Order PELECANIFORMES

Medium-sized to very large aquatic birds of marine and inland waters. Worldwide distribution. Six families all breeding in our region. Feed mainly on aquatic animals including fish, arthropods and molluscs. Take-off from water aided by hopping or kicking with both feet together, in synchrony with wing-beat. Totipalmate (four toes connected by three webs). Hind toe rather long and turned inwards. Claws of feet curved and strong to aid in clambering up cliffs and trees. Body-down evenly distributed on both pterylae and apteria. Contour-feathers without after shaft, except slightly developed in Fregatidae. Pair of oil glands rather large and external opening tufted. Upper mandible has complex rhamphotheca of three or four plates. Pair of salt-glands or nasal glands recessed into underside of frontal bone (not upper side as in other saltwater birds) (Schmidt-Nielson 1959; Siegel-Causey 1990). Salt-glands drain via ducts under rhamphotheca at tip of upper mandible. Moist throat-lining used for evaporative cooling aided by rapid gular-flutter of hyoid bones. Tongue rudimentary, but somewhat larger in Phaethontidae. Throat, oesophagus and stomach united in a distensible gullet. Undigested food remains are regurgitated. Only fluids pass pyloric sphincter.

Sexually dimorphic plumage only in Anhingidae and Fregatidae. Selection of nest-site and initiation of pair-formation by male, but in Pelecanidae female first leads several males in a male-selection (or persistence) chase as in ducks. Nest built by female with material brought to nest-site mainly by male. Copulation normally on nest-site. Both sexes take turns guarding nest-site, incubating eggs, and brooding and feeding chicks. Eggs unicoloured with chalky finish except for Phaethontidae. Webbed feet used to warm eggs. Chicks hatch naked (except in Phaethontidae) and blind. Later fully covered with down for several weeks. Newly hatched chicks take fluid food from tip of parental bill. Older chicks take partly digested food from parental gullet, except in Phaethontidae, in which parent inserts bill into gullet of chick. Chicks become independent usually within a few weeks after fledging and at fledging in gannets *Sula* spp. At nesting colonies severe loss of eggs and chicks may result from human disturbance, parents being forced off nests, so that eggs and chicks become cold or overheat or are taken by predators.

Anatomical and behavioural similarities suggest close phylogenetic affinities between Pelecaniformes and Ciconiiformes, which could perhaps be united. Cottam (1957) found skeletal characters that suggest that the Shoe-billed Stork *Balaeniceps rex*, only member of the African family Balaenicipitidae, ought to be in Pelecaniformes rather than Ciconiiformes. Linnaeus (1758) included all pelecaniform birds known to him, except those in *Phaethon*, in the genus *Pelecanus*, from which Brisson (1760) removed the genera *Sula*, *Anhinga*, *Phalacrocorax* and *Fregata*. Subsequently these genera became the bases of six families in the order Pelecaniformes, formerly known as the Steganopodes. Over the last 200 years there has been debate about whether *Phaethon* and even *Fregata* ought to be included, and whether *Anhinga* ought to be in the same family as *Phalacrocorax*. There is ample behavioural (van Tets 1965), osteological and palaeontological (Olson 1985) evidence to demonstrate that there are six distinct extant families in the Pelecaniformes.

REFERENCES

Brisson 1760. *Orn.* 1: 60, 6: 511.
Cottam, 1957. *Bull. Br. Mus. nat. Hist. Zool.* 5: 49–72.
Linnaeus, C. 1758. *Systema Naturae Ed.* 10, Vol. 1.
Olson, S.L. 1985. *Av. Biol.* 8: 79–238.
Schmidt-Nielson, K. 1959. *Sci. Am.* 200: 109–16.
Siegel-Causey, D. 1990. *Auk* 107: 110–18.
van Tets, G.F. 1965. *AOU orn. Monogr.* 2.

Family FREGATIDAE frigatebirds

Medium-sized to large tropical seabirds; among the most aerial of birds. Five species, all in genus *Fregata*; three in our region. Body, slender; neck, short; tail, long and forked; female larger than male. Wings, very long, narrow, pointed, held flat and high above body with short humeri raised. Often soar for long periods in thermals or in wind, constantly manoeuvring with deeply forked tail and occasional deep wing-beats. Also sustained flight, sometimes in unorganised flocks, with strong deep wing-beats. Eleven primaries; p10 longest, p11 vestigial; *c.* 23 secondaries; diastataxic. Tail deeply forked, but forking not obvious except when tail fanned during manoeuvres; 12 rectrices, outer longest. Bill, long, slender, deeply hooked; no serrations on cutting edges. Nostrils as thin slits. Face, fully feathered. Legs, extremely short, feathered; foot, small, weak, totipalmate, with reduced webs; middle claw pectinate. No aftershaft. Barely able to walk but perch in trees and sometimes on edges of cliff tops. Plumage, predominantly black or black-and-white, females typically showing more white than males. No seasonal changes, though males of all species inflate and deflate bright-red gular sacs during courtship. Moult, poorly known; primaries replaced in staffelmauser. In some populations may be suspended during breeding. Young, altricial, nidicolous, naked at hatching, develop down. Juveniles usually have varying amount of rufous or russet on head and neck, which fades with age; typically abdomen and lower breast white, separated from white or russet throat by dark breast-band, which disappears with age. Much variation between populations of same species in colour of soft parts and extent of russet and white plumage of juveniles, which makes specific identification difficult. Change towards adult plumage poorly known but perhaps begins from end of second year and is complete by 4–5 years old.

Throughout all tropical oceans. Strictly marine and all species pelagic except *F. magnificens*, which tends to feed inshore. Entirely aerial feeders with poor ability to take off from water; rarely, if ever, settle on sea. Feed either by surface-dipping in flight, taking mostly flying fish, or squid, or by piracy from other seabirds such as boobies, though this habit often over-emphasized in the literature. Foraging range from breeding localities unknown but certainly up to 500 km from land. Parents may be absent from chick for 10 days but many birds appear to return nightly to land to roost; others could spend night on the wing.

Pair-bond monogamous; probably maintained for only one breeding attempt. At start of breeding season, males take up display positions on site of future nest and direct conspicuous displays to passing females: visual display consists of presenting inflated gular sac and trembling outstretched wings towards female; auditory display may be entirely non-vocal, by bill-clattering, with or without accompanying calls. Defence of display-site varies between species and within populations of same species, there apparently being none in *F. ariel*, whereas in *F. minor* it may include threat and fighting. Copulation occurs within a few hours of attracting the female; then male leaves to begin collecting material. One member of pair stays on site to prevent pilfering of material or loss of site. Gular sac of male rarely inflated after incubation starts. Voices of sexes differ, male being more vocal during courtship and when landing. Comfort-behaviours include: drinking on the wing by skimming bill through water; dissipation of heat by gular-fluttering; sunning of ventral parts by lying or sitting back on tail facing sun and turning wings upside down; true yawning; and head-scratching at rest indirectly or in flight directly.

Breeding stations typically on remote oceanic islands. Prefer to nest in trees or on bushes, if available but often on ground on poorly vegetated islands where nothing better. Colonies large, up to 5000, but arranged in smaller groups of nests, usually 10–30 but up to 100, derived from clusters of displaying males. Breeding usually every other year and seasonal, though laying may extend over 6 months. In some species males try to breed every year by abandoning care of chicks to female, perhaps especially where food is abundant. Sex-ratios unequal, either sex predominating in different species. Nest of loosely woven sticks, becoming cemented with guano. Most material brought by male; most building by female but neither role exclusive. Only one egg per clutch. Re-laying after loss said to occur in some species. Egg, white, ovate and 6–7% of female's mass. Courtship lasts for 1–4 weeks; incubation, for 41–55 days, with equal share by both sexes; egg brooded under breast. Chick guarded by parents for 4–6 weeks after hatching. Feeding by incomplete regurgitation and insertion of head by chick into parent's mouth and throat. Nestling period lasts for 5–6 months. Rate of feeding varies with supply of food but rarely more than every second day. All species have long (5–14 months) period of post-fledging dependence on parents. Age of maturity not known but probably 4–5 years. Adult mortality and longevity not known but one female *F. minor* known to have lived for 38 years.

Fregata minor Great Frigatebird

COLOUR PLATE FACING PAGE 933

Pelecanus minor Gmelin, 1789, *Syst. Nat.* 1: 572; based on *Fregata minor* Brisson, 1760, *Ornithologie* 6: 509 — no locality; fixed as e. half of Indian Ocean by Rothschild, 1915, *Novit. zool.* 22: 145, and restricted to Christmas I. by Lowe, 1924, *Novit. zool.* 31: 306.

Fregata is a modern Latinization of the French *fregate* (see under Black-bellied Storm-Petrel for the variant *Fregetta*). The specific name *minor* has become a misnomer, being based on Brisson's original unfortunate designation. Smaller species were discovered later.

OTHER ENGLISH NAMES Greater Frigatebird, Man-o'-war Bird or Hawk, Sea-hawk.

An inevitable and unavoidable contradiction occurs between scientific and English names unless an undesirable innovation is made but certainly **Greater** is to be avoided because *F. magnificens* and *F. andrewsi* are larger species.

MONOTYPIC

FIELD IDENTIFICATION Length 85–105 cm; wingspan 205–230 cm; weight 1–2 kg. Very large black or black-and-white seabird, larger than most other seabirds in Tropics, except slightly larger Christmas Frigatebird *F. andrewsi*; typical frigatebird structure and actions: long bill with hooked tip, long slender pointed wings carried well forward and strongly bowed at carpals, and long deeply forked tail normally held open during sailing and soaring flight. Sexes differ. Juveniles and immatures separable. No seasonal changes of plumage but red gular pouch of male develops during breeding.

DESCRIPTION ADULT MALE. Entirely black with metallic green and purple gloss; large red gular pouch, inflated like balloon during displays. Feathers of nape, mantle and scapulars, long and lanceolate. Tail, long and very deeply forked. Upperwing, glossy black with slightly browner bar across inner upperwing. Iris, dark brown. Eye-ring, black-brown. Bill, long and slender, with strongly hooked tip, dark grey to almost black with narrow blue-grey streaks. Legs and feet, dull pink. ADULT FEMALE. Forehead, crown, nape and hindneck, black, forming dark cap sharply demarcated from grey of chin and throat along line that extends from base of bill, below eye and along sides of neck; rest of upperparts, black apart from scaly buff wing-bar on inner upperwing. Grey of chin and throat merges into white of upper breast, flanks and belly; white does not extend onto hindneck; white patch bordered behind by black abdomen, vent and tail; white patch on underparts reminiscent of upside-down heart. Lacks inflatable gular pouch, though residual gular patch, light salmon. Eye-ring, pink. Bill, grey-blue or light grey. Iris, legs and feet, as adult male. JUVENILE. Head, throat and upper neck, rusty brown (white in some populations) with white bases to feathers; when plumage worn, bases of feathers exposed giving mottled appearance. Rest of upperparts, black apart from pale wing bar, paler than that of female. Broad black breast-band, thinnest at mid-breast. Centre of breast to legs, white without broad white spurs extending onto central wing-bases in Aust. populations (Hawaiian birds [not recorded in our region] show these white spurs; Harrison 1983). Underparts behind legs and underwing, black. Eye-ring, brown. Bill, pale grey with grey-mauve shade; maxillary unguis, pink-buff. Legs and feet, brown grey. Sequence of plumage changes from juvenile to adult not determined. IMMATURE THROUGH TO SUBADULT MALE. Initially like juvenile; breast-band disappears, followed by gradual darkening of head, chin, throat and abdomen, all at first mottled black before becoming black; flanks and upper breast, mottled black and white, and the last areas to turn all black. IMMATURE THROUGH TO SUBADULT FEMALE. Breast-band disappears, then cap and abdomen gradually turn black; possible development of black band across lower breast isolating mottled black-and-white abdomen from white upper breast, chin and throat (Harrison 1983).

SIMILAR SPECIES Only likely to be confused with other frigatebirds; Christmas *F. andrewsi* and Least *F. ariel* in our area. In all plumages, **Least** smaller and lighter than Great; **Christmas** only slightly larger than Great (though markedly larger than smallest form of Great, found on Christmas I. [Ind.]). However, size difficult to judge in birds soaring at great heights. **Adult male** distinguished by pattern on underparts. Christmas Frigatebird differs from Great in having large white patch on abdomen; Least has black underparts with narrow white band on each side of abdomen, from flanks to wing-pit (in our area, Great has entirely black underparts). All other ages and sexes separated from adult male Great by white in plumage. **Adult female**: Christmas and Least have black hood encompassing chin and throat (in Great, chin and throat, grey), white nuchal collar (absent in Great), white spurs extending onto subhumerals (absent in Great), and Christmas has white abdomen (black in Great). Juvenile and immatures separated from adult female Great by rusty-brown or white head and neck. **Juveniles**. Pose biggest identification problem and field characters have not been fully determined; see Least Frigatebird for discussion. **Immature** difficult to identify with certainty from other species. Plumages and phase changes may vary within species, and further study needed. **Immature male**. Gradually attain adult plumage and separable from other immatures using combinations of adult characters. Immature male Christmas always show white on central abdomen; immature Least always show white spurs extending onto underwing. **Immature female**. Christmas and Least Frigatebirds develop black hoods encompassing chin and throat and show white spurs extending onto subhumerals.

Restricted to blue-water tropical seas; exceptionally farther S in warmer subtropical waters. Mainly pelagic; also, specially during rough weather, inshore waters, along coast-

lines and, sometimes, short distances inland. Highly aerial; usually seen flying high above sea, gliding and soaring gracefully, with only occasional deep wing-beats; very manoeuverable, especially when chasing other seabirds while trying to pirate food. Feed in flight, plummeting vertically to ocean surface to snatch at flying fish, or engage in pursuit of other seabirds, forcing them to disgorge their food and catching it before it hits water; also catch prey from ocean surface and beaches, and steal eggs and chicks from seabird colonies. Never enter or alight on water except accidentally. Rarely on ground, except accidently, or in some circumstances when nest built on ground; perch and display from bushes and trees. Primarily diurnal, normally returning to soar over islands during evening before roosting in trees overnight. Solitary or gregarious in loose congregations at sea; readily attracted to ships. Breed colonially; on oceanic and continental islands and atolls. Usually silent at sea; produce various mechanical sounds, and utter warbles and pulsed calls at colonies.

HABITAT Marine, pelagic, aerial. In tropical waters of surface-temperatures, >22.0 °C, and varying salinities (Pocklington 1979; Ainley & Boekelheide 1983; Dunlop *et al.* 1988). Possibly depend for feeding on upwellings of cool nutrient-rich water (Bourne 1963), especially when breeding. Occasionally over inshore waters; in central Pacific, observed 800 km or more from nearest land (Sibley & Clapp 1967).

Breed on isolated oceanic and continental islands and atolls, where trees, bushes or mats of vegetation available for nesting. At low or high elevations; up to 150 m asl on Christmas I. (Ind.), where Christmas Frigatebirds nest at lower elevations (Stokes 1988). Usually on vegetated cliffs, slopes or ridges, protected from prevailing wind (Gibson-Hill 1947; Woehler 1984; King & Buckley 1985; Stokes 1988); but on Raine I., in central depression on rock piles and earth mounds (King 1986).

Roost and rest in trees or bushes (Woehler 1984), needing perches at least 1.5 m above ground for ease of take-off (Gibson-Hill 1947). Readily fly high, soaring above nesting colonies, and in updrafts over cliffs and lagoons of atolls (Stokes *et al.* 1984); fly high when returning to roosts, and probably locate prey from considerable heights; may descend to 20–30 m when feeding.

On Christmas I. (Ind.), 48 ha of forest suitable for breeding have been cleared for settlement and mining. Most breeding habitat protected in Christmas Island NP; additional area being considered for inclusion. Some birds drown in mine-slurry ponds (up to 100 birds/year), hit electric lines, or become entangled in discarded fishing line (Stokes 1988). Breeding colonies sensitive to human disturbance.

DISTRIBUTION AND POPULATION Essentially confined to tropical Indian and Pacific Oceans with small population off Brazil in w. Atlantic Ocean, most of range being extralimital.

AUST. Claimed to occur from Pt Cloates, WA, across n. Aust. to NSW (HASB) but Aust. Atlas had no records W of 130°E (Darwin); few in Timor Sea and Gulf of Carpentaria; more plentiful from C. York Pen. to Fraser I., Qld; stragglers to Brisbane, and Coffs Harbour, NSW. Vagrant elsewhere: **Vic.** Mornington, 1902 (Anon. 1902); specimen (MV B3225), Brighton 1861 (Hitchcock 1952). **WA.** Live specimen, Swan R., 4 May 1917; one sighted, Fremantle, 5 May 1951 (Serventy & Whittell 1976); Walpole, June 1972.

NZ Vagrant; twelve records since 1861, most southerly at Westport (NZCL).

BREEDING

Locality	Year	No. pairs	Ref.
CHRISTMAS I.		3000+	1
COCOS-KEELING IS		1000+	2
QLD			
Manowar I.	1982	1	3
Raine I.	1980	5 (always <10)	4
Quoin I.	1980–81	1–2	5
CORAL SEA			
Herald Grp			
NE Cay	1985	380	6
	1986	250	6
SW Cay	1984	148	6
Coringa Grp	1985	64	6
	1986	660	6
Chilcott I.	1984	114	6
Magdelaine Cay	1985	57	6
Diamond Grp			
East I.	1984	222	6
Mid and West			7

References: (1) Stokes (1988); (2) Stokes *et al.* (1984); (3) Garnett & Crowley (1987); (4) King (1986); (5) King & Buckley (1985); (6) ANPWS; (7) HASB.

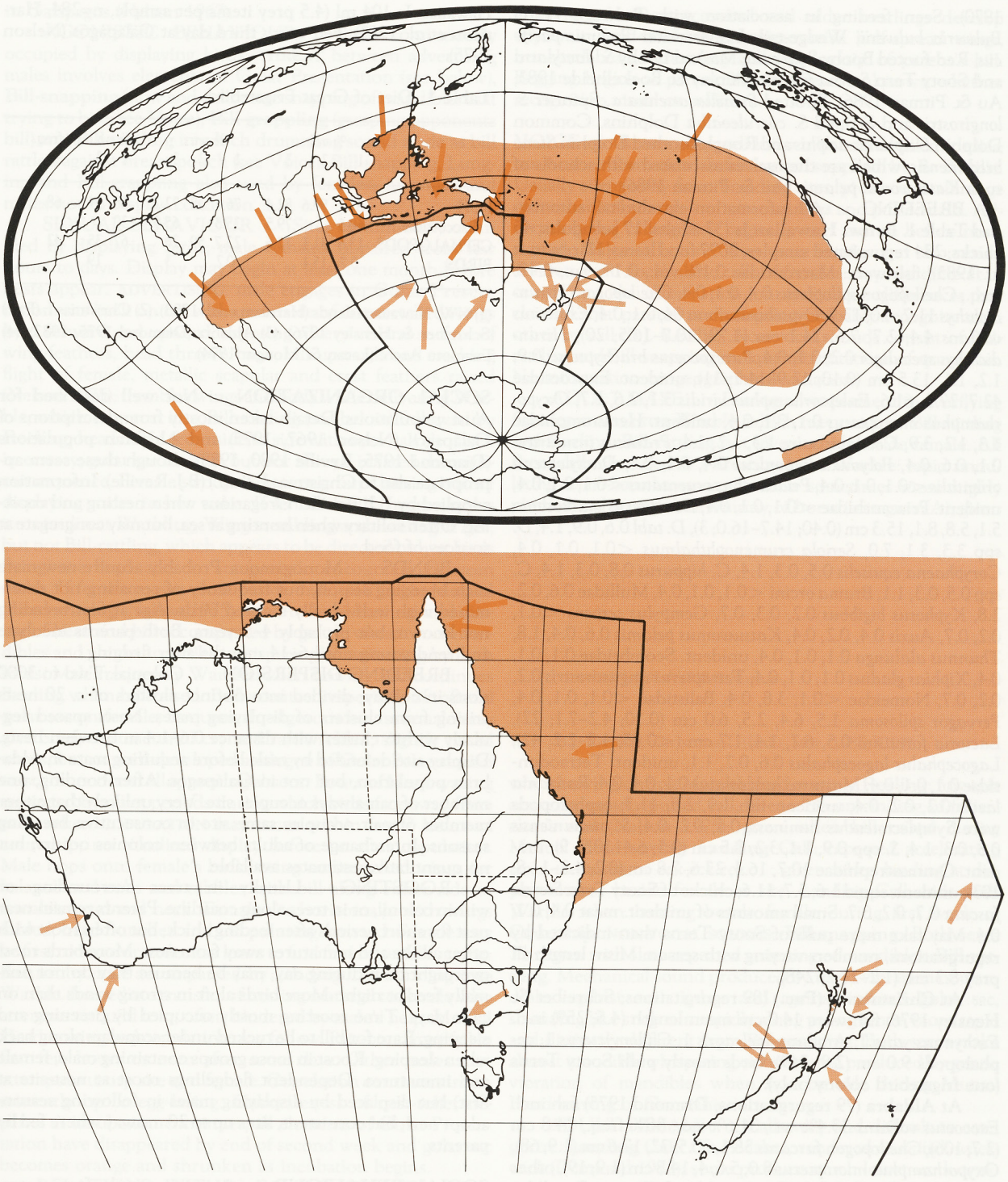
Extralimitally: breed Indonesia and Paracel Is, China (de Korte 1984; Melville 1984); Cook Is, Tonga, Fiji, Kiribati, Hawaii, Pitcairn, French Polynesia, New Caledonia and Sala Y Gomez (du Pont 1976; Tarburton 1978; Jenkins 1980; Harrison 1983; Garnett 1984; Harrison *et al.* 1984; Schlatter 1984); w. Atlantic Ocean.

Status, probably stable. Were taken for food on Cocos-Keeling and Christmas Is, as also on St Brandon I., Mauritius (Feare 1984) and elsewhere, but probably in fewer numbers since enforcement of prohibition in 1986. Survival of populations depends on lack of disturbance during nesting and survival of populations of species that birds rob for food.

MOVEMENTS No clear pattern. Fewer birds present on Kure Atoll, n.-central Pacific (Woodward 1972) and Aldabra (Diamond 1975) Aug.–Apr. than rest of year, but long breeding season confuses the matter and some birds may be essentially sedentary. Numbers at Christmas I. (Pac.) did not vary through year (Schreiber & Ashmole 1970) and young thought to disperse much later than those of Least Frigatebird (Schreiber & Ashmole 1970). May travel at great altitude: recorded at 1200 m (Nelson 1968). Consistent differences in measurements between breeding populations (Schreiber & Schreiber 1988) suggests little mixing between populations though faithful to neither mate nor nest-site (Nelson 1975).

BANDING 25S171E 06 2 U 09 *c.* 1400 330 BBL. Extralimitally, six long-distance returns from Kure Atoll, two from Marshall Is, four from Philippines. Birds from both places later returned to breed on Kure, which may indicate regular trans-Pacific migration (Woodward 1972). None banded Aust. recovered away from banding site.

FOOD Mostly flying fish, some cephalopods. BEHAVIOUR. Feed entirely on wing. Flying fish taken by flight-feeding above surface, small fish and cephalopods by dipping, sometimes while hovering above sea surface (Gibson-Hill 1947). Rarely enter water, except inadvertently but capable of



rising from surface even in flat calm (Nelson 1968). Possibly depend on predatory fish and porpoise to force prey to surface (Schreiber & Hensley 1976). Obtain food from many species of seabird, particularly boobies, by aerial piracy though stolen food probably contributes only small proportion of intake except when food scarce (Schreiber & Hensley 1976). At Galápagos, 12% of chases successful; at Christmas I. (Ind.), 63%; at Aldabra, 18% (Diamond 1975); males chase more often than females in Galápagos, reverse at Christmas I. and Aldabra. Will take food from flying birds and those, including conspecifics, feeding young (Nelson 1968). Fish manipulated in bill and swallowed head first. Though density of frigatebirds declines with distance from land (King 1970), probably travel hundreds of kilometres to feed; at Galápagos, most fish regurgitated were pelagic (Harris 1977). Usually catch food during day but chicks also fed at night (Schreiber & Ashmole

1970). Seen feeding in association with Bulwer's Petrel *Bulweria bulwerii*, Wedge-tailed Shearwater *Puffinus pacificus*, Red-footed Booby *Sula sula*, Masked Booby *S. dactylatra* and Sooty Tern *Sterna fuscata* (Ainley & Boekelheide 1983; Au & Pitman 1986), Spotted *Stenella attenuata*, Spinner *S. longirostris* and Striped *S. coeruleoalba* Dolphins, Common Dolphin *Delphinus delphis* and Rough-toothed Dolphin *Steno bredanensis*, which are themselves associated with schools of tuna *Katsuwonus pelamis* (Au & Pitman 1986).

BREEDING All information extralimital: summarized Table 1. In **nw. Hawaiian Is** (37 adults, 17 subadults, 45 chicks; 284 regurgitated samples, 2097 food items; Harrison *et al.* 1983), fish were: Macrouridae 0.1% vol., 0.1% no., 0.4% freq., *Cheilopogon spilopterus* 0.4, 0.1, 0.4, *Cheilopogon/Hirundichthys* 11.7, 4.0, 13.7, *Cypselurus simus* 04, 0.1, 0.4, *Exocoetus volitans* 4.4, 2.7, 7.4, 14.1 cm (1.79; 10.7–16.5; 20), *Hirundichthys speculiger* 0.2, 0.1, 0.4, *Parexocoetus brachypterus* 0.9, 1.2, 1.1, 13.5 cm (0.10; 12.9–14.1; 11), unident. Exocoetidae 42.7, 27.2, 61.6, *Euleptorhamphus viridis* 3.1, 2.6, 6.7, *Oxyporhamphus micropterus* 0.1, 0.1, 0.4, unident. Hemiramphidae 1.3, 1.2, 3.9, *Cololabis saire* 1.3, 1.2, 1.4, *Pranesus insularum* 0.1, 0.6, 0.4, *Polymixia japonicus* 0.4, 0.1, 0.4, *Dactyloptena orientalis* <0.1, 0.1, 0.4, *Priacanthus cruentatus* <0.1, 0.1, 0.4, unident. Priacanthidae <0.1, 0.1, 0.4, *Decapterus macrosoma* 5.1, 5.8, 8.1, 15.3 cm (0.40; 14.7–16.0; 3), *D. tabl* 0.6, 0.9, 1.4, *D.* spp 3.3, 3.1, 7.0, *Seriola crumenophthalmus* <0.1, 0.1, 0.4, *Coryphaena equiselis* 0.5, 0.3, 1.4, *C. hippurus* 0.8, 0.3, 1.4, *C.* spp 0.5, 0.3, 1.1, *Brama orcini* <0.1, 0.1, 0.4, Mullidae 0.6, 0.2, 2.8, *Kyphosus bigibbus* 0.2, 0.3, 0.7, *Gempylus serpens* <0.1, 0.2, 0.7, *Auxis* 0.4, 0.2, 0.4, *Katsuwomus pelamis* 0.6, 0.4, 1.8, *Thunnus alalunga* 0.1, 0.1, 0.4, unident. Scombridae 0.1, 0.1, 0.4, *Xiphias gladius* 0.1, 0.1, 0.4, *Tetrapterus angustirostris* 0.2, 0.2, 0.7, Nomeidae <0.1, 3.8, 0.4, Balistidae <0.1, 0.1, 0.4, *Pervagor spilosoma* 1.5, 6.4, 2.5, 6.0 cm (0.10; 4.2–7.1; 22), *Lactoria fornasini* 0.5, 6.7, 1.4, 1.7 cm (<0.05; 1.2–2.2; 42), *Lagocephalus lagocephalus* 0.6, 0.2, 1.1, unident. Tetraodontidae 0.1, 0.1, 0.4, *Masturus lanceolatus* 0.1, 0.4, 0.4, *Ranzania laevis* 0.2, 0.2, 0.4, unident. fish 1.9, 2.5, 11.3; cephalopods were *Symplectoteuthis luminosa* 0.1, 0.2, 0.4, *S. oualaniensis* 0.3, 0.3, 1.4, *S.* spp 0.9, 1.1, 3.2, 8.5 cm (0.5; 6.4–10.5; 9), unident. Ommastrephidae 10.7, 16.4, 23.6, 7.8 cm (0.2; 4.2–11.8; 103), unident. squid 1.6, 5.7, 11.6; chicks of Sooty Tern *Sterna fuscata* 0.7, 0.2, 0.7. Small amounts of unident. meat 0.4, 0.1, 0.4. May take more pulli of Sooty Terns than indicated by regurgitations, numbers varying with season. Mean length all prey 8.3 cm (1.2–27.2; 248).

At **Christmas I. (Pac.)** (89 regurgitations; Schreiber & Hensley 1976) fish were 14.0 cm mean length (4.5; 259) incl. *Euthynnus yaito* 1, *Arothron meleagris* 1, *Chilomycterus* 1; cephalopods 9.0 cm (2.9; 349); birds mostly pulli Sooty Terns (one frigatebird colony only).

At **Aldabra** (79 regurgitations; Diamond 1975) fish incl. *Exocoetus volitans* 33.4% wt., 31.6% no., 38% freq., 14.8 cm (2.7; 106), *Cheilopogon furcatus* 38.1, 20.5, 32, 17.6 cm (1.9; 68), *Oxyporhamphus micropterus* 8.0, 5.6, 4, 14.8 cm (1.9; 19), other Hemiramphidae 0.3, 2.9, Pomatomidae 3.6% no., Zanclidae 2.4; cephalopods were Ommastrephidae 7.4 cm (2.2; 130). At **Tuamotu Arch.** (19 stomachs; Lacan & Mougin 1974) samples also contained vegetable matter 5% freq. At **Galápagos** predominance of cephalopods in 1964 changed to mostly flying fish 1965–67 (Harris 1977). Have also been recorded taking hatchling marine turtles and young of conspecifics (Nelson 1975).

INTAKE Mean vol. of regurgitated samples nw. Hawaiian Is 104 ml (4.5 prey items per sample, n=284; Harrison *et al.* 1983). Fed every third day at Galápagos (Nelson 1975).

Table 1. Diet of Great Frigatebird.

	% vol.			% wt.			% no.		% freq.
	1	2	3	1	2	3	2	3	4
FISH	85.7	59.6	82.4	76.1	38	72.2	88	94	68
Exocoetidae	60.5		79.5	35.3		65.9	30		
CEPHALOPODS	13.6	31.1	17.6	23.7	59	26	67	35	42
BIRDS	0.7	15.1		0.2		3		19	

(1) NW. Hawaiian islands (Harrison *et al.* 1983). (2) Christmas I. (Pac.) (Schreiber & Hensley 1976). (3) Aldabra (Diamond 1975, 1983). (4) Tuamotu Arch. (Lacan & Mougin 1974).

SOCIAL ORGANIZATION Not well described for Aust. populations. Details taken mostly from descriptions of Galápagos (Nelson 1967, 1975) and Aldabran populations (Diamond 1975; Reville 1980, 1983), though these seem appropriate also to Christmas I. (Ind.) (B.J. Reville). Information supplied by B.J. Reville. Gregarious when nesting and roosting. Often solitary when hunting at sea, but may congregate at sources of food.

BONDS Monogamous. Probably acquire new mate each breeding season, but frequency of remating not determined with individually marked birds. Age at first breeding not known, but probably 4–5 years. Both parents incubate and tend young until 6–14 months after fledging.

BREEDING DISPERSION Colonial. Two to 3000 nests in colony; divided into distinct clusters of *c.* 20 nests arising from clusters of displaying males. Nests spaced regularly within cluster with distance 0.6–1.4 m between nests. Display-site defended by male before acquiring mate in Aldabran population, but not in Galápagos. After bonding, one member of pair always occupies site. Very unlikely that either member of pair occupies same site in consecutive breeding seasons. Interchange of adults between colonies occurs, but no quantitative estimates available.

ROOSTING Usually in trees surrounding or within colony, or in trees along coastline. Parents remain near nest for short periods after feeding chick, but often roost with other adults and immatures away from nest. More birds roost overnight than during day; may be because they do not normally feed at night. More birds aloft in strong winds than on calm days. Time roosting mostly occupied by preening and sleeping. Rare for bill to be tucked under scapulars along back when sleeping. Roost in loose groups containing male, female and immatures. Dependent fledgelings roost at nest-site at first, but displaced by displaying males in following season; adopt new, but consistent, sites up to 20 m away where fed by parents.

SOCIAL BEHAVIOUR Account mostly from extralimital observation, as for Social Organization. At onset of new breeding season, males begin displaying to females flying overhead. Display groups usually consist of four or five males at any one time, but vary from isolated males to groups of 8–10. Spacing within groups 1.0–1.5 m, but wings and tails of adjacent males may overlap during display. In Aldabran population, males threaten, fight and supplant each other before obtaining female (Diamond 1975; Reville 1980); not observed

in Galápagos (Nelson 1967).

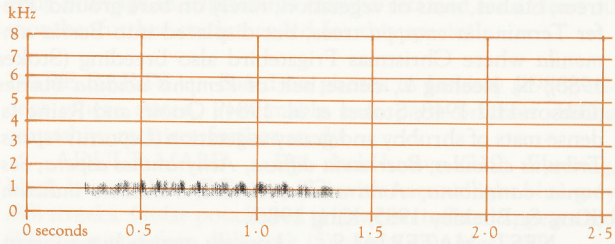
AGONISTIC BEHAVIOUR Sites continuously occupied by displaying birds. THREAT between advertising males involves elements of Gular Presentation (see below), **Bill-snapping** (slow and deliberate snapping of mandibles as if trying to bite; see Voice), **Bill-grappling** (grasping opponents bill) and **Bill-rattling** in which drumming sound made as bill rattled against breast pouch (see Voice). Bill-snapping, Lunging and Bill-grappling also used by females, juveniles and males not in display condition.

SEXUAL BEHAVIOUR Sites continuously occupied by displaying birds; male remains unpaired from few hours to days. Display may begin at least one month before nests appear. ADVERTISING: male engages in **Gular Presentation**: sits back on tail with underside of outstretched wings held forward and upward, exposing silvery ventral surface of wing-feathers, head thrown back, bill upwards and tracking flight of female, metallic scapular and crest feathers raised (Nelson 1975); trembles wings and body while delivering Warble, which may run into Bill-rattling (see below) followed by **Reeling**: head lolled from side to side with eyes half shut as if in ecstasy; gular sac usually, but not always, inflated throughout sequence. Female swoops low over groups leaving trail of displaying males in her wake. If female lands, nearby males turn to direct Warbling, Wing-trembling and Reeling at her, but not Bill-rattling, which appears to be directed only at birds flying overhead and in antagonistic encounters between males. If female moves close beside male, pair begin **Mutual Head-waving** (Nelson 1975): head-to-head bowing, and raising of head and bill accompanied by gentle vibration of mandibles and almost inaudible whispering or twittering by both birds. Male frequently Warbles when bowing and continues Reeling when bill raised. Body contact, especially of inflated gular sac on female, frequent. In vigorous bouts, female may give brief, unstructured cry and rattle folded, slightly raised wings, but no well-developed analogue of Gular Presentation exists. Functional allopreening absent. Bouts of Head-waving separated by quiet periods during which birds face away from each other. COPULATION may occur within first 2 hours of courtship; no ritualized display before or after copulation. Male hops onto female's back, using outstretched wings for balance and rubs and nibbles with bill along either side of female's head and neck. Female sits horizontally with wings folded, head hunched and bill pointing forward. Female may be first to leave or male may leave to find first material for nest. Return by male accompanied by Landing Call running into Warble. Immediate transfer of nesting material to female who attempts to build it in, often hindered by male's help. Mutual Head-waving and copulation may follow. Pair-bond may fail in first few hours or even after some days. Other males may attempt to usurp site and female. Copulation continues intermittently up to egg-laying. Elaborateness of nest-relief declines as incubation continues; all elements of Gular Presentation have disappeared by end of second week and gular sac becomes orange and shrunken as incubation begins.

RELATIONS WITHIN FAMILY GROUP Parents share incubation, brooding (for two weeks) and feeding (before fledging) equally; after fledging at Aldabra, females feed young more often than male (Diamond 1975; Reville 1980). During first days after hatching, parent feeds chick by dribbling fluid into its open bill (Gibson-Hill 1947). Slightly older chick taps base of parent's bill as parent holds bill upward to bring food from stomach to mouth; bill pointed downwards, chick stretches upwards to insert head in parent's mouth. Down-covered and older nestlings develop rhythmic head-bobbing behaviour with half-spread wings, hunched head, screaming and tapping tip of parent's bill. Begging begins as parent flies overhead; unknown whether recognition visual or auditory.

VOICE Reasonably well known but no detailed studies; no Aust. information. Information supplied by B. Reville. Usually silent away from breeding sites; produce small range of mechanical sounds and utter warbles and pulsed calls. Advertising and calling may begin up to 1 month before nests started. Males call more often than females and also sexual differences in vocabulary; calls of females vary and difficult to categorize. No information on individual differences but claimed that parents and offspring probably recognize each other by call (B.J. Reville). Non-vocal sounds consist of Bill-rattling and Bill-snapping and quieter vibrations of mandibles. No information on geographical variation.

ADULT MALE During advertisement to overflying females, males utter Warble, which may run into Bill-rattling and Reeling. Bill-rattling not given when beside female. All three calls also used as Threat by male. **Warble**: rapid undulating *whoo-hooo-hooo-ooo* which is sometimes more highly pitched and sounds like whinny of horse (sonagram A); given



A B.J. Reville; Christmas I. (Ind.), Mar. 1985; C132

when bowing during Mutual Head-waving. **Reeling**: fine soft scratchy, rapidly pulsed call, likened to unwinding of fisherman's reel (Nelson 1975); given when bill raised during Mutual Head-waving. **Landing Call**: repeated accelerating *teeeu-teeuu-teu* or *eck-eck-eck* . . . given when landing at display site or beside female at site. Landing Call ends with Warble when landing beside female during first week of Courtship. NON-VOCAL SOUNDS. **Bill-snapping**. Both sexes Threaten with slow repeated snapping of mandibles. **Bill-rattling**. Mechanical sound produced by rapid vibration of mandibles against each other and against inflated gular sac, sounding like stick run rapidly along paling fence; more rapid and distinctly different from Bill-snapping. Both sexes make almost inaudible whispering or twittering produced by gentle vibration of mandibles when side by side during Mutual Head-waving of Courtship.

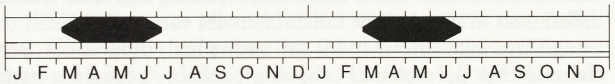
ADULT FEMALE Calls vary and difficult to categorize. **Landing Call**. On Aldabra, rendered as *wiiiick-wiick-wick* (Diamond 1975); some produce much lower *urnk-urnk-urnk* and many silent when landing (B.J. Reville). Also unstructured cries during Mutual Head-waving. NON-VOCAL SOUNDS as for male.

YOUNG Beg with repeated harsh braying *a-a-r-k, a-a-r-k, a-a-r-k*. . . accompanied by bobbing head, hunched shoulders and partial spreading of wings.

BREEDING No detailed Aust. studies. Detailed accounts for Galápagos (Nelson 1967, 1968, 1975) and Aldabra

(Diamond 1975; Reville 1980, 1983). Information supplied by B.J. Reville. Breed in simple pairs, colonially, arboreally. Colonies of 2000–3000 pairs, subdivided distinctly into clusters of *c.* 20, judged by clusters of displaying males.

SEASON Protracted and varying with locality. Christmas I. (Ind.): display starts late Jan.; laying, Mar.–June. In ne. Barrier Reef: eggs and small young late Sept. (HASB). Coral Sea: display and laying, Mar.–May (ANPWS). Aldabra: display starts early June, laying probably Sept.–Nov. Christmas I. (Pac.): display started early Jan.; laying probably from early Apr. (Schreiber & Ashmole 1970).



(Christmas I.)

SITE On shrubs and trees, often on their flat tops. At Aldabra, in three of four mangrove species but not *Avicennia marina*; sheltered from se. trade winds (Diamond 1975). On Christmas I. (Ind.), nest on sea cliff and slopes and lip of inland cliff, up to 150 m asl (Gibson-Hill 1947; Stokes 1988); largest colonies where shore terrace faces NW, protected from prevailing winds (Woehler 1984). Nests built in trees, bushes, mats of vegetation; rarely on bare ground. Prefer *Terminalia catappa* trees, but displaced into *Berria ammonila* where Christmas Frigatebird also breeding (Stokes 1988); N. Keeling I., dense belt of *Pemphis acidula* bushes (Gibson-Hill 1948; Stokes *et al.* 1984); Quoin and Raine Is, dense mats of shrubby and grassy vegetation (*Lepturus repens, Tribulus cistoides, Boerhavia diffusa, Achyranthes aspera, Sesbania cannabina, Amaranthus viridus, Abutilon indicum*) (King & Buckley 1985; King 1986).

NEST, MATERIALS Loosely woven but substantial platform of sticks, twigs and leaves; mainly of mangroves and *Pemphis acidula* on Aldabra (Diamond 1975). Collected mostly by male, built into nest by female; dead twigs broken off, floating material picked up, nests of boobies, other frigatebirds plundered. Building starts with courtship, then most activity for 10 days but building may continue till hatching. Nest becomes covered with guano. No site fidelity. At Aldabra, four nests measured 29–33 x 26–29 cm across, 10–13 cm deep.

EGGS Elliptical; smooth, thin shelled; white. Size varies between subspecies (Nelson 1975).

MEASUREMENTS:

Christmas I. (Ind.): 66 x 47 (n=1)

Aldabra: 67 (1.8; 8) x 47.4 (1.6)

Provenance unknown: 68 (64–71; 7) x 48 (46–59) (HASB).

WEIGHTS:

Christmas I. (Ind.): 81 (n=1)

Aldabra: 81 (7.5; 9) or 5.7% of female weight.

CLUTCH-SIZE One. Replacement laying probable, not quantified. Successful pairs breed only once in 2 years.

LAYING Fairly synchronized, probably best in subcolonies. Time of laying during day not known.

INCUBATION By both sexes alternately and equally. Shifts vary greatly: at Aldabra, 6.4 days (4–13); Christmas I. (Pac.), *c.* 4 days (R.W. Schreiber in Diamond 1975); in Galápagos, 10 or 15 days (Nelson 1968). INCUBATION PERIOD: 55 days in Galápagos.

YOUNG Altricial, nidicolous. Brooded by both parents equally for 2 weeks, guarded for 2 weeks more. Parents relieve one another at intervals of 1–2 days. Fed by both parents by incomplete regurgitation; 3–4 times a day immediately after hatching; at 1–2 day intervals when larger, even to 7 days if food scarce. Most feeds given from 09:00 to 12:00. At Aldabra, fed by both parents equally till fledging; after fledging, female feeds more than male (Diamond 1975). NESTLING PERIOD: at Aldabra: 169 days (148–202; 15; Diamond 1975).

GROWTH Rate of growth K = 0.0391 for Gompertz curve (Richlefs 1967, 1968). Reaches half asymptotic weight in 30 days (Diamond 1975). Day 7 after hatching, egg-tooth lost; day 14, white down extensive except on throat and neck; day 21, dorsal and scapular feathers emerge; day 42, upper wing-coverts emerge; day 49, primaries, upper wing-coverts emerge; day 56–60, secondaries, rectrices appear; day 60–70, primaries. Dependent on parents for av. 221 days after fledging (154–292; 36 wing-tagged fledgelings, Aldabra); at Christmas I. (Pac.), for 14 months (Schreiber & Ashmole 1970).

SUCCESS At Galápagos: 39 fledgelings (19%) from 206 eggs. Aldabra: 60 (54%) chicks from 111 eggs, 57 fledgelings or 51% total success; 27 of 33 fledgelings survived to independence (84%). Losses on Galápagos caused by conspecific interference, especially usurpation of sites by males (48.8% plus probably 29.8%), and by predation by owls (12.2%). At both, breeding synchrony correlated with hatching success (Nelson 1968; Diamond 1975). On Christmas I. (Pac.), breeding failed during El Niño Southern Oscillation; increased sea surface-temperature, deepened thermocline and high sea-level preceded failure of food supply and heavy rainfall may have inhibited breeding activity and flooded nests (Schreiber & Schreiber 1984).

PLUMAGES Nominate *minor*.

ADULT MALE Age of first breeding unknown. HEAD AND NECK. Crown and sides of head, glossy pale black-green (162) with glossy purple (172B) shade; concealed bases of feathers, dark brown (121); feathers on head and neck, lanceolate; feathers at nape *c.* 30 mm long. Bare distensible gular pouch over throat and foreneck; at egg laying, gular pouch regresses; narrow rows of sparse feathers visible on outer margins of gular pouch when inflated. UPPERPARTS. Feathers of mantle, back and rump, lanceolate; concealed bases, dark brown (121) for half length, rest glossy pale black-green (162), which, in some lights, has glossy purple (172B) shade. Feathers at middle of mantle are *c.* 40 mm long; at lower margins of mantle, *c.* 75 mm long. Scapulars, moderately short, but lanceolate and black-brown (119); outer webs glossed pale black-green (162) with glossy purple (172B) shade. Subscapulars similar, but with more rounded tips and faint purple (172B) gloss on outer webs. Upper tail-coverts similar, but with less gloss. When worn, tips of feathers on upperparts, dark brown (119A). TAIL, strongly forked, black-brown (119); outer margin of webs have slight pale black-green (162) gloss, with glossy purple (172B) shade; rachis, black (89). When worn, tips of rectrices, dark brown (119A). UPPERWING. All remiges, black-brown (119); rachis, black (89). Inner webs of remiges, dark brown (121); outer webs have faint gloss of pale black-green (162), with glossy purple (172B) shade. When worn, tips of remiges, dark brown (119A). Alula feathers, black-brown (119) with faint gloss of pale black-green (162), with glossy purple (172B) shade. All coverts similar to alula feathers, but more strongly glossed; coverts often have worn dark-brown (119A) to dull-white fringes and form diagonal bar from humeral joint to carpal joint. UNDERPARTS. Feathers, glossy pale

black-green (162); some outer breast-feathers lanceolate, with glossy purple (172B) shade; concealed bases, dark brown (121). Abdominal feathers similar to breast-feathers, but concealed bases, light grey-brown (119D). Most flank-feathers, black-brown (119) with faint gloss of pale black-green (162) with glossy purple (172B) shade; outer ones, dark brown (119A), lanceolate and *c.* 45 mm long. Axillaries, black-brown (119) with pale black-green (162) gloss, suffused with gloss of purple (172B); axillaries have slightly pointed tips. TAIL. Rachis on underside of tail, white basally, merging to brown (219B) distally. UNDERWING. Greater primary coverts and greater coverts, glossy dark-grey (83) with dark-brown (121) shade. All other coverts, black-brown (119) with pale black-green (162) sheen and purple (172B) gloss.

ADULT FEMALE HEAD AND NECK. Feathers on crown and hindneck similar to adult male; at nape, lanceolate feathers *c.* 25 mm long. Feathers at side of neck, glossy pale black-green (162). Bare gular pouch covers chin. Throat to lower foreneck, white. UPPERPARTS. Mantle, back, rump and upper tail-coverts, black-brown (119) with pale black-green (162) sheen and purple (172B) gloss; concealed bases of feathers, dark brown (121); gloss less evident on rump and upper tail-coverts. Mantle-feathers, slightly pointed, but not lanceolate. Scapulars similar to male, but less glossed on webs. Subscapulars, similar, with still less gloss; long and broad with rounded tips to webs. TAIL, similar to male, but with less gloss on outer webs. UPPERWING. Similar to adult male; tips of coverts often worn and dark brown (119A) to dull white; greater coverts often have black-brown (119) centres, surrounded by dark brown (119A); dull white tips often occur in broad diagonal bar, from humeral joint to carpal joint. UNDERPARTS. Feathers mostly white, extending to base of axillaries, lower breast or abdomen; apparently extent varies. Some feathers of lower breast, including thighs, to abdomen, black-brown (119); black-brown (119) feathers have faint gloss of pale black-green (162), with purple (172B) shade on webs. Most of rest of underparts, similar. Demarcation of white and dark underparts, varies; feathers, white, tipped black-brown (119). Axillaries, black-brown (119) with pale black-green (162) gloss, with glossy purple (172B) shade. UNDERWING, similar to adult male.

DOWNY YOUNG Naked at hatching. Down, woolly; on crown, long, thin and white; on malar region, ear-coverts and forehead, and round eye, short and light-brown (39); throat and chin, bare. Rest of body covered in thick white down. Feathers develop first on outer mantle and scapulars, short and black-brown (119) with faint gloss of pale black-green (162) on webs; feathers have rounded tips; when worn, tips, dark brown (119A). For further details, see Growth in Breeding.

JUVENILE HEAD AND NECK. Feathers on crown to hindneck and side of head, rufous-brown (340); feathers long and slightly lanceolate at nape; rachis, brown (119B). Feathers paler at lores and forehead; concealed bases white and often exposed. UPPERPARTS. Most feathers, black-brown (119) with worn dark-brown (119A) to brown (119B) tips; feathers on mantle have rounded tips to webs. Scapulars, black-brown (119), tipped dark brown (119A); faint gloss of pale black-green (162) on webs. Subscapulars, black-brown (119). TAIL, black-brown (119); slight pale black-green (162) gloss on outer webs in some birds, and tipped brown (119B). UPPERWING. Remiges, black-brown (119); outer margins of webs of tertials and humerals, brown (119B). Marginal and median primary coverts, black-brown (119), fringed dark brown (119A). All greater, rest of median, and lesser coverts, dark brown (119A), fringed dull white through wear; marginal coverts near carpal joint, similar. Dull white tips to coverts, form diagonal band from humeral joint to carpal joint; apparently band much less conspicuous than in juvenile Least Frigatebird (Gibson-Hill 1950), but needs further study. Marginal coverts and lesser coverts near humeral joint, black-brown (119) with faint pale black-green (162) gloss on webs. UNDERPARTS. Upper breast-feathers, tipped pale rufous-brown (340); concealed bases, light grey-brown (119C); rachis, dark-brown (119A). Across lower breast, varyingly distinct black-brown (119) band of feathers; these feathers have concealed light grey-brown (119C) bases, with distal tip, black-brown (119) for one-quarter to half length. Lower flanks, inner thighs and under tail-coverts, similar. Abdomen to base of axillaries, white, forming large heart-shaped patch. Demarcation of white patch from rest of underparts moderately sharp; feathers at demarcation varying. Outer thighs, black-brown (119) narrowly tipped white. Axillaries, black-brown (119) with faint pale black-green (162) gloss on webs. UNDERWING. Greater coverts and greater primary coverts, glossy grey (84) with dark-brown (119A) shade. Rest of coverts, black-brown (119) with very faint pale black-green (162) gloss on webs in some birds. Nelson (1975) states as general remark that juvenile plumage in frigatebirds may be retained for at least 30 months; further study needed for this species.

BARE PARTS Based on photos in Lindsey (1986), except where stated. Presumably bare parts brighter during courtship; requires further study.

ADULT MALE Iris, dark brown (219). Eye-ring, black-brown (119). Bill, grey (87) with narrow light blue-grey (88) streaks. Gular pouch, red (11); when inflated appears red (10). Legs and feet, dull pink (5); claws grey-black (82).

ADULT FEMALE Iris, dark-brown (219). Eye-ring, pink (3). Bill, pink (3) to dirty pink (4); maxillary unguis, tipped grey-black (82); in Coral Sea, bill, greyish blue or light grey (Hindwood *et al.* 1963). Gular pouch, light salmon when breeding (Gibson-Hill 1950). Legs and feet, dull pink (5); dull purplish pink when breeding (Gibson-Hill 1950).

DOWNY YOUNG Iris, black-brown (119). Bill, light grey-brown (119D); narrow margins along tomia, dull white; bare skin on throat and gular pouch, dull white. Legs and feet, light grey-brown (119D). Voous (1964) states: at Christmas I. (Ind.): iris, greyish-green; bill blue-grey-green; gular pouch, greyish blue; feet, greyish green.

JUVENILE Iris, black-brown (119). Eye-ring, brown (119B) to dull white. Bill, pale grey (86) with grey-mauve (77) shade; maxillary unguis, pink-buff (121D). Legs and feet, brown-grey (80). Gibson-Hill (1950) states that males have very light blue eye-lids, with free border greyish or slightly mauve, and bill, very light blue or light purplish grey, almost white. Gular pouch, very light blue or blue-grey. Legs and feet, off-white. In females, eye-lids white or very pale blue. Bill, very pale mauve-grey, almost white. Gular pouch, very light grey. Legs and feet, off-white.

MOULTS Few data; see Moults for Least Frigatebird.

MEASUREMENTS (1) Christmas I. (Ind.), adults, live; BILL(G) = bill to gape (details not given), other methods unknown (Chasen 1933). (2) Cocos-Keeling Is, adults, live; BILL(G) = at gape, other methods unknown (Gibson-Hill 1950). (3) Cocos-Keeling Is, immatures, live; BILL(G) = bill to

gape (details not given), other methods unknown (Gibson-Hill 1950).

		MALES	FEMALES	
WING	(1)	562.4 (6.11; 552–570; 5)	587.0 (4.08; 582–592; 3)	*
	(2)	581.6 (20.17; 540–612; 12)	606.9 (23.28; 552–638; 13)	*
	(3)	590.5 (37.15; 528–620; 4)	602.2 (38.88; 540–648; 5)	
TAIL	(1)	378.5 (8.76; 370–390; 4)	402.3 (12.68; 385–415; 3)	
	(2)	390.5 (26.93; 314–428; 12)	414.5 (16.75; 392–444; 13)	*
	(3)	361.5 (40.94; 297–408; 4)	366.6 (39.76; 298–413; 5)	
BILL	(1)	95.6 (2.05; 92–98; 5)	106.7 (1.08; 105–108; 4)	*
	(2)	102.0 (3.45; 96–108; 12)	115.9 (5.68; 105.5–123; 13)	*
	(3)	106.2 (1.47; 104–108; 4)	120.8 (1.93; 118–123; 5)	*
BILL(G)	(1)	115.0 (1.41; 113–116; 3)	128.2 (1.92; 126–131; 4)	*
	(2)	121.4 (3.07; 117–127; 12)	136.3 (6.05; 125–144; 13)	*
	(3)	121.7 (2.48; 118–125; 4)	141.8 (1.32; 140–144; 5)	*
TARSUS	(2)	26.7 (1.02; 25–28; 12)	28.3 (1.19; 26–30; 13)	*
	(3)	27.5 (1.65; 25–29; 4)	29.8 (0.74; 29–31; 5)	*

Additional measurements in Nelson (1975). Some measurements of fledgelings in Hindwood *et al.* (1963).

WEIGHTS Few data. Voous (1964) gives weight of adult male, Christmas I. (Ind.), June, 1075 g; label data from adult male skin (ANWC), same locality and month, 1150 g. Extralimital: Aldabra Atoll: males 1201 (1000–1450), females 1427 (1215–1640); Galápagos Is: males 1239 (950–1450), females 1630 (1400–1950) (Nelson 1975). Some weights of chicks given in Voous (1964). No data on seasonal changes. Further study required.

STRUCTURE Wing, long, narrow and pointed. Eleven primaries: p10 longest; outer web of p10, narrow; p9 30–52, p8 80–93, p7 119–141, p6 165–186, p5 202–235, p4 242–274, p3 276–309, p2 305–330, 348–372, p11 minute. No emarginations. Six humerals. Twenty-three secondaries, including five of tertial form. Underside of webs of remiges and tail, glossy. Tail, forked; 12 rectrices, t6 longest, t1 225–250 mm shorter. Bill slender; maxillary unguis hooked. Bill smooth in adults, flaky in juveniles. Nostrils slit-like, in groove of culminicorn and latericorn, near bill base. Gular pouch in male highly distensible during courtship and at breeding; gular pouch regresses at time of laying; narrow rows of sparse feathers visible on outer margins of gular pouch when inflated; when inflated, heart-shaped. Tarsus, short and feathered. Toes, totipalmate. All claws curved. Middle claw, long, curved outwards; serrated on inner margins. Outer toe *c.* 75% of middle, inner *c.* 65%, hind *c.* 33%.

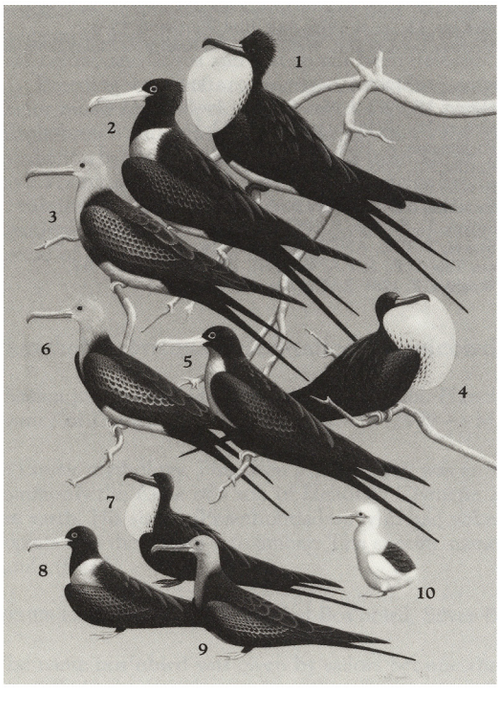
RECOGNITION Juvenile frigatebirds indistinguishable in field; see discussion in Nelson (1975) and Harrison (1987); further study required to establish characters of birds in hand, where species sympatric.

GEOGRAPHICAL VARIATION Five subspecies have been recognized: *minor, aldabrensis, palmerstoni, ridgwayi* and *nicolli* (Peters). Birds from Christmas I. (Ind.) much smaller than from Cocos-Keeling Is (see Measurements); further, adults on Christmas I. (Pac.) larger than those on Johnston Atoll (Schreiber & Schreiber 1988)

RMO

REFERENCES

Ainley, D.G., & R.J. Boekelheide. 1983. *Studies avian Biol.* 8: 2–23.
Anon. 1902. *Victorian Nat.* 18: 175.
Au, D.W.K., & R.L. Pitman. 1986. *Condor* 88: 304–17.
Bourne, W.R.P. 1963. *Proc. Int. orn. Congr. XIII*: 831–54.
Chasen, F.N. 1933. *Bull. Raffles Mus.* 8: 51–87.
de Korte, J. 1984. *ICBP Tech. Publ.* 2: 527–45.
Diamond, A.W. 1975. *Ibis* 117: 302–23.
Diamond, A.W. 1983. *Studies avian Biol.* 8: 24–46.
Dunlop, J.N., *et al.* 1988. *Aust. J. mar. freshwat. Res.* 39: 661–9.
du Pont, J. 1976. *Delaware Mus. Monogr.* 3.
Feare, C.J. 1984. *ICBP Tech. Publ.* 2: 457–71.
Garnett, M.C. 1984. *ICBP Tech. Publ.* 2: 547–58.
Garnett, S.J., & G.M. Crowley. 1987. *Corella* 11: 73–4.
Gibson-Hill, C.A. 1947. *Bull. Raffles Mus.* 18: 87–169.
Gibson-Hill, C.A. 1948. *J. Malay. Branch R. Asiatic Soc.* 21: 68–103.
Gibson-Hill, C.A. 1950. *Bull. Raffles Mus.* 22: 212–70.
Harris, M.P., 1977. Pp. 65–76. **In**: Stonehouse & Perrins 1977.
Harrison, C.S., *et al.* 1983. *Wildl. Monogr.* 85: 1–71.
Harrison, C.S., *et al.* 1984. *ICBP Tech. Publ.* 2: 513–126.
Harrison, P. 1983. *Seabirds: An Identification Guide.*
Harrison, P. 1987. *Seabirds of the World: A Photographic Guide.*
Hindwood, K.A., *et al.* 1963. *Tech. Pap. Div. Wildl. Res. CSIRO Aust.* 3.
Hitchcock, W.B. 1952. *Emu* 52: 273–84.
Jenkins, J.A.F. 1980. *Notornis* 27: 205–34.
King, B.R. 1986. *Corella* 10: 73–7.
King, B.R., & R.C. Buckley. 1985. *Corella* 9: 75–7.
King, W.B. 1970. *US Fish. Wildl. Serv., Spec. scient. Rep, Fish.* 586.
Lacan, F., & J-L. Mougin. 1974. *Oiseaux Revue fr. Orn.* 44: 191–284.
Lindsey, T.R. 1986. *The Seabirds of Australia.*
Melville, D.S. 1984. *ICBP Tech. Publ.* 2: 501–11.
Nelson, J.B. 1967. *Nature, Lond.* 214: 318.
Nelson, J.B. 1968. *Galápagos, Islands of Birds.*
Nelson, J.B. 1975. *Living Bird* 14: 113–55.
Pocklington, R. 1979. *Marine Biol.* 51: 9–21.
Reville, B.J. 1980. Unpubl. Ph.D. thesis, Aberdeen Univ.
Reville, B.J. 1983. *Biol. Conserv.* 27: 59–76.
Richlefs, R.E. 1967. *Ecology* 48: 978–83.
Richlefs, R.E. 1968. *Ibis* 110: 419–51.
Schlatter, R.P. 1984. *ICBP Tech. Publ.* 2: 261–9.
Schreiber, R.W., & D.A. Hensley. 1976. *Pac. Sci.* 30: 241–8.
Schreiber, R.W., & N.P. Ashmole. 1970. *Ibis* 12: 363–94.
Schreiber, R.W., & E.A. Schreiber. 1984. *Science* 225: 713–16.
Schreiber, E.A., & R.W. Schreiber. 1988. *Condor* 90: 90–9.
Serventy D.L., & H.M. Whittell. 1976. *Birds of Western Australia.*
Sibley, F.C., & R.B. Clapp. 1967. *Ibis* 109: 328–35.
Stokes, T. 1988. *ANPWS Occ. Pap.* 16.
Stokes, T., *et al.* 1984. *Emu* 84: 23–8.
Stonehouse, B. & C.M. Perrins (Eds). 1977. *Evolutionary Ecology*
Tarburton, M.K. 1978. *Notornis* 25: 303–16.
Voous, K.H. 1964. *Nytt Mag. Zool.* 12: 38–47.
Woehler, E.J. 1984. *RAOU Rep.* 12.
Woodward, P.W. 1972. *Atoll Res. Bull.* 164: 1–318.

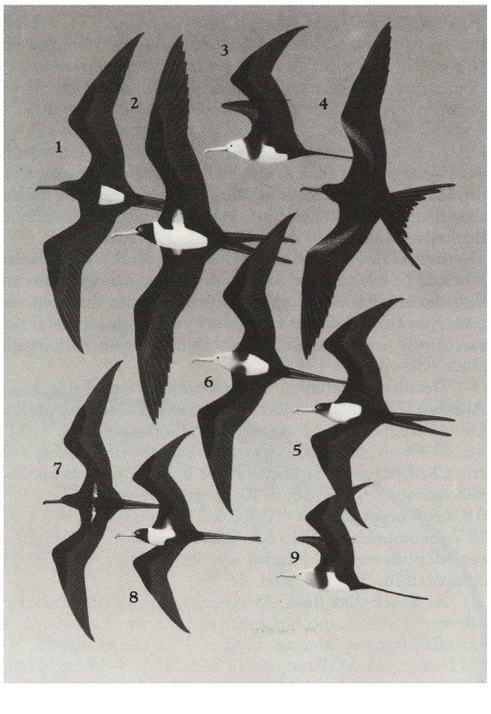


Volume 1 (Part B), Plate 66

Christmas Frigatebird *Fregata andrewsi*
1. Adult male
2. Adult female
3. Juvenile

Great Frigatebird *Fregata minor*
4. Adult male
5. Adult female
6. Juvenile

Least Frigatebird *Fregata ariel*
7. Adult male
8. Adult female
9. Juvenile
10. Downy young



Volume 1 (Part B), Plate 67

Christmas Frigatebird *Fregata andrewsi*
1. Adult male
2. Adult female
3. Juvenile

Great Frigatebird *Fregata minor*
4. Adult male
5. Adult female
6. Juvenile

Least Frigatebird *Fregata ariel*
7. Adult male
8. Adult female
9. Juvenile