular, directed forwards and upwards. Tarsus, slender and round.

RECOGNITION Similar Jouanin's Petrel larger; pale wing bar smaller and absent on juveniles (Zonfrillo 1988). Harrison's (1987) observation that Bulwer's has short outer tail-feathers forming a 'midway step' in the tail needs confirmation; possibly due to moult. For other species see Field Identification.

DIR

REFERENCES

Bailey, R.S., *et al.* 1968. *Ibis* 110: 27–34.
Bannerman, D.A., & W.M. Bannerman. 1963–68. *Birds of the Atlantic Islands.*
Bourne, W.R.P., & W.F. Curtis. 1985. *Sea Swallow* 34: 18–28.
Bourne, W.R.P. 1984. *Sea Swallow* 33: 39–53.
Brooke, R.K., & J.C. Sinclair. 1978. *Cormorant* 4: 10–17.
Bundy, G. 1986. *Sandgrouse* 7: 29–42.
Carter, M.J., & T. Reid. 1989. *Aust. Bird Watcher* 13: 114–7.
Chapman, S.E. 1984. *Sea Swallow* 33: 12–21.
Cheshire, N.G. 1989. *Aust. Bird Watcher* 13: 61–2.
Dunlop, J.N., *et al.* 1988a. *Rec. West. Aust. Mus.* 14: 237–47.
Dunlop, J.N., *et al.* 1988b. *Aust. J. mar. freshwat. Res.* 39: 661–9.
Harrison, C.S., *et al.* 1983. *Wildl. Monogr.* 85: 1–71.
Harrison, C.S., *et al.* 1984. *ICBP Tech. Publ.* 2: 513–26.
Harrison, P. 1979. *A'sian Seabird Grp Newsl.* 12: 32–41.
Harrison, P. 1987. *Seabirds of the World: A Photographic Guide.*
Holyoak, D.T., & J-C. Thibault. 1984. *Mem. Mus. natn. Hist. nat. Ser. A, Zool.*, 127.
Jouanin, C., *et al.* 1979. *Oiseaux Revue fr. Orn.* 49: 165–84.
King, W.B. 1967. *Seabirds of the Tropical Pacific Ocean.*
King, W.B. 1970. *US Fish Wildl. Serv. Spec. Sci. Rept. Fish.* 586.
Lockley, R.M. 1952. *Ibis* 94: 144–57.
Loomis, L.M. 1918. *Proc. Calif. Acad. Sci.* 4: 1–186.
Meeth, P., & K. Meeth. 1986. *A'sian Seabird Grp Newsl.* 23: 15–35.
Mörzer Bruyns, W.F.J. 1965. *Sea Swallow* 17: 57–66.
Phillips, W.W.A. 1959. *Bull. Br. Orn. Club* 79: 100–101.
Pitman, R.L. 1986. *Atlas of Seabird Distribution and Relative Abundance in the Eastern Tropical Pacific.* SW Fish. Center Adm. Rept. LJ-86-02C.
Pocklington, R. 1979. *Marine Biol.* 51: 9–21.
Robertson & James 1988. *Bull. Br. Orn. Club* 108: 79–87.
Shuntov, V.P. 1974. *Seabirds and the Biological Structure of the Ocean.*
Watling, D., & R.F. Lewanavanua. 1985. *Ibis* 127: 230–33.
Zonfrillo, B. 1988. *Bull. Br. Orn. Club* 108: 71–5.



Volume 1 (Part A), Plate 41

Christmas Shearwater *Puffinus nativitatis*
1. Adult, ventral
2. Adult, dorsal

Bulwer's Petrel *Bulweria bulwerii*
3. Adult, ventral
4. Adult, dorsal, fresh
5. Adult, dorsal, worn