

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 pterygiae 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 PHALACROCORACIDAE cormorants and shags

Medium-sized to large aquatic birds of marine and freshwater habitats. Worldwide, 30–40 species, depending on recognition of forms as full species or subspecies. Many isolated insular forms are sensibly regarded as full species. Here we recognize 19 species occurring in our region; after Peters, placed in a single genus *Phalacrocorax*. However, latest arrangements (Siegel-Causey 1988; G.F. van Tets) are more elaborate and divide the family into two sub-families: Phalacrocoracinae (cormorants) with two genera (*Phalacrocorax* or macrocormorants and *Microcarbo* or microcormorants) and Leucocarbininae (shags) with three genera (*Stictocarbo* or cliff-shags, *Nannopterum* or island-shags and *Leucocarbo* or trek-shags). The genus *Phalacrocorax* has two sub-genera: *Phalacrocorax* (s.s.) of two species, *carbo* occurring in our region, and *Hypoleucos* of five species, *varius* and *sulcirostris* occurring in our region. *Stictocarbo* has seven species, *punctatus* and *featherstoni* forming a superspecies in our region. *Nannopterum* has 15 or more species, 12 of which belong to our region; their distribution and association in superspecies is most easily shown on Fig. 1. *Leucocarbo* has six species but only *fuscescens* occurs in our region. Long broad head with patterns of tuft-like crests, which are the origin of the term 'shag'; rather long serpentine neck; broad elongate body; wings broad at base, less broad in outer part, with 11 primaries (p8 and 9 longest) and 17–23 secondaries, diastataxic; stiff wedge-shaped tail, short in shags and long in cormorants, 12–14 feathers. Bill, sub-conical, strong, medium-long, hooked, laterally compressed, without serration; nostrils closed. Gular skin, bare, varying in extent and colour in different species. Tarsus, thick; long toes with outermost longest, totalpalmate; middle toe, pectinate. Tibia, feathered. Oil-gland, feathered. Plumage, black, often with metallic sheen, or black above and white below. Sexes similar with some seasonal changes, mostly affecting crests and facial colours. Juveniles recognizable by colour-patterns of plumage; attain adult plumage when 1–4 years old.

Stance upright; gait waddling, legs being set far back towards tail; cormorants, but not shags, able to perch in trees, on wire and similar thin perches. Swim well, body low in water and even partly submerged, tail flat on water; on surface use feet alternately but under water use both feet together in unison. Plumage is permeable under water and sheds air so that buoyancy is reduced; out of water, plumage repels the water, traps air and increases thermal insulation. Thus, swimming in cold water limited to less than 30 min, otherwise hypothermia sets in. Some species reduce buoyancy further by swallowing pebbles (van Tets 1968, 1976). Indigestible matter regurgitated as pellet about once a day with repetitive *gock-gock-gock...* sound that attracts gulls *Larus* spp for scavenging. In some species, distinctive posture held with wings spread on either side of body during loafing when out of water; thought to be mainly for drying wings but plumage is thoroughly waterproof and oil gland often used when preening. Some hours each day may be spent flying between colonies or roosts and feeding areas. Flight powerful with alternating periods of wing-beats and gliding as in gannets; adopt V-formation in travelling flight. Where colonies far from feeding areas, females leave to feed in mornings, males in afternoon. Much of day spent loafing and so plenty of time for courtship rituals, which take up a major part of activities all year in some species. Feed mostly on fish, caught by surface-diving or pursuit-swimming; sometimes co-operatively and often in dense flocks. Migratory and dispersive; movements probably usually by day. However, island shags seem to be entirely sedentary.

Pair-bond monogamous, maintained mostly or entirely at nest-site. Male selects site and advertises for mate; once accepted, female builds nest with material brought by male. Copulation takes place on nest. Advertising displays by male specially well developed. Movements by both sexes associated with ritualized take-off, landing and locomotion postures and include Pre- and Post-take-off postures, Kink-throating, Circle-flying, Hopping with Pre- and Post-hop postures, and Penguin-walking, which is particularly noticeable in females in search of mate and in males seeking nesting material. Allopreening and entwining of necks occur, probably to maintain pair-bond. Calls are mostly unspecialized; males generally give a variety of croaks, grunts, and groans, whereas females hiss or are relatively silent; calling usually confined to breeding colonies. Bathing in groups may be spectacular and has been misidentified as display (van Tets 1965). Comfort-behaviour consists of gular fluttering to dissipate heat; direct head-scratching; true yawning and jaw-stretching.

Typically breed colonially. Defend small nest-territory. Nests often densely packed and associated with other species such as herons, ibises and spoonbills. Season extended but least so in temperate latitudes. Nests on ground, on cliffs and in trees; used from year to year; built of any available plant material, seaweed and debris to form substantial heap but sometimes nothing more than a scrape in the ground. Tend to continue building during incubation and nestling periods. Eggs, elongate oval, pale blue or green with white chalky coating. Clutch-size, usually 2–4 (1–7 extremes); single-brooded but replacements laid after loss. Incubation by both sexes in approximately equal shares; change-overs at least once or twice a day. Incubation starts with first egg; eggs incubated on feet. Incubation period, 27–31 days. Eggshells removed from nest. Hatching asynchronous. Young

altricial, nidicolous; hatched naked but develop a single coat of dense white, brown or black down. Cared for by both parents; brooded continuously while small; fed by incomplete regurgitation; in cormorants, but not in shags, adults may bring water to young in hot weather. Nestling period, c. 70 days at most but usually 48–53 days. Young attended and fed by both parents for 2–3 months or more after fledging.

REFERENCES

Siegel-Causey, D. 1988. *Condor* 90: 885–905.

van Tets, G.F. 1965. *AOU orn. Monogr.* 2.

van Tets, G.F. 1968. *Emu* 67: 224.

van Tets, G.F. 1976. *Emu* 76: 151–2.

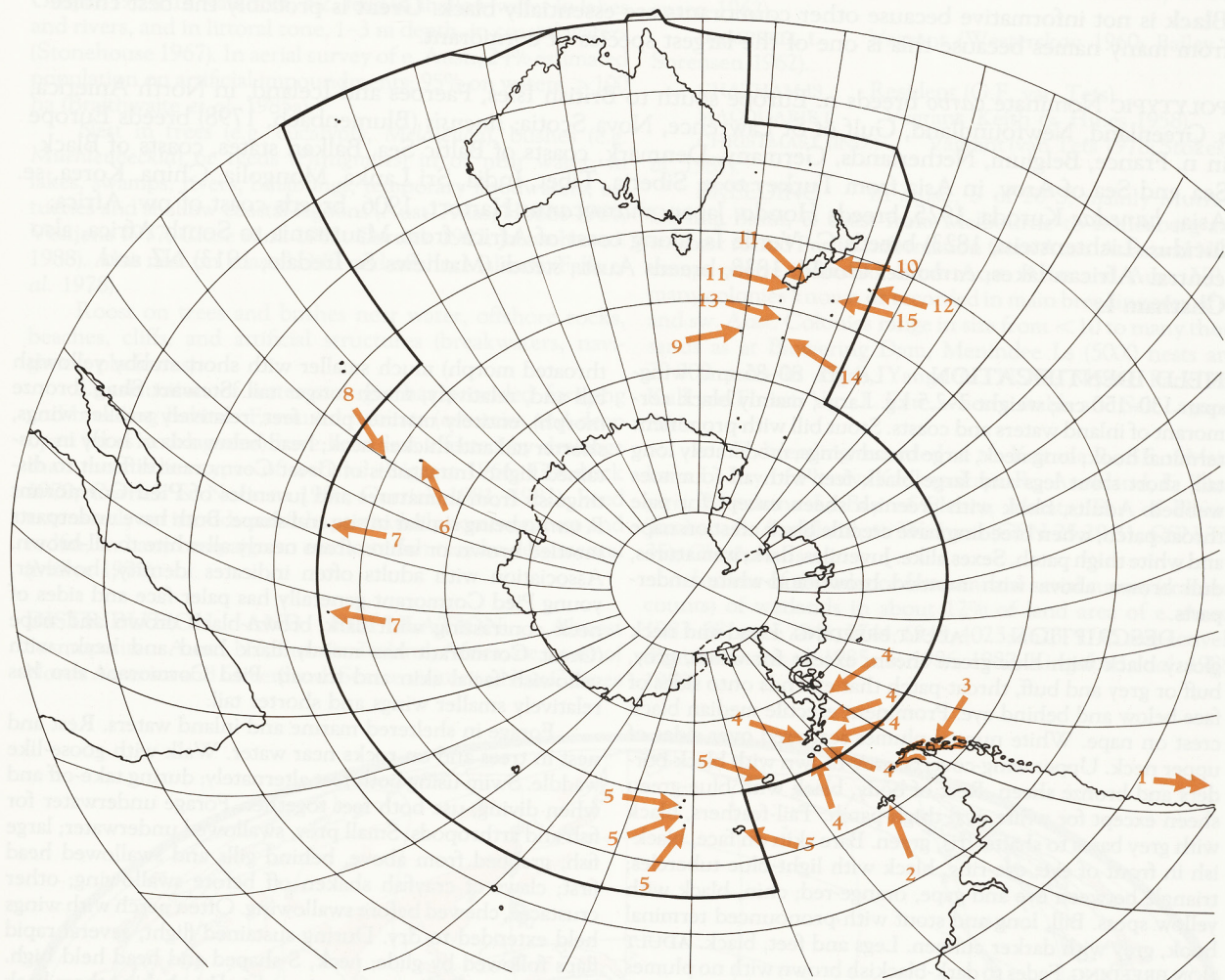


Fig. 1. Distribution of island forms of *Phalacrocorax*.

- | | | | |
|----|-------------------------------|----|------------------|
| 1 | <i>harrisi</i> (Galapagos Is) | 12 | <i>onslowi</i> |
| 2 | <i>albiventer</i> | 13 | <i>colensoi</i> |
| 3 | <i>atriceps</i> | 14 | <i>campbelli</i> |
| 4 | <i>bransfieldensis</i> | 15 | <i>ranfurlyi</i> |
| 5 | <i>georgianus</i> | | |
| 6 | <i>nivalis</i> | | |
| 7 | <i>melanogenis</i> | | |
| 8 | <i>verrucosus</i> | | |
| 9 | <i>purpurascens</i> | | |
| 10 | <i>carunculatus</i> | | |
| 11 | <i>chalconotus</i> | | |

Phalacrocorax varius Pied Cormorant

COLOUR PLATE FACING PAGE 868

Pelecanus varius Gmelin, 1789, *Syst. Nat.* 1: 576; based on 'Pied Shag' of Latham, 1785, *Gen. Syn. Birds* 3: 605 — Queen Charlotte Sound, New Zealand.

Varius or parti-coloured refers to the striking black-and-white plumage.

OTHER ENGLISH NAMES Large Pied, Black-and-white or Yellow-faced Cormorant or Shag.

POLYTYPIC Nominate *varius*, NZ including Stewart I.; *hypoleucos* (Brandt, 1837) Aust., vagrant Tas. and Lord Howe I.

FIELD IDENTIFICATION Length 65–85 cm; wingspan 110–130 cm; weight 1.3–2.2 kg. Large black-and-white, generally marine cormorant of coastal Aust. and NZ, though also occurs on large inland waterways. Bill, long and stout with prominent terminal hook; long neck, rather short broad wings, moderately short tail, short legs and large black feet with all four toes webbed. Adults black above, white below with pure white face to above eye. Sexes alike but female smaller with much shorter bill. Juveniles separable, dark brown above, underparts streaked with brownish grey especially across breast.

DESCRIPTION ADULT BREEDING. Forehead, crown and nape, black, sharply demarcated from white face and foreneck. White extends to, or just above, eye. Crown and hind neck have a few short white nuptial plumes. Feathers on middle of throat extend farther forward in NZ than in Aust. birds. Upper wing-coverts, grey-black with bronze sheen and thin black borders; flight-feathers, black. Back, black with blue or blue-green sheen. Tail, black with white or grey shaft-bases. Underparts, pure white except for black thighs. Underwing, black. Bill, long and stout with pronounced terminal hook, grey with dark culmen. Bare skin on face, fleshy orange or yellow in front of eye; eye-ring, bright blue; gular pouch, chin and triangle above gape, bright pinkish purple or red-pink. Iris, green. Legs and feet, black. **ADULT NON-BREEDING.** Fades to dark brown above; nuptial plumes absent. Upper wing-coverts have sandy edges. Facial skin, yellow in front of eye; eye-ring, pale greenish, blue or grey; gular pouch, chin and triangle above gape, salmon pink. **Morphs.** At large breeding colony near Port Pirie, SA, a few (<1%) birds resemble the subantarctic blue-eyed shags (*atriceps-albiventer* group) in having white patches on upperwing and scapulars, and white line along humeral area of underwing. **JUVENILE.** Upperparts, dark silky brown, clearly separated from streaked white and brownish grey underparts. Brownish markings usually heaviest across breast, but some NZ juveniles have entire underparts brownish, resembling juvenile Great Cormorant *P. carbo*. Bill, pinkish white or pale grey with dark culmen. Facial skin, cream or pale yellow; eye-ring, grey. Iris, dark brown. **IMMATURE.** Mottled dark brown and light brown above; varying mottled white and pale brown below. Brown may be extensive in some NZ birds, but usually confined to upper breast in Aust. birds. Iris, green. Bill, horn with dark culmen. Facial skin, yellow in front of eye; eye-ring, grey; chin, pale pink.

SIMILAR SPECIES Range overlaps with four other 'pied' cormorants or shags: pied morph of Little Pied Cormorant *P. melanoleucos* in Aust. and NZ; Black-faced Shag *P.*

fuscescens in s. Aust.; King Shag *P. carunculatus* in Marlborough Sounds, NZ; pied morph of Stewart Shag *P. chalconotus* in se. of SI, and round Stewart I., NZ. **Little Pied Cormorant** (pied morph) much smaller with short stubby yellowish bill, much longer tail and, in adults, no black thigh-patch. **Black-faced Shag** flies with head held lower than axis of body and does not perch on trees or cables; bill, dark grey; facial skin in adults, black; dark feathering extends below eye, giving dark-faced appearance compared with Pied Cormorant. White feathering on chin extends to base of lower mandible where Pied Cormorant has pink skin. Juvenile Black-faced Shag has dark head and grey facial skin. **King Shag** and pied morph of **Stewart Shag** have black faces with white feathers confined to chin and throat; at rest, do not extend wings to dry, and usually show white patches along alar region of upperwing; feet pink; fly with head held lower than axis of body and show thicker neck and dark face; usually have white patches on upperwings and back. Juvenile **Great Cormorant** similar to darker examples of juvenile Pied Cormorant in NZ region. Great Cormorant differs, usually having darker face without clear demarcation between dorsal and ventral plumage; also has relatively shorter bill, larger wings and longer tail.

Forage in sheltered marine gulfs, bays and inlets and in rivers, lagoons and large lakes. Rest and nest in trees and bushes near water. On hot days, may also rest in shade of bushes, trees and rock overhangs near water. Often perch with wings held extended. When standing on flat surfaces, tail seldom touches ground, normally held almost horizontal and body inclined to c. 60°; on branches, three toes wrapped around front of limb, first toe directed backward to grasp rear of branch; body held slightly more upright than when on ground, head and bill horizontal, neck in S-shaped position. Walk with goose-like waddle. In water, swim at surface using both feet alternately; during take off and when diving, use both feet together. Forage underwater, mainly for fish. Sustained flight, straight and low over water with neck S-shaped and head held high. Flight weaker than that of other species of cormorant. Usually solitary except near marine waters where groups form to rest and nest together. At nest-site, males loud and raucous; females use very soft hiss call.

HABITAT Mainly marine; in e. Aust., inhabit terrestrial wetlands and coastal waters. Inland on lakes, swamps, rivers, billabongs, pools, sewage ponds (Thompson 1977; Vestjens 1977; Fjeldså 1985). Associated with large sheets of open water (Fjeldså 1985); particularly permanent freshwater lakes and reservoirs, and open water in deep freshwater marshes (Corrick & Norman 1980; Corrick 1982). Birds unaffected by

fluctuations in turbidity and salinity, and nature of shoreline vegetation unimportant, so long as islands, fringing or projecting tree trunks, branches or posts available for perching (Fjeldsà 1985). Less common in shallow vegetated waters; semi-permanent swamps, and swampy edges of lakes (Vestjens 1977; Gosper 1981). Along coast, abundant in estuaries (Corrick 1982; Gosper 1981; Fjeldsà 1985; Jaensch *et al.* 1988); also occur in saltfields (Cooper 1980), mangrove swamps (Gosper 1981), coastal lagoons (Corrick & Norman 1980; Corrick 1982), on beaches and rock platforms and over inshore waters along unindented coasts (Gosper 1983). In coastal Kaikoura, NZ, feed most often 100–300 m from shore in depths of 3–10 m; also in littoral zone, depth 1–3 m (Stonehouse 1967). Observed feeding across 16 km of sea between Fremantle and Rottneest I., WA, but less common in central sector >5 km from shore (Storr 1964).

In Aust., breed coastally on rocky or sandy islands offshore or in bays, or in estuaries and tidal creeks; in trees or on woody or matted bushes able to support nests; mangroves, *Melaleuca*, *Acacia*, *Nitraria*, *Atriplex*, introduced boxthorn *Lycium ferocissimum* (Serventy & White 1943; Thompson 1977; Dunlop & Storr 1981; Corrick 1982; Gosper 1983; Pescott 1983; Lashmar 1987; Menkhorst *et al.* 1988). On Carnac I., WA, colonies move when trampling and guano deposition destroy *Acacia* and *Nitraria* bushes and encourage growth of soft annuals unsuitable for nesting; regeneration takes 4–5 years (Wooller & Dunlop 1981). Also nest on bare or sparsely vegetated cliff tops, rocky shores and islets (WA; Whitlock 1921; Serventy & White 1943; Johnstone 1978). In e. Aust., inland breeding in trees standing in lakes and swamps (Bright & Taysom 1932; Vestjens 1977). In NZ, on coasts and offshore islands, in trees overlooking sea; less often in freshwater lakes near coast; *Metrosideros exelsa* often used (Sibson & Davenport 1956; Taylor 1987).

Roost in trees near water, or on cliffs, offshore rocks, sandspits (Moisley 1960; Skegg 1963; Stonehouse 1967; Gosper 1981). At L. Rotorua, NZ, guano deposition at roosting sites enhances nutrient levels and encourages growth of rich algal flora (Stonehouse 1967).

Large, permanent open wetlands and estuaries favoured by Pied Cormorants less affected by drainage than most other wetland types (Riggert 1966; Goodrick 1970; Corrick & Norman 1980; Corrick 1981, 1982). Artificial impoundments used for breeding e.g. at L. Borrie, Vic., nest in *Melaleuca* trees drowned when lake filled for use in sewage treatment (Norman 1974). Artificial structures (navigation beacons, piles) used for breeding (McNally 1956; L. King; G.F. van Tets) and for perching. Feed much on introduced fish, particularly common carp and redfin, and a campaign to eradicate fish could be detrimental (Miller 1979).

DISTRIBUTION AND POPULATION Endemic to Aust., excluding Tas., and NZ.

AUST. Widespread on coastal, subcoastal and inland waters of mainland, except in driest area of central WA, sw. NT and e. SA (Great Sandy, Gibson and Great Victoria Deserts, and Nullarbor Plain), very roughly between 120° and 133°E and 20° and 30°S (Aust. Atlas); also offshore islands of WA and SA. In Tas., extinct historic times (van Tets *et al.* 1976); vagrant since 1971 (Green 1977).

NZ Restricted to three main islands: NI, SI and Stewart I. Coastal NI: North Cape, S to Auckland and E to Gisborne, Cook Str., few records from permanent inland waters. SI: C. Farewell to Christchurch, Milford Sound to

Invercargill; Stewart I.

LORD HOWE I. Vagrant; two, Apr. 1978 (NSW Bird Rep. 1978).

BREEDING In Aust., S of 19°S, mostly in coastal and subcoastal areas from Melbourne, Vic., to Eucla, WA, and on w. coast of WA from Perth to Carnarvon (Aust. Atlas). Probably sparsely throughout range in suitable places. Recorded localities since about 1960, with years, sizes of colonies if recorded (numbers of nests unless otherwise stated), listed below (from Aust. Atlas or Aust. NRS unless stated).

Qld: Coolmunda Res.: 1982.

Facing I.: 1980, many.

Mt Isa (20 km N): 1977.

Townsville: 1978.

NSW: Avoca Beach: 1977.

Blayney: 1978.

L. Menindee: 1974, 500 pairs.

Toukley: 1981

Wyangala Res.: 1978.

Vic.: Coolart: 1981.

L. Borrie: 1965, 35; 1971, 54; 1972, 60; 1973, 56; 1978, 100; 1980–90, 300+ pairs p.a. (R. Swindley).

L. Charm: 1978–79; 1981.

L. Corangamite: 1979, 8.

Mud I.: regular 1980s (P. Menkhorst).

Mystic Park: 1981, 4; 1984, 6.

Swan I.: 1978, 32+.

SA: Franklin Harbour: 1978–83.

Goyder Lagoon: 1977, many.

Kingscote: 1979, many.

L. Eyre: 1984, 50+.

Little Goose I.: 1972, 72.

Port Gawler: 1973, c. 1050.

Price: 1973, 1500.

Salt Lagoon Is.: 1962–63; 1964–65, 50; 1966, 500+; 1967, <500; 1968; 1969, 0; 1971, 300; 1972, 200; 1973–74, 150; 1975, 4; 1976, 100; 1977, few; 1978, 0; 1979, c. 25 (Close *et al.* 1982).

Winceby I.: 1970, 100+; 1972, 150; 1974, 200; 1975, 150; 1976, 200; 1980, 200; 1981, 1983, 200 pairs.

WA: Adele I.: 1978, 400 (Abbott 1979).

Baudin Rocks: 1922; 1981, c. 30 pairs (Bonnin 1982).

Carnac I.: 1976, c. 500; 1977–78, 450–550 pairs p.a. (Dunlop & Storr 1981); 1981.

Dorre I.: 1978, c. 800 birds.

Flat Rock: 1958, c. 50 pairs (Dunlop & Storr 1981)

L. Gregory: 1983, 11.

North Turtle I.: 1975, 1500 pairs (Kolichis 1977).

Rottneest I.: 1981.

Shark Bay: 1920, 10 000 birds; 1948, 15 000–20 000 birds.

South Fishermans I.: 150 pairs (Johnstone 1978).

NT: Sir Edward Pellew Grp: 1966, 19.

Darwin Harbour: 12 pairs.

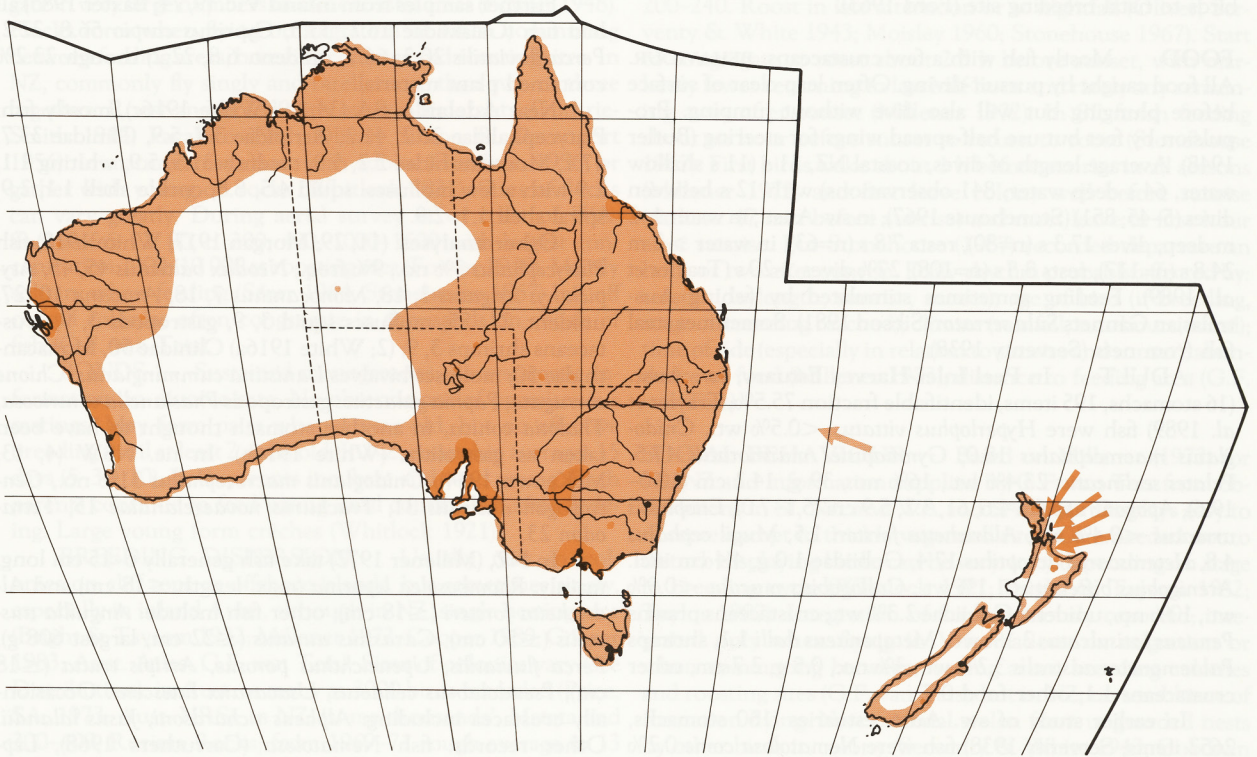
NZ Localities and population estimates listed below (from Millener [1972] and pairs unless indicated).

NI

Whale I.: 1970, 10

Cavalli I.

Okiato Pt.: 1972, 36 (CSN 34)



Matauri Bay
 Whangaruru
 Kawerua
 Great Barrier I.
 Little Barrier I.: 1969, 10 nests
 Hen & Chickens Is: 1903-64 (Skegg 1964)
 Mokohinau I.
 Upper Waitemata: 1980, 30 (CSN 28); 1985, 47 (CSN 34)
 Kaipara
 Goat I.: 1971, 14
 Cuvier I.: 1979, 5 (CSN 28)
 Stanmore Bay: two colonies; 1969-71, 23
 Mercury I.
 Red Mercury I.: 1971, 8
 L. Pupuke: four colonies; Colony 1: 1969-71, 53
 Greenhithe, 2 colonies; 1970, 31
 Otata: 1962-70, 1981-83 (Cunningham & Moors 1985)
 Ponui I., two colonies: 1970, 15
 Kennedy Bay: 1970, 26
 Okahu Pt.: 1970, 25
 Panmure Basin: 1970, 84
 Parau (Lower Nihotup) Res.: 1971, 8
 Slipper I.: 1983, 7 (CSN 32)
 Mayor I.
 Hingaia, S. Manukau: 1979, 31 (CSN 28)
 Orakei Basin: 1971, 19; 1982, 30-40 (CSN 31); 1986, few (Taylor 1987)
 Tapara: 1986, 25 (CSN 34)
 Whitianga, two colonies; 1971, 16 nests
 Rurima Rocks: 300-400 (Buller 1888)
 Matata: some thousands (Buller 1888)
 Kaituna R.: 1980-82, 20 (CSN 29-31); 1986, 21 (CSN 35)

Kapiti I.
 SI
 Marlborough Sounds
 Rocks Rd, Nelson: 1979-81, 1 (Owen & Sell 1985)
 D'Urville I.
 L. Rotorua: 1982, 64 (CSN 31)
 L. Brunner (Moana)
 Hurunui R.
 Motonau R.
 Waimakariri R.
 Banks Pen.
 L. Ellesmere
 Fiordland
 Sawyers Bay: 1982, 36 (CSN 31)
 Codfish I.
 Half Moon Bay
 Paterson Inlet
 Hobson Bay: 1979-84, 22-47 (Taylor 1987).

MOVEMENTS Largely sedentary but some juvenile dispersal. Reporting rate in Vic. constant throughout year suggesting no seasonal movements (Vic. Atlas) but numbers present during annual Oct. counts near Brisbane, se. Qld positively correlated with rainfall in sw. Qld (Woodall 1985). On estuaries in ne. NSW, most common July-Dec. (Hunter R.) and summer (Richmond R.; Gosper 1981) and in sw. NSW, where scarce, apparently absent Apr.-Oct. (Hobbs 1961). No information on movement in NZ.

BANDING Most nestlings banded SA recovered near banding site but some movement along coasts or up Murray-Darling river system (van Tets *et al.* 1976). Also some dispersal along coasts of birds banded sw. Aust. where young birds moved farthest and some evidence of return by older

birds to natal breeding site (Ford 1963).

FOOD Mostly fish with a few crustaceans. **BEHAVIOUR.** All food caught by pursuit-diving. Often leap clear of surface before plunging but will also dive without jumping. Propulsion by feet but use half-spread wings for steering (Butler 1948). Average length of dives, coastal NZ, 31 s (11 s shallow water, 64 s deep water; 841 observations) with 12 s between dives (5–45; 851) (Stonehouse 1967); in sw. Aust., in water 1–2 m deep, dives 17.3 s (n=80), rests 7.8 s (n=63), in water > 2 m 24.8 s (n=117), rests 8.5 s (n=108); 27% dives > 20 s (Trayler *et al.* 1989). Feeding sometimes stimulated by fishing Australasian Gannets *Sula serrator* (Sibson 1981). Sometimes steal fish from nets (Serventy 1938).

ADULT In Peel Inlet-Harvey Estuary, sw. Aust. (16 stomachs, 195 items, identifiable fraction 75.5%; Trayler *et al.* 1989) fish were *Hyperlophus vittatus* <0.5% wt., *Cnidoglanis macrocephalus* 18.0, *Gymnapistes marmoratus* 17.5, *Pelates sexlineatus* 23.4% wt., 16% no., 39 g, 14.2 cm (10.0–19.6), *Apogon ruppellii* 4.6, 61, 3.2, 5.9 cm (5.1–7.0), *Enoplosus armatus* <0.4% wt., *Aldrichetta forsteri* 1.5, *Mugil cephalus* 4.8, *Heteroscarus acroptilus* 17.4, Gobiidae 1.0 g, 4.4 cm incl. *Arenigobius bifrenatus* 1.1% wt., *Callogobius mucosa* <0.9% wt., 10% no., unident. Gobiidae 2.3% wt.; crustaceans prawns *Penaeus latisulcatus* 2.1% wt., *Metapenaeus dalli* 1.1, shrimps *Palaemonetes australis* 3.2% wt., 3% no., 0.5 g, 2.7 cm, other crustaceans 1.1; other food 0.7.

In earlier study of sw. Aust. estuaries (160 stomachs, 2652 items; Serventy 1938) fish were *Nematolosa come* 0.2% no., 1.9% freq., max. no per stomach 3, *Sardinops neopilchardus* 0.5, 5.0, 4, *Gonorynchus greyi* <0.1, 0.6, 1, *Cnidoglanis macrocephalus* 4.0, 21.3, 14, *Paraplotosus albilabris* <0.1, 0.6, 1, *Atherinomorus endrachtensis* 3.7, 6.3, 63, *Gymnapistes marmoratus* <0.1, 0.6, 1, *Platycephalus bassensis* 0.3, 3.8, 3, *Pelates octolineatus* 0.3, 4.4, 2, *Apogon ruppellii* 48.9, 38.1, 139, *Sillago maculata* 0.2, 1.3, 3, *Pomatomus saltatrix* 0.1, 1.3, 1, *Arripis trutta* 0.2, 1.9, 3, *Gerres ovatus* 1.3, 6.9, 14, *Rhabdosargus sarba* <0.1, 0.6, 1, *Aldrichetta forsteri* 0.7, 6.3, 3, *Mugil cephalus* <0.1, 0.6, 1, Labridae/Scaridae 0.1, 0.6, 2 *Odax* <0.1, 0.6, 1, *Siphonognathus radiatus* 0.2, 0.6, 6, *Arenigobius bifrenatus* 12.7, 18.8, 100, *Glossogobius suppositus* 18.6, 24.4, 112, *Scobinichthys granulatus* <0.1, 0.6, 3 and unident. 0.2, 2.5, 1, the crustaceans were prawns *Metapenaeus monoceros* 5.1, 25.6, 23, shrimps *Alpheus edwardsii* 2.0, 13.9, 7, *Palaemonetes australis* 0.4, 4.4, 3, crabs *Portunus pelagicus* 0.2, 2.5, 1. In same study samples from marine environments (30, 160) contained fish: *Heterodontus portusjacksoni* 0.6, 3.3, 1, *S. neopilchardus* 4.3, 13.3, 3, *C. macrocephalus* 1.8, 10.0, 1, *A. endrachtensis* 17.2, 6.7, 25, *Filicampus tigris* 1.2, 6.7, 1, *Stigmatopora argus* 12.3, 23.3, 6, *Maxilliscosta scabriceps* 0.6, 3.3, 1, *P. bassensis* 1.2, 3.3, 2, *P. sp.* 1.8, 10.0, 1, *P. octolineatus* 1.8, 6.7, 2, *A. ruppellii* 1.2, 6.7, 1, *A. trutta* 0.6, 3.3, 1, *G. ovatus* 1.8, 6.7, 2, *R. sarba* 0.6, 3.3, 1, *Notolabrus parilus* 1.8, 6.7, 2, *Heteroscarus filamentosus* 1.2, 3.3, 2, *Odax* 16.6, 40.0, 6, Blenniidae 0.6, 3.3, 1, *A. bifrenatus* 3.1, 3.3, 5, *S. granulatus* 14.7, 53.3, 4, *Diodon nictemerus* 0.6, 3.3, 1 and cephalopods: cuttlefish 6.1, 33.3, 1, octopus 0.6, 3.3, 1.

In Vic. (17, 22; McNally 1957) diet on inland waters: fish *Nematolosa erebi* 27.3% no., 11.8% freq., *Retroinna semoni* 27.3, 11.8, *Carassius auratus* 31.8, 35.3, *Perca fluviatilis*, *Philypnodon* 13.6, 11.8 and the crustacean *Cherax destructor*, in marine habitats (32, 44) also largely fish *Gymnapistes marmoratus* 38.6, 21.9, *Platycephalus*, *Mugilidae*, *Gobius* 34.1, 15.6, unident. 11.3, 9.4 with a few crustaceans 15.9, 15.6.

Further samples from inland Vic. (9, 74; Baxter 1985) all had fish (*Galaxiidae* 16.2, 33.3, *Cyprinus carpio* 56.8, 22.2, *Perca fluviatilis* 20.3, 66.7, unident. 6.8, 22.2) though 22.2% contained plant material.

Near Adelaide, SA (34, 89; White 1916c), mostly fish: *Platycephalidae* 20.2, 41.2, *Arripidae* 3.4, 5.9, *Clinidae* 33.7, 47.1, *Monacanthidae* 2.2, 5.9, toadfish 31.5, 5.9, whiting 1.1, 2.9 with a few molluscs: squid 4.5, 8.8, cockle shell 1.1, 2.9, spiral shell 1.1, 2.9.

Other analyses: (11, 29; Morgan 1917; White 1918) fish *Platycephalus* 3% no., 9% freq., *Neodax balteatus* 45, 45, *Atypichthys strigatus* 3, 18, *Monacanthus* 7, 18, *Aracana* 10, 27, unident. 21, 55; molluscs squid 3, 9, gastropods 3, 9; crustaceans shrimps 3, 9; (2; White 1916a) *Clinidae* 50, *Monacanthidae* 50; molluscs bivalves *Lanistina cummingianus*, *Chione corrugata*, *Paphia galactites* gastropods *Phasianella ventricosa*, *Thalotia conica*, in another stomach thought to have been taken as gastroliths (White 1916b). In ne. NSW (4, 13; McKeown 1944): *Cnidoglanis macrocephalus* 31% no., *Centropogon australis* 31, *Trachurus novaezelandiae* 15, *Tetraodon* 23.

In NZ, (Millener 1972) take fish generally 6–15 cm long, mainly: *Rhombosolea leporina* (max. length ≤ 18 cm) and *Aldrichetta forsteri* (≤ 18 cm); other fish include: *Anguilla australis* (≤ 50 cm), *Carassius auratus* (≤ 22 cm, largest 608 g), *Perca fluviatilis*, *Upeneichthys porosus*, *Arripis trutta* (≤ 18 cm), *Pseudolabrus celidotus*, *Usacaranx lutescens*. Occasionally crustacea including: *Alpheus richardsoni*, *Jasus lalandii*. Other records: fish *Nematolosa* (Carruthers 1968), *Lepidichthys fistularius*, *Stigmatopora argus* (Hale 1938), *Sphaeroides pleurogramma* (Stranger 1970); birds Australian Shelduck *Tadorna tadornoides* ducklings (Storr 1965). For additional summary see Barker & Vestjens (1989).

NESTLING At Werribee, s. Vic. (Norman 1974), fed with fish, mostly *Sardinops neopilchardus*, *Sprattus novae-hollandiae*, *Engraulis australis*, also *Gymnapistes marmoratus*, *Lepidotrigla*, *Aldrichetta forsteri*. Remains collected under one set of nests se. SA, all *Nematolosa erebi* (Close *et al.* 1982); under another, *Cnidoglanis macrocephalus*, *Platycephalus*, *Pelates octolineatus*, *Haletta semifasciata* (Paton 1973).

INTAKE Adults take about <500 g per day. (Millener 1972); max. intake by almost fully grown chicks, about 600–800 g (G.F. van Tets); stomach contents, Vic. 29.1 g (5.5–87.0; 13; Norman 1974); sw. Aust. 79.9 g (15; Trayler *et al.* 1989).

Table 1. Summary of diet of Pied Cormorant

Percentages	weight		number					
	1	2	2	3	3	4	5	6
FISH	90.4	92.3	93.3	100	84.0	100	93.3	91
CRUSTACEANS	7.4	7.7	—	—	15.9	—	3	—
NO. SAMPLES	16	160	30	17	32	9	34	11

(1) Trayler *et al.* (1989); (2) Serventy (1938); (3) McNally (1957); (4) Baxter (1985); (5) White (1916c); (6) Morgan (1917), White (1918).

SOCIAL ORGANIZATION Based on study in NI, NZ (Millener 1972), and information supplied by G.F. van Tets from personal observations (Port Pirie, SA and Rottneest I., WA). Solitary or gregarious (Campbell); typically feed singly; roost and breed in colonies; in small numbers inland, congre-

gate in very large numbers in some coastal areas (Fowler 1948). Flocks form when flying on migration or when commuting between feeding areas, breeding colonies and roosting sites. In NZ, commonly fly singly and rarely more than two or three together. Roost and breed with other cormorants (Guthrie-Smith 1914; Favaloro 1952; Oliver; Sibson & Davenport 1956). Immatures may roost with adults (Goodwin 1956) or gather with young on rocks (Whitlock 1921). Sizes of flocks can vary greatly. During aerial survey of w. coast of WA, flocks of 6–12, 80, c. 200, 400, 1000–1500 with largest concentration 7000–10 000 at roosting area (Fowler 1948). Mainly solitary when feeding (Storr 1964; Stonehouse 1967) but off coastal colonies often congregate in thousands on shoals of fish (G.F. van Tets).

BONDS Sustained monogamous; no systematic information on divorce rate. No observations of promiscuous matings. May form pairs when 1 year old, but no effective breeding until at least 2 years old. In NZ, courtship averages 15 days (5–30; 30). Both parents incubate and tend young. Both parents continue to feed young until contact lost after fledging. Large young form crèches (Whitlock 1921).

BREEDING DISPERSION Usually nest in colonies on cliff tops or offshore islands, but sometimes singly, especially in inland Aust., although in NZ, single nesting rare (Bright & Taysom 1932; Millener 1972; Cooper 1980; Gosper 1983; Aust. Atlas; G.F. van Tets). Sizes of colonies vary (see Distribution): in Aust. as many as 3000 birds recorded (Price, SA, 1973; Aust. NRS); in NZ, 'some thousands', Matata and 300–400, Rurima Rocks; from 1969–71 rough average in 13 colonies 17–18 pairs (1–84) (Millener 1972). In colonies, may nest close together (North; Serventy & White 1943). Sometimes scattered through colonies of other species (Favaloro 1952); in NZ, often in association with Little Pied Cormorant, occasionally with Great Cormorant, Little Black Cormorant, or both (Oliver; Sibson & Davenport 1956; Millener 1972). Territorial; nest-site defended against conspecifics; roost-site defended against other species (Goodwin 1956). In NZ, rarely range outside feeding areas and roosts. Pair may re-use own nest or that of others; may change nest-site annually (Serventy & White 1943; Wooller & Dunlop 1981).

ROOSTING Solitary or communal roosts, often with other species of cormorants (Goodwin 1956), in trees near water e.g. macrocarpa *Cupressus macrocarpa* in NZ, bushes near water, in mangroves; on sandspits, on cliffs, rocks, offshore rocks, stacks, partly submerged posts, boats and navigation platforms (Skegg 1963; Storr 1964; Gosper 1981; G.F. van Tets); old breeding colonies may be re-used (Skegg 1963); Oliver records roosts in trees in which bird was reared. In NZ, prefer feeding areas near roosts and rarely range outside these localities. May have separate diurnal and nocturnal roosts, depending on locations of food and shelter (G.F. van Tets). Loaf during day but strongly diurnal in behaviour and sleep during darkness. Often sun on perch i.e. dead trees, boats and poles. At nest-site, both birds usually sleep within 1 m of each other at, or close to, nest-site; fledglings try to roost at or near nest-site, but unable to do so if nest taken over by new pair. Sizes of roosts: 7000–8000, Quoin Bluff, WA; 1000 on beach, C. Levillain, Dirk Hartogs I., WA; 100 on sandspit, near Carnarvon, WA (Fowler 1948); up to 200 on sandspits, with numbers highest in summer at Richmond R., NSW (Gosper 1981); up to 63 on rocks and beaches near Ballina, NSW (Gosper 1983); groups of four on cliffs, 19 on stack at Middle I., 20 on rocks offshore, c. 20 on cliffs and six at old breeding colony area (Skegg 1963); Panmure, NI, NZ,

200–240. Roost in late afternoon or at nightfall (Oliver; Serventy & White 1943; Moislely 1960; Stonehouse 1967). Start to congregate at roost about 2.5 h before sunset, with markedly fewer returning in last half hour and rarely any remaining away after sunset (Millener 1972). In SI, finish feeding about an hour before sunset to return to roost (Stonehouse 1967). First birds wake about 1 h before sunrise in all seasons (Millener 1972) and first leave colony well before sunrise (earliest: 47 min before sunrise) and most leave in first hour after sunrise. But Stonehouse (1967) recorded departure an hour or two after sunrise. Daily rhythm probably affected by: season (daylength, sunrise, sunset); age of bird (if breeding, stage of breeding reached); climate (rainfall, sun-hours, wind); time of tide (especially in relation to sunrise and sunset); abundance of food (Millener 1972); distance to feeding area (G.F. van Tets).

SOCIAL BEHAVIOUR Based on Millener (1972) for NI, NZ and information supplied by G.F. van Tets from observations in SI, NZ, and WA and SA, Aust. Displays easy to observe except in thickly vegetated sites. Care needed not to disturb displaying birds; can be very wary depending on stage in breeding cycle (Whitlock 1921; Bright & Taysom 1932; Taylor 1987). Integration of flocks variously reported; integrated only when flying in V-formations on migration or when commuting between feeding areas, breeding colonies and roosting sites (G.F. van Tets); but in NZ, no semblance of formation flying. Nest material stolen from unguarded nests by other birds in colony (Serventy & White 1943; Goodwin 1956). Following account based mainly on behaviour at nest-site. In both sexes, neck-feathers below prominent nape line raised when bird on or beside nest-site, thus making black feathers on hind neck look like broad ruff (G.F. van Tets).

AGONISTIC BEHAVIOUR Individual distance just out of pecking reach of each other. Compete for favoured perch; male for possession of nest-site and female for mate. **THREAT.** Extends neck and directs bill at opponent eliciting aggression. While sitting or standing on or at nest-site, threaten by jerking head and bill back and forth and sideways with irregular sinusoidal movements of neck. At low intensity bill remains closed, bill and gular pouch slightly extended; at higher intensity, expands gular pouch, raises feathers of head and neck, elevates tail and thrusts bill repeatedly towards opponent while opening bill at forward limit of thrust; males screech loudly and females hiss softly. Nest-worrying often follows. This threat typical of stationary bird and usually seen at nest-site. Away from nest, mobile display often seen where threaten with wings held slightly away from body and sometimes half spread; advance towards intruder and thrust partly opened bill repeatedly towards intruder (Millener 1972). At nest-site, also threaten with **Nest-worrying**: birds pick up nearby object (twig or nest material) and shake it vigorously with down-pointed bill; males sometimes call, females silent. Threatening displays often seen when birds land and make way overland through colony to nest. Young threaten intruders, either conspecifics or different species, or humans, at 16–21 days old, using threat-posture similar to that of adult and jab with bill; at 21 days, markedly more aggressive to intruders and emit high-pitched threat calls. Juvenile males often threaten with harsh nasal threat-call. **FIGHTING.** Rare, disputes usually settled by Threat displays; fights normally occur between members of same sex. Clash beaks when disputing perch and also peck at head and body of intruder; usually one of combatants flies away.

SEXUAL BEHAVIOUR **ADVERTISING.** Courtship always initiated by male advertising at or near future nest-site. Consists of Wing-waving given by single birds or mated birds reunited at nest (HASB). **Wing-waving** (Fig. 1): raises and lowers partly folded wings 1–2 times/s (as in Great Cormorant) while raising rump, resting head on back, and pointing closed bill upward, or upward and forward. Repeated up to eight times (Millener 1972). Display silent, *contra* Serventy & White (1943) and HASB, where mistake probably due to difficulty in associating sound with movement and posture in dense and noisy colonies (G.F. van Tets). **RECOGNITION.** Consists of Gargling, Pointing, Gaping and Head-lowering and used by both sexes on nest-site; body of bird horizontal in all these displays except for Pointing, where breast slightly. **Gargling** (Fig. 2a,b): with straight neck, swings head backwards then forwards through vertical arc. During backward and first half of forward movement, bill wide open, throat bulges and male screeches whereas female silent. During second half of forward movement, bill closed, throat remains bulged, and head proceeds forward till in front of body, finishing either higher or lower than body; during this phase, and at its end, rotates head several times from side-to-side round axis of bill and throat; male gargles, gobbles or barks loudly whereas female wheezes softly. Screech, gargle and wheeze vary greatly in sound, duration and number of syllables. Males often fuse Gargling onto end of bout of Wing-waving; at end of Gargling display, keep head and stretched neck forward in **Pointing** display (Fig. 3) where breast slightly and slowly raised while bill (closed) and tail point c. 30° above horizontal (similar to Great Cormorant). Either sex also acknowledges arrival of their mate at nest by **Gaping** (Fig. 4): directs wide-open bill forward and moves it slowly back and forth; throat has angular bulge, neck S-shaped and tail tilted up to c. 45° above horizontal; male makes squealing (tri-syllabic) sound, female silent. **Head-lowering:** two birds perform together, one bird on nest-site and other beside it, both facing same direction; with bills closed and pointing slightly upwards, lower and raise heads in front of bodies to position slightly higher than bodies. **OTHER DISPLAYS AT SITE.** Include Pre-take-off and Post-landing Postures, Kink-throating and the Hop. **Pre-take-off Posture** (Fig. 5), at departure from nest-site, similar to Great Cormorant but differs in that front of throat bulges forward at obtuse angle; base of neck pulsates and bill opens and closes slightly in time with ticking sound uttered by males, but not females. Before and on landing, as far as 100 m from nest-site, perform **Kink-throating** (Fig. 6): bill closed and males give repeated whistling call which, when flying, in time with wing-beat; females silent. **Post-landing Posture** (Fig. 7), with discoid head, as in Great Cormorant, but silent in both sexes. **Hop:** with both feet, bird rapidly straightens legs and jumps up to one metre; bill usually closed but opens at end; tail raised above horizontal; wings, head and neck usually do not move in relation to body, though wings may move slightly in larger leaps; used when moving round nest-site and in mounting and dismounting. **Pre-hop** (Fig. 8) and **Post-hop Postures** (Fig. 9) differ from Pre-take-off and Post-landing Postures, in neck being less straight and tail being raised above horizontal. **Circle-flying:** short flight from and back to nest-site during courting, pair-formation and early nest-building; gular region often kinked. **ALLOPREENING** occurs; may be seen after copulation. **COURTSHIP, PAIR-FORMATION.** Females land near displaying males and latter stop Wing-waving and increase frequency of Gaping and Gargling; females approach males, Kink-throating continuously.

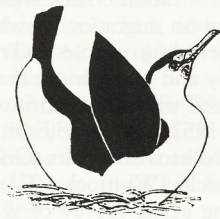


Fig. 1 Wing-waving

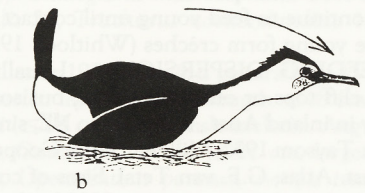
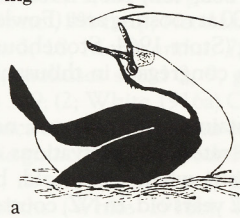


Fig. 2 Gargling

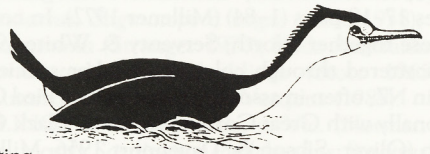


Fig. 3 Pointing

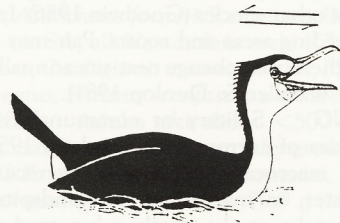


Fig. 4 Gaping

Fig. 5
Pre-take-off Posture

Fig. 6 Kink-throating



Fig. 7 Post-landing Posture

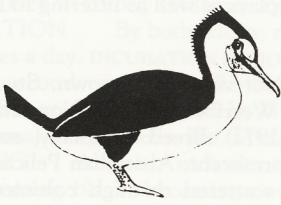


Fig. 8 Pre-hop

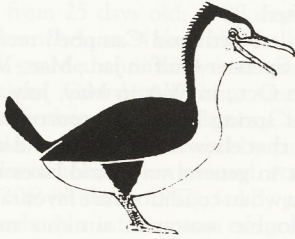


Fig. 9 Post-hop

When close, pair display further e.g. intertwining necks, Allopreening. Females often then Circle-fly, return and sequence repeated; or fly off and males resume advertising. Female may visit same male a number of times or may approach three or four displaying males; male may display to one or more females. Female may be driven off by threat display or pecking. In courtship and pair-formation, bird newly arriving at nest-site may perform Pointing and Gaping alongside bird already present at site; male often presents token material to females and this continues after nest built, during nest-relief. COPULATION. Pointing commonly performed before, during and after copulation. Mounting often preceded by Gaping; normally occurs only between paired birds at or near nest-site, usually after change-over at nest. First copulation occurs after male presents first nest material. Before copulation, female sits with tail raised vertically and Nest-worries. Male Hops onto female, mounting her with characteristic *huurp* call; grips head or neck of female with mandibles and treads with both feet alternately on female's back; lowers tail vertically and cloacal contact takes place; wings not flapped but may be flexed to aid in balancing. Male may call *kerlik* but usually both sexes silent. Copulation lasts 5–20 s, then male Hops to adjacent branch.

RELATIONS WITHIN FAMILY GROUP Parental care same as in Great Cormorant (G.F. van Tets). Nest-building averages 21.4 days (4–57; 47). Males collect most material; in early stages, token material often presented by males to females but seldom incorporated into nest; when material brought, males approach Kink-throating and females respond with Gaping, Head-lowering or Nest-worrying. Both sexes build; perhaps represents play but probably strengthens social bonds. Incubation and brooding shared equally by sexes. Incubation behaviour, with regular change-overs, begins up to two weeks before first egg laid. During change-over, typically incoming bird alights and Hops to side of nest; sitting mate usually performs Gaping and Nest-worrying; change-over usually occurs soon after but sitting bird may remain on nest for some time, eventually being pushed aside by mate. Relieved bird usually leaves within 10 min; 81% of males (n=104) left within 10 min, 67% females (n=90). When incoming bird sits, usually performs Gaping then Nest-worrying; male calls. Chicks brooded on upper surfaces of webbed feet. Change-over occurs at least three times a day until chicks

able to ward off predators. At least one parent in constant attendance from laying till young four weeks old; if both parents at nest, non-sitting bird perches on edge of nest (Guthrie-Smith 1914). Chicks totally depend on parents throughout nestling period, and wholly or partially so for some time after fledging. Other pairs may take over nests with unfledged chicks and physically displace chicks; usually occurs when chicks average 42 days (35–90; 19), a time when parents often away foraging; returning parents often not aggressive towards intruders and may abandon young. In cold weather, parent incubates chicks closely; older chicks that cannot be covered lie close to each other. In hot weather, chicks of all ages, shaded by parents; when very young, sitting bird crouches above chicks and may extend one or both wings to cover them; protection from rain similar; for older nestlings, parent stands with back to sun, shading chicks who squat or stand facing parent. Both sexes feed young by incomplete regurgitation; parent lands near nest, all hunched up, while partly digesting food, then moves to nest (Goodwin 1956); stands upright at full height (Guthrie-Smith 1914) with bill horizontal or slightly raised and makes repeated swallowing motions. Gular region then kinked, stimulating chick to beg more actively; parent opens bill more and more widely, lowering it until chick inserts its head and part of neck into parent's throat and parent regurgitates (Guthrie-Smith 1914). Begging of young very similar to Kink-throating of adult. Always flap wings vigorously when begging starting; from c. 12 days old until parents give up feeding them. **Begging:** raise head and neck and, with depressed hyoid projected forwards and kinking gular region, waggle head from side to side, point bill at kinked gular pouch of parent and emit monotonously repeated call; bill always closed. Young fed up to 6 times/day, decreasingly with age to 1–2 times/day near fledging. When very young and still blind, fed by sitting parent, which often appears to stimulate feeding response; food pre-digested for some hours before being regurgitated; interval between arrival of parent and feeding of chick decreases as chicks get older and after 3–4 weeks fed within minutes of parent's arrival. Up to 4 weeks old, chick fed on nest; older chicks often move toward incoming parent and may be fed up to 1 m from nest-site; fledgelings usually fed at nest-site, but if soliciting unsuccessful, follow parent to water to be fed; juveniles move towards food-bearing parent when it lands. Competition for food between siblings intense and first hatched chicks almost always fare better than siblings; if last chick hatches more than 2 days after first, usually dies from starvation (Millener 1972). **COMMUNICATIONS.** Males, bringing food for chicks, sometimes emit Kink-throating call; possibly as individual recognition signal between parent and young. Chicks begin begging from 2–3 days. Downy or feathered siblings allopreen; parents preen chicks but never vice versa. Begging calls of chicks possibly individually recognizable by parents who may react to, and feed, soliciting young while ignoring weaker young too weak to make adequate signals. Adult male call possibly individual recognition signal between parent and young. Juvenile males as young as 10 weeks perform displays analogous to male advertising or greeting displays uttering very harsh *ark* calls. **DEPENDENCE OF YOUNG ON ADULTS.** Chicks leave nest at about four weeks old and fledge between 47–60 days; both parents continue to feed young, most of which totally dependent for at least 80 days; once, young still being fed at 133 days old. Guthrie-Smith (1914) reports parents feeding young from previous seasons although this has not been recorded by others.

VOICE Reasonably well known; studied in NZ by Millener (1972); some information from G.F. van Tets. Apparently, usually silent away from breeding colonies; males loud and noisy at colonies during breeding season especially during pair-formation. Two main types of calls by males: *ark* and *kerlik*, with much variation; females virtually silent after fledging except for almost inaudible *hiss*; also ticking call by males which perhaps variation of *kerlik*. Thus, obvious sexual differences in vocabulary. Calls essentially of same type for all males but individual differences recognizable. Begging calls of chick and calls of adult male possibly individually recognizable between parent and young. Form of calls differs with different displays. Wing-waving Display performed silently *pace* Serenty & White (1943). No information on geographical variation. Calls named and described after displays in which given.

ADULT MALE Only two types (*ark* and *kerlik*) of male call with much variation. **ARK-TYPE CALLS.** **Threat Call:** harsh guttural *ahrk*, *arrh-eh* or *eeh-h*; also given during fights. **Gargling Call:** described as initially slow, loud screeching or squeaking *aahr*, *whzee-eeer* or *whzee-eh-eh-eh*, followed by loud gargling, gobbling or barking *quog wog-wog-wog*, *goh-goh-goh-goh*, *gug-gug-gug* or *coeee coeee coeee*; calls last 2–4 s; rendered as *aaark-ark-ark-ark-ark-ark-ark-argk-argk-argk*, last three notes of lower pitch and the first note longer than others. Used during advertising and greeting. **Gaping Call:** a squeaking *eeeh-eh-eh* or screaming *aark*, may be single drawn-out syllable, up to 0.75-s duration or, often, shorter (c. 0.25-s duration) syllables repeated up to six times with 0.1 s intervals. **KERLICK-TYPE CALLS.** Distinctive, best described as repeated ticking or *kerlik*; given during Courtship, early nest-building when manipulating material at nest; sometimes given during copulation. **Kink-throating Call:** repeated high-pitched whistling *prrit-prrit-prrit* . . . , *rick-tick-tick* . . . or *prrr-prrit-t-t-t* . . . ; notes uttered in time with wing-beats. **Pre-landing (Arrival) Call:** a repeated rhythmic *kerlik* repeated at c. 4–6/s; rarely call after landing. **Pre-hop and Pre-take-off Call:** ticking *t-t-t-t* . . . or *tik-tik-tik* . . . repeated more rapidly just before take-off; sometimes utter *orgh* after take-off. In NZ, **Hop Call** reported: consists of short (<0.04 s), rapidly repeated (up to ten times) multi-frequency (<1–4 kHz) ticking or *kerlik* notes about 0.3 s apart but repeated more rapidly (about 0.1 s apart) just before leaping up, followed by a *huuuurp* formed by similar notes (up to 15 repeats) about 0.03 s apart, rendered *t-t-t-t-t-t* . . . *huuuurp*; ticking notes given before actual Hop (Pre-hop), second part as bird leaps up; may be given as male mounts female during copulation and occasionally after dismounting.

ADULT FEMALE **Threat Call:** utter hoarse *hissing* exhalations during Threat display. **Gaping Call:** occasionally utter faint wheezy *haa*, repeated up to four times during display. Female silent at other times.

YOUNG Chicks utter one call (Food-begging Call) till about 3 weeks old; thereafter use a second (Threat Call) call as well. **Food-begging Call:** repeated high-pitched *whzee whzee* or squeaking *ahwee-ahwee-ahwee* . . . or *chirrup* (Goodwin 1956); each note about 0.39 s duration; in males, this call remains unaltered for complete nestling period and even after fledging, though pitch gradually drops with age; females begin to lose voice at 5–6 weeks old and virtually silent after fledging and remain so. **Threat Call.** After about 3 weeks, chicks begin to utter a harsh nasal *ahrk* when threatened; in males, this call remains the same throughout life (see Threat Call above). Juvenile males may perform early greeting

and advertising displays as well as uttering loud *ark* from 10 weeks old.

BREEDING Not very well known. Studied for three years at L. Borrie, Werribee, Vic., by Norman (1974) and in NZ by Millener (1972). Breed colonially, sometimes with other species of cormorant, Australian Pelicans, spoonbills; sometimes singly, scattered through colonies; densities of nests not recorded but evidently some colonies are or were large with closely packed nests (North). Impermanent colonies, often shifted.

SEASON North and Campbell record breeding at Kangaroo I. and Spencer Gulf in Jan., Mar.–May and July; in The Coorong in Oct.; in WA in May, July, Oct.–Nov. but HASB state that spring breeding occurred in WA only at Abrolhos Is and that elsewhere autumn and winter breeding was normal; that in general on inland lakes birds nest from spring to autumn when conditions are favourable, whereas on coast there is double season in autumn and spring, with autumn favoured. At L. Borrie, laying started on or soon after 19 May and stopped entirely only by 2 Nov.; hatching from 16 June to 1 Dec. (Norman 1974). Evidently breeding season varies geographically and perhaps annually, doubtless influenced by conditions of water, food and shelter.

SITE On ground but not on bare rocks or earth; on tops of broken-down bushes; sometimes in mangroves near water; not more than 1 m high (North; Campbell); on navigational platform (McNally 1956). Inland, nests in trees. Notorious for killing nesting trees by excretions and perhaps by plucking twigs and leaves for material, thus causing colonies to shift (Millener 1972). At L. Borrie, in forks and on limbs of dead *Melaleuca pubescens*, which tended to disintegrate so that some nests lost; others lost after high winds; averaged 1.9 m (0.6; 0.5–3.0; 56) above water (Norman 1974). At L. Cooper, Vic., generally as high as possible, 7–17 m above water (Favaloro 1952).

NEST, MATERIALS On ground, nests are round compact heaps with shallow cup-shaped depression on top, about 45 cm in diameter at base and 30 cm at top, 30–45 cm high, with cup about 5 cm deep; made of twigs, salt-bush sticks, seaweed and rubbish (North; Campbell). At L. Borrie, mostly made of *Ariples hastata* (91%) and *Aster subulatus* (6.4%) with some material from other plants, feathers and sticks; averaging 24 (17–31) cm across (n=56, Norman 1974). Male selects and claims site; female builds with material brought by male; take turns at guarding nest. Building may occur whenever both are at nest and continues during incubation and nestling periods.

EGGS Elliptical, with one end slightly more pointed than other; mat, coarse texture; pale blue, greenish white, with white chalky coating.

MEASUREMENTS: **Aust.:** 59 (54–62; 24) × 38 (34–40) (Schönwetter 1967); 60 (55–67; 23) × 38 (34–40) (HASB); 58.9 (2.9; 51.9–60.3; 47) × 38.7 (1.9; 35.9–48.5) (Norman 1974). **NZ:** 60 (57–60; 5) × 37 (36–40) (Schönwetter 1967); 59 (53–68; 315) × 38 (35–41) (Millener 1972).

CLUTCH-SIZE Usually said to be 2–4, occasionally five, with three commonest. At L. Borrie av. 3.32 (0.77; 256): 7xC/1, 24xC/2, 107xC/3, 116xC/4, 2xC/5 (Norman 1974). No certain information on replacement after loss or on second broods but bimodal peaks of laying at L. Borrie, in June and mid-Aug. to early Sept., suggest replacements after loss or failure to hatch (Norman 1974).

LAYING At intervals of 48 h. May be synchronized

within nesting tree in colony (Millener 1972).

INCUBATION By both adults; reliefs take place at least three times a day. **INCUBATION PERIOD:** first egg ($n=25$), 28.5–33 days; second egg ($n=31$), 27–31.5 days; third egg ($n=23$), 25–29.5 days; fourth egg ($n=12$), 25–28 days (Millener 1972). No disposal of egg-shells. No further information.

NESTLING Altricial, nidicolous; hatched naked, skin pink becoming black; becoming covered with down, dark brown above, white below; facial area, yellow; bill, pale cream. At 16 days old, chicks can sit up, squatting on tarsi, and do so regularly from 25 days old; at 28 days old, can move sideways along branches; at 34 days old, walk and perch like adults. Brooded, guarded and fed by both parents by incomplete regurgitation. Guard-stage lasts until young large enough to ward off other adults, predators. Chicks stay in nest for about 4 weeks, constantly guarded by parents, and then may form crèches in colonies on ground. **FLEDGING PERIOD:** 53 days (47–60; 206) (Millener 1972); fed by parents for up to 80 days afterwards. No information on growth of chicks, fledging to maturity.

SUCCESS At L. Borrie in 1971, 1972, of 511 eggs laid 221 (43.3%) hatched and 134 (60.6) young fledged, for total success of 26.2% with no significant difference between years (Norman 1974). Three was most productive clutch-size. **PREDATORS.** Humans perhaps the only serious predator, taking eggs for food (at least in past; North; HASB) and disturbing adults so that corvids and larids can take eggs. Raptors (White-bellied Sea-Eagles *Haliaeetus leucogaster*; HASB) may take chicks.

PLUMAGES Described for *P.v. hypoleucos*, with some information for nominate *varius* from Millener (1972).

ADULT BREEDING HEAD AND NECK. Crown to base of hindneck, glossy black-green (162). At hindcrown and nape, some white filoplumes. Lores, bare; covered by fleshy skin, extending above and round behind eye; in *P.v. varius*, loreal skin ends above eye; loreal skin has small white papillae. Rest of neck, white; demarcation of feathering begins at forehead, extends above eye, and continues down sides of neck. At demarcation on outer nape, in *P.v. varius*, small intrusion of dark feathering forms small notch. Gular pouch, largely bare; skin of gular pouch extends on to the base of lower mandible; on base of upper mandible, at gape, similar bare skin forms triangular patch. Feathers on throat, extend on to basal quarter of gular pouch in inverted V. Feathers on head and neck with silky texture. **UPPERPARTS.** Mantle-feathers, glossy dark olive-brown (30), fringed black (89). Concealed bases, light grey-brown (119C); rachis, basally brown (119B), distally black-brown (119). Fringes become progressively broader towards base of mantle and outer margins. Narrow margin down mid-mantle, whole of back and rump, glossy black-green (162) with blue-black (173) sheen. Upper tail-coverts, short and black-brown (119) with slight gloss of dark olive-brown (30) on webs. Scapulars, similar to outer mantle-feathers; subscapulars lack fringes, black-brown (119) with dull gloss of dark olive-brown (30). **TAIL,** black-brown (119) with slight gloss of dark olive-brown (30) on webs. Rachis, basally rigid and thick, thinner at distal tip; grey (84) basally, merging to grey-black (82) distally. **UPPERWING.** All coverts, glossy dark olive-brown (30), fringed black (89). Fringes progressively broader towards greater upper wing-coverts. Greater primary coverts and alula, black-brown (119) with slight gloss of dark olive-brown (30) on outer webs. Remiges, and short humerals, black-brown (119). Tertials and secondaries

have slight gloss similar to alula and narrowly edged black (89) on outer webs. **UNDERPARTS,** almost entirely white. Lateral breast-feathers, moderately long and white; beneath these on outer flanks, small patch of concealed dark-brown (119A) semiplumes. At outer flanks, concealed beneath wing, feathers dull glossy black-green (162) with blue-black (173) shade. Thighs, glossy black-green (162) with blue-black (173) shade. Tibio-tarsal feathers similar to feathers of outer mantle; beneath these, small patch of concealed dark-brown (119) semiplumes. Axillaries, dull glossy dark olive-brown (30); no black (89) fringes. **UNDERWING.** Greater primary coverts and greater coverts, glossy brown-grey (79). Rest of under wing-coverts, black-brown (119) with dull gloss of dark olive-brown (30); feathers narrowly fringed black (89).

ADULT NON-BREEDING Similar to adult breeding; differs in bare parts.

DOWNY YOUNG Naked at hatching. Protoptile sparse; neck largely bare; on foreneck, very short white down. Down on upperparts, black-brown (119), on underparts, white. Mesoptile, thicker and woolly. **HEAD AND NECK.** Head largely bare; short sparse white down on foreneck, thicker on lower neck; down on hindneck, dark brown (119A). **UPPERPARTS.** Similar to hindneck, but down longer on back. **UPPERWING.** Similar to upperparts. **UNDERPARTS.** Mostly white, except for thighs, which are similar to upperparts. **UNDERWING.** Similar to underparts. In *P.v. varius*, first neosoptiles appear by eighth day. By twelfth day, body (except anterior half of neck, and wings) well covered in down. Between 40 and 50 days, most down lost, persisting on neck and rump only. Some downy young show black down on side of head, below level of eye, thus differing from *P.v. hypoleucos*, which has this area white.

JUVENILE HEAD AND NECK. Crown to hindneck, dark brown (121) with feathers edged light grey-brown (119D); pale edges impart streaked appearance. Feathers adjoining gular pouch, white, and form inverted V on basal quarter of gular pouch. Rest of neck and sides of head, to demarcation just on top of eye, white. **UPPERPARTS.** Mantle, dark brown (121) with light grey-brown (119D) shade; feathers, fringed dark brown (119A); fringe at tips black-brown (119). Fringes on mantle, become progressively broader from feathers of uppermost mantle to lowermost; concealed bases of feathers, pale dark-brown (121). Back and rump, similar to adult, but with concealed pale dark-brown (121) bases exposed. Upper tail-coverts, similar to mantle. Sub-scapulars, dark brown (121) with slight gloss of dark olive-brown (30) on webs; feathers, narrowly fringed black-brown (119). Scapulars similar to mantle, but feathers have pointed tips; fringes, black-brown (119), which, in some lights, is glossy pale black-green (162). **TAIL,** black-brown (119); rachis, black (89); tips of rectrices, notched. **UPPERWING.** Remiges, black-brown (119), with pointed tips to webs; inner webs, basally dark brown (121). Tips of remiges, usually brown (119B) through wear. Humerals, short, narrowly edged black-brown (119) on outer webs; secondaries and tertials, similarly edged. All coverts, except marginal, dark brown (121) with light grey-brown (119D) shade, fringed black-brown (119). Marginal coverts, largely black-brown (119), fringed dark brown (121). Greater primary coverts, edged black-brown (119) on outer webs. Alula feathers, black-brown (119) on outer webs, dark brown (121) on inner webs. **UNDERPARTS,** entirely white, except where stated. Lateral breast-feathers moderately long. Thighs, similar to back. Tibio-tarsal feathers, similar to mantle, but fringes less distinct. Axillaries, dark brown (121). **UNDER-**

WING. Greater under primary coverts and greater under wing-coverts, similar to adult. Rest of under wing-coverts, dark brown (121) with narrow slightly darker (c119) fringes. In *P.v. varius*, some birds (almost always males), have underparts brown, particularly on breast and foreneck; this colour lost through moult, beginning at 4–5 months and lost entirely at 6–7 months. All juveniles have brown cheeks; demarcation between light and dark feathers occurs at level of gape.

IMMATURE Similar to juvenile, only differences described here. Throat to lower neck, irregularly tipped dark brown (119A). Feathers on most of upperparts, except back, rump and upper tail-coverts, fringed dull white to light grey-brown (119D) on existing fringes of dark brown (119A), through wear. Back and rump, narrowly fringed dark brown (119A). Underparts, extending as far as abdomen, similar to lower neck. Rectrices narrowly tipped dull white, through wear. Upperwing, similar to mantle-feathers. In *P.v. varius*, adult plumage attained c. 10–18 months. Full details of plumage acquisition, based on known age birds, in Millener (1972).

ABERRANT PLUMAGES Adult skin at MV has one rectrix entirely white. In *P.v. varius*, albino has been recorded, which had light-brown flanks and thighs, and faint stain of light brown on hindneck, scapulars and rump (Falla 1932).

BARE PARTS Based on photos in Lindsey (1986) and NZRD, except where stated.

ADULT BREEDING *P.v. hypoleucos*. Based on photo in Serventy (1973). Iris, dark green (162A). Eye-ring, dark blue (170). Loral skin, extending round back of eye, orange-yellow (18). Loral skin below eye, grey-black (82). Bill, dark brown (121), with tip pink-buff (121D). Skin at base of lower mandible, gape and gular pouch, pale dull-orange (94). Label data on skin at SAM: iris, light blue-green; eye-ring, sky, blue above, purplish below; loral skin, orange-yellow; gular pouch and gape region, light maroon; mouth, pale pink; bill, dark grey with pale mottling along underside; legs, blackish, some light mottling on sides. Legs and feet, usually black (89).

P.v. varius. Iris, dark green (162). Loral skin patch, orange-buff (153), later fading to buff (123D). Eye-ring, light blue (93), with light violet (170C) below eye. Gular pouch, dirty pink (4); not yellow as stated in Oliver. Culmen, dark brown (119A); side of tomia, light grey-brown (119C) with irregular transverse ridges of dark brown (119A).

ADULT NON-BREEDING *P.v. hypoleucos*. Similar to adult breeding, but bare parts not so intense, particularly on head (full details given in White 1916a). *P.v. varius*, similar.

DOWNY YOUNG *P.v. hypoleucos*. Based on photo in Serventy (1973). In protoptile: crown, bill and side of head, pale dull-pink (5), merging to grey (87) at hindcrown. Supra-orbital patch, light blue-grey (88). Small grey-black (82) spot on mid-hind eye-ring. Body skin, grey (84). Label data on skins at SAM, colours recorded 21 hours after death: bill, very pale lilac-pink; tip, greyish white; lores, pale blue-grey; gular, cream-pink; forehead, dull rose-lilac; crown similar and tinged blue-grey; sides of head, dull pale cream-lilac; rest of neck, dull purplish grey.

P.v. varius. At hatching, body skin, greyish-pink; at one day skin, dull grey. Egg-tooth lost at 10–16 days; bill, creamy. Iris, grey. At 24 days, bill darker, especially dorsally.

JUVENILE *P.v. hypoleucos*. No data; see description

in Field Identification (from live birds; G.F. van Tets; W.J.M. Vestjens).

P.v. varius (Juvenile and immature). Based on Millener (1972). Iris, brown till 7 months; at c. 9 months, as adult. Eye-ring, pale yellow; later, dull blue-grey. Loral skin and gular pouch, creamy, becoming medium yellow at c. 4 months; at 5–7 months, gradual change; complete by 9 months, where loral skin as adult. Further details of bare parts, for all age categories, given in Oliver, Millener (1972).

IMMATURE *P.v. hypoleucos*. Label data from skins at SAM. Iris, very pale brown. Upper mandible, dark grey on culmen, merging to pale cream on sides. Lower mandible, pale cream (buff). Mouth, pale cream. Bare loral skin, orange-yellow, but not so bright as adult. Legs blackish with purplish tinge.

MOULTS Few data for *hypoleucos*. Based on skins.

ADULT Staffelmuser. Remiges and rectrices, moult outwards. Duration of moult series unknown. Protracted breeding season, no definite moult period can be ascribed.

POST-JUVENILE Undescribed.

SUBSEQUENT MOULTS Undescribed.

In *varius*, 'adult moult' similar to *hypoleucos*.

POST-JUVENILE At colonies round Auckland, Millener (1972) states that brown juvenile cheek-feathers replaced gradually from 6.5–9 months.



Plate 59

Darter *Anhinga melanogaster*

1. Adult male breeding

2. Adult male non-breeding

3. Adult female

4. Immature male

5. Juvenile

6. Downy young

7. Adult female in flight

MEASUREMENTS *P.v. hypoleucos*. (1) Adults, skins (MV, ANWC, SAM, AM, QM, WAM, NMNZ) (G.F. van Tets). (2) Adults, skins (MV, ANWC, SAM, AM, QM) (R. O'Brien).

	MALES	FEMALES
WING	(1) 318 (16; 287-356, 27)	300 (20; 277-353; 26)
TAIL	(1) 145 (11; 128-170; 26)	135 (12; 102-162; 25)
BILL	(1) 73 (4; 64-80; 27)	67 (5; 59-79; 25)
TARSUS	(1) 68 (3; 63-74; 27)	64 (3; 60-69; 26)
TOE	(2) 80.4 (2.82; 75.1-85.4; 17)	76.9 (3.72; 71.8-88; 16) *

P.v. varius. (1) Skins; methods unknown (Falla 1932; based on skins at Auckland Mus.). (2) Skins (AWMM, OT, CM, NMNZ, AM).

	MALES	FEMALES
WING	(1) 285.0 (10.0; 275-295; 2) (2) 309 (8; 298-323; 13)	277.3 (2.49; 274-280; 3) 287 (12; 271-320; 12)
TAIL	(1) 129.0 (4.0; 125-133; 2) (2) 141 (10; 121-156; 11)	133.3 (9.67; 126-147; 3) 131 (9; 117-151; 12)
BILL	(1) 64.0 (5.0; 59, 69; 2) (2) 66 (3; 63-73; 13)	58.3 (1.24; 57-60; 3) 60 (5; 55-75; 12)
TARSUS	(1) 55.0 (5.0; 50-60; 2) (2) 68 (3; 64-71; 13)	56.6 (0.94; 56-58; 3) —

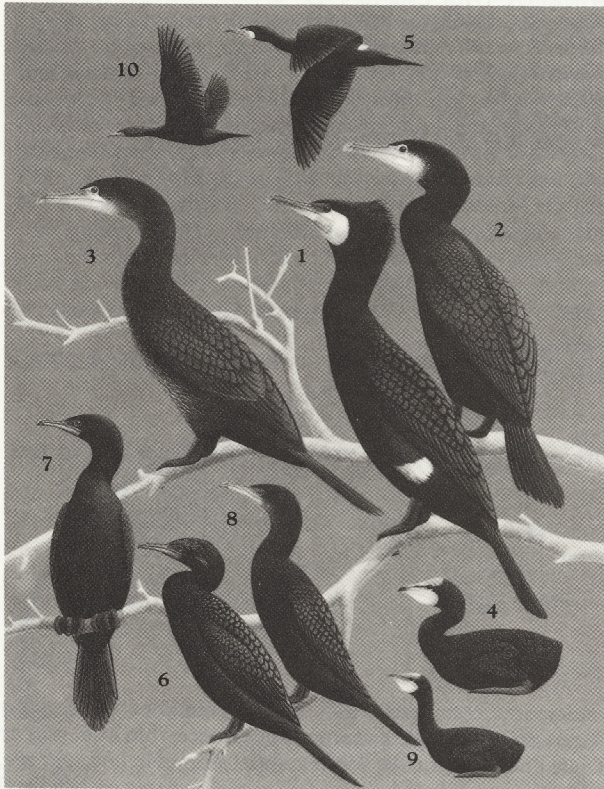


Plate 60 Great Cormorant *Phalacrocorax carbo*

1. Adult breeding
2. Adult non-breeding
3. Juvenile
4. Downy young
5. Adult non-breeding

- Little Black Cormorant *Phalacrocorax sulcirostris*
6. Adult breeding
7. Adult non-breeding
8. Juvenile
9. Downy young
10. Adult non-breeding

Additional measurements of *hypoleucos* in White (1916a,c; 1918) and HASB; for *varius*, in Oliver. Full details of growth rates of chicks in Millener (1972).

WEIGHTS *P.v. hypoleucos*: adult, skins (MV, ANWC, SAM, AM, QM), males 1.8 kg (0.3; 1.5-2.2; 5), females 1.4 kg; P.R. Millener, G.F. van Tets, W.J.M. Vestjens and specimen labels, males 2.1 (0.4; 1.7-2.9; 10), females 1.6 (0.2; 1.0-1.9; 3).

P.v. varius: P.R. Millener, G.F. van Tets, W.J.M. Vestjens and specimen labels, males 2.1 (n=2), females 1.3 (0.5; 0.8-1.6; 3); additional weights in White (1918), Serventy (1939), HASB and Morris (1978). Males heavier than females. Adults lose weight in summer and gain weight in winter, for details see Serventy (1939).

STRUCTURE Wing, long and broad. Eleven primaries: p9 longest, p10 6-10 mm shorter, p8 0-3, p7 2-7, p6 23-30, p5 39-47, p4 53-61, p3 61-74, p2 77-86, p1 85-95, p11 minute. P10-9 emarginated on inner web; p9-8 slight on outer web. Tips of remiges pointed in juveniles, rounded in adults. Tail, wedge-shaped; 12 rectrices, t1 longest, t6 30-48 mm shorter. Bill, long; nail hooked at tip. Upper mandible, extends to gape, where sharply ridged. At base of upper mandible, numerous fine striae. Small groove on side of culmen. Near base of upper mandible, small secondary external nostril plate, adjoining cutting edge. Bill, flaky in juveniles, smoother in adults. Tarsus, short. Feet, totipalmate. Claw of middle toe serrated; in *varius* serration absent till 45 days; fully developed from 57 days (Millener 1972). Outer toe longest c. 132% of middle, inner c. 67%, hind c. 43%.

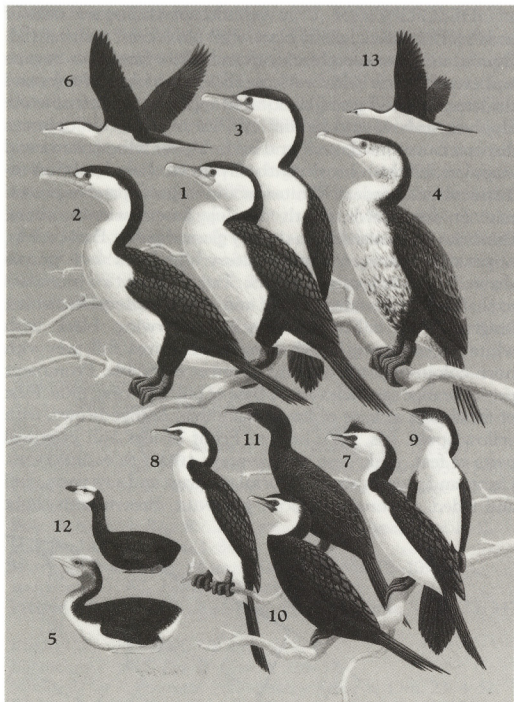
GEOGRAPHICAL VARIATION Two subspecies occur in A'asia: nominate *varius* in NZ and *hypoleucos* in Aust. Nominate *varius* differs in colour of bare parts of head, having smaller loreal skin-patch, and black feathering at upper nape protrudes as small notch on white neck. Feathers on middle of throat extend farther forward than in *hypoleucos*; black and white border on side of head starts from eye but just above eye in *hypoleucos*. Oliver mentions discernible differences: *varius* has bronze-grey scapulars, greenish-black lower back and longer wings. No difference in coloration of scapulars or back between subspecies was recorded by R. O'Brien but G.F. van Tets confirms that, as also noted by Ogilvie-Grant (1898), sheen on back, green in *varius* and blue in *hypoleucos*. Measurements presented by Falla (1932) did not indicate greater wing length (see Measurements), but allowance should be made for small size of sample. Measurements do suggest that average bill length of *varius* shorter than *hypoleucos* for both sexes. Based on skeletal characters, Siegel-Causey (1988) placed this species in genus *Hypoleucos*. Based on external morphology and on behaviour, van Tets (1976) placed it in sub-genus *Hypoleucos* of which it is type-species.

RMO

REFERENCES

- Abbott, I. 1979. *Corella* 3; 93-102.
 Barker, R.D., & W.J.M. Vestjens. 1989. *Food of Australian Birds*. 1.
 Baxter, A.F. 1985. *Arthur Rylah Inst. Env. Res. Tech. Rep.* 13: 1-26.
 Bonnin, M. 1982. *S. Aust. Orn.* 29: 23-4.
 Bright, J., & A.R. Taysom. 1932. *Emu* 32: 42-8.
 Buller, W.L. 1888. *A History of the Birds of New Zealand*.

- Butler, W.H. 1948. *West. Aust. Nat.* 1: 85.
- Carruthers, R.K. 1968. *Emu* 68: 280-2.
- Close, D.H., et al. 1982. *Corella* 6: 25-36.
- Cooper, R.P. 1980. *Birds of a Salt-field*.
- Corrick, A.H. 1981. *Proc. R. Soc. Vict.* 92: 187-200.
- Corrick, A.H. 1982. *Proc. R. Soc. Vict.* 94: 69-87.
- Corrick, A.H., & F.I. Norman. 1980. *Proc. R. Soc. Vict.* 91: 1-15.
- Cunningham, D.M., & P.J. Moors. 1985. *Notornis* 32: 221-43.
- Dunlop, J.N., & G.M. Storr. 1981. *Corella* 5: 71-4.
- Falla, R. 1932. *Rec. Auck. Mus.* 1: 139-54.
- Favaloro, N.J. 1952. *Emu* 52: 161-2.
- Fjeldså, J. 1985. *Emu* 85: 141-9.
- Ford, J. 1963. *West. Aust. Nat.* 8: 177-81.
- Fowler, S. 1948. *West. Aust. Nat.* 1: 69-73.
- Goodrick, G.N. 1970. *Tech. Memo Div. Wildl. Res. CSIRO Aust.* 5.
- Goodwin, J. 1956. *Notornis* 7: 21-2.
- Gosper, D.G. 1981. *Corella* 5: 1-18.
- Gosper, D.G. 1983. *Corella* 7: 7-13.
- Green, R.H. 1977. *Birds of Tasmania*.
- Guthrie-Smith, H. 1914. *Mutton Birds and Other Birds*.
- Hale, N.M. 1938. *S. Aust. Orn.* 14: 177.
- Hobbs, J.N. 1961. *Emu* 61: 21-55.
- Jaensch, R.P., et al. 1988. *RAOU Rep.* 30.
- Johnstone, R.E. 1978. *Corella* 2: 46-47.
- Kolichis, N. 1977. *West. Aust. Nat.* 13: 191-4.
- Lashmar, A.F.C. 1987. *Corella* 11: 89-92.
- Lindsey, T.R. 1986. *The Seabirds of Australia*.
- McKeown, K.C. 1944. *Emu* 43: 259-69.
- McNally, J. 1956. *Emu* 56: 93-4.
- McNally, J. 1957. *Vic. Fish Game Dept. Fauna Contrib.* 6.
- Menkhorst, P.W., et al. 1988. *Corella* 12: 72-7.
- Millener, P.R. 1972. Unpubl. M.Sc. thesis, Univ. Auckland.
- Miller, B. 1979. *Aust. Wildl. Res.* 6: 79-95.
- Moisley, W.L. 1960. *Notornis* 9: 58-60.
- Morgan, A.M. 1917. *S. Aust. Orn.* 3: 75-8.
- Morris, F.T. 1978. *Birds of the Australian Swamps*. 1.
- Norman, F.I. 1974. *Emu* 74: 223-7.
- Ogilvie-Grant, W.R. 1898. *Cat. Birds. Br. Mus. Nat. Hist.* 26: 394-397.
- Owen, K.L., & M.G. Sell. 1985. *Notornis* 32: 271-309.
- Paton, D.C. 1973. *S. Aust. Orn.* 26: 77-84.
- Pescott, T. 1983. *Birds of Geelong*.
- Riggert, T.L. 1966. *Study Wetlds Swan Coastal Plain. Dept. Fish. Fauna, Perth*.
- Schönwetter, M. 1967. *Handbuch der Oologie*.
- Serventy, D.L. 1938. *Emu* 38: 293-316.
- Serventy, D.L. 1939. *Emu* 38: 357-71.
- Serventy, V. (Ed.) 1973. *Australia's Wildl. Heritage* 1: 161-80.
- Serventy, V.N., & S.R. White. 1943. *Emu* 43: 81-95.
- Sibson, R.B. 1981. *Notornis* 28: 260-2.
- Sibson, R.B., & J.C. Davenport. 1956. *Notornis* 7: 20.
- Siegel-Causey, D. 1989. *Condor* 90: 885-905.
- Skegg, P.D.G. 1963. *Notornis* 10: 153-68.
- Skegg, P.D.G. 1964. *Notornis* 11: 159-76.
- Stonehouse, B. 1967. *Ibis* 109: 600-605.
- Storr, G.M. 1964. *Emu* 63: 297-303.
- Storr, G.M. 1965. *Emu* 64: 105-11.
- Stranger, R.H. 1970. *West. Aust. Nat.* 11: 101-10.
- Taylor, M.J. 1987. *Notornis* 34: 41-50.
- Thompson, H.A.F. 1977. *Sunbird* 8: 83-91.
- Trayler, K.M., et al. 1989. *J. Zool., Lond.* 218: 87-98.
- van Tets, G.F. 1976. *Proc. Int. orn. Congr. XVI*: 121-4.
- van Tets, G.F., et al. 1976. *Aust. Bird Bander* 14: 43-6.
- Vestjens, W.J.M. 1977. *Tech. Memo Div. Wildl. Res. CSIRO Aust.* 12.
- White, S.A. 1916a. *Emu* 16: 1-15.
- White, S.A. 1916b. *Emu* 16: 69-77.
- White, S.A. 1916c. *Emu* 16: 77-80.
- White, S.A. 1918. *Emu* 17: 214-15.
- Whitlock, F.L. 1921. *Emu* 20: 168-186.
- Woodall, P.F. 1985. *Aust. Wildl. Res.* 12: 495-506.
- Wooller, R.D., & J.N. Dunlop. 1981. *Corella* 5: 97.



Volume 1 (Part B), Plate 61

Pied Cormorant *Phalacrocorax varius*

1. Adult breeding, subspecies *hypoleucos*
2. Adult non-breeding, subspecies *varius*
3. Adult non-breeding, subspecies *hypoleucos*
4. Juvenile, subspecies *hypoleucos*
5. Downy young, subspecies *hypoleucos*
6. Adult non-breeding, subspecies *hypoleucos*

Little Pied Cormorant *Phalacrocorax melanoleucos*

7. Adult breeding, subspecies *melanoleucos*
8. Adult non-breeding, subspecies *melanoleucos*
9. Juvenile, subspecies *melanoleucos*
10. Adult non-breeding, subspecies *brevirostris*
11. Juvenile, subspecies *brevirostris*
12. Downy young, subspecies *melanoleucos*
13. Adult non-breeding subspecies *melanoleucos*

© Jeff Davies