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.

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Family ANHINGIDAE darters

Large, aquatic birds of still inland waters. On all continents except Europe and Antarctica, but does occur on Madagascar. Not in areas where lakes freeze over in winter. One genus with 2–4 species, depending on whether *melanogaster* is split into three full species or regarded as having three subspecies; one breeding in our region. The American Anhinga *A. anhinga* is clearly a separate species. Following the Aust. CL, we have listed the Old World anhingas (*rufa, melanogaster* and *novaehollandiae*) as conspecific under the name *melanogaster*. More recent opinion (G.F. van Tets) considers it better to regard the three as full species, forming a superspecies: *rufa* in Africa, *melanogaster* in s. Asia, E to Wallace's Line, and *novaehollandiae* in New Guinea and Aust.

Needle-tipped, slender, straight stiletto-like bill, with terminal half serrated, no terminal hook. Long, thin head. Long, slender, G-shaped, heron-like neck with special hinge between eighth and ninth vertebrae to help stab fish (Garrod 1876). Large slender elongated body. Long broad wings adapted for soaring, up one thermal and then gliding down to another as in pelicans. Naked gular pouch. Erectile, striped, lanceolate scapulars prominent on breeding birds. Long, stiff, wedge-shaped tail with 12 rectrices. Inner remiges and central rectrices corrugated with transverse waves. Short stout legs with large feet. Comb on claw of mid-toe. In flight looks like a flying cross. Forage usually alone in calm water; sink slowly and then stalk large fish underwater, as herons do above water. Wings and tail are spread underwater and may lure fish into the shade underneath them. Fish are stabbed just behind the gills by tip of bill, slightly open so that two punctures are produced; bird then surfaces, flings fish into the air, catches it head first and swallows it. Small prey, including insects and spiders are taken above water by using tip of bill as forceps.

Rest and nest normally in trees and bushes over water and rarely on ground or in reeds. During hot dry weather parents give water to their chicks by pouring it from their bill down the gullet of the chicks. Wing-waving, a male advertising display, with wings going up and down alternately is a derivative of Sky-pointing in gannets and boobies. Snap-bowing, a recognition display, with wings raised and lowered together appears related to Crouch-bowing in pelicans (Vestjens 1975, 1977), Head-jerking in Abbott's Booby *Sula abbotti* (Nelson 1971) and Snap-bowing in herons (van Tets 1965: 47–48).

Tend to be gregarious. Monogamous pair-bonds, possibly maintained for more than one season. Nest solitarily or in small groups, sometimes with cormorants. Maintain nest-territories. Male selects nest-site and collects most material; female builds; at least one bird always at nest from time of building. Nests in trees, bushes or reeds. Eggs elongate, pale green or bluish white with chalky coating. Clutch-size, 3–5. Incubation period, probably 25–28 days; by both sexes. Young, semi-altricial, nidicolous; fed by complete and incomplete regurgitation. May scramble out of nest when quite small but nesting period and attainment of independence from parents, not determined.

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Anhinga melanogaster Darter

COLOUR PLATE FACING PAGE 828

Anhinga melanogaster Pennant, 1769, *Indian Zool.*: 13, Pl. 12; Sri Lanka and Java.

Anhinga (or sometimes *Anhima*) is the name given to the American species of the genus by Brazilian natives, according to Margrave (*Hist. Rev. Nat. Brasil*: 218; see Newton & Gadow 1896); 'black' (Greek μέλας,-ανος) and 'bellied' (γαστήρ) for the plumage character of this species.

OTHER ENGLISH NAMES Australian or Oriental Darter, Diver, Shag or Needle-beaked Shag, Snakebird.

So long as only one species is recognized in the Old World, there is no need to qualify the name **Darter**. The American species is named **Anhinga**.

POLYTYPIC Nominate *melanogaster* India to SE Asia, Sumatra, Java, Borneo, Philippines and Celebes; *rufa* (Daudin 1802) Africa, Madagascar, Middle East; *novaehollandiae* (Gould 1847), New Guinea and Aust.

FIELD IDENTIFICATION Length 86–94 cm; wingspan 120 cm; weight 0.9–2.6 kg. Large slender cormorant-like bird of inland waters. Fine stiletto-like bill, slender head, very long sinuous snake-like neck, elongated body and very long tail give diagnostic silhouette. Distinct kink half way down neck, associated with trigger mechanism that facilitates sudden forward thrust of bill to impale fish. All four toes webbed. Adult males distinguishable from females and immatures. No seasonal plumage changes.

DESCRIPTION ADULT MALE. Head and neck, brownish black; upperwings and back, glossy black with prominent white, silver-grey or pale-brown central streaks and spots on upper wing-coverts and scapulars. Tail, long and blackish, browner with wear. White or pale-brown stripe runs from gape along sides of head and upper neck. Underparts, blackish with irregular patches of white and dark brown on foreneck, breast and abdomen. Bill, long, slender and sharply pointed with distal half of cutting edges serrated; yellow with brownish-grey culmen. Yellow skin round eye and on throat. Iris, yellow. Legs and feet, pink or yellow. ADULT FEMALE. Head, neck and body, grey-brown above with same upperwing markings as male. White stripe from gape along sides of upper neck has black border. Underparts, white to pale buff. Bare parts as for male. JUVENILE. Brownish above. White head- and neck-stripe incomplete and without black borders. Silver-grey or pale brown streaks and spots on upperwing; blackish on flight-feathers and tail. Underparts, pale brown. Iris, pale yellow or pale brown. IMMATURE. Similar to adult female but with less distinct markings on sides of head and neck, and on upperwing; also with shorter upper wing-coverts and scapulars. Legs and feet, dull brown or yellowish.

SIMILAR SPECIES None in Aust. or NZ. Cormorants bulkier with larger heads, terminally hooked bills and shorter tails but at first glance bird in flight or perched with spread wings may give appearance of large cormorant. Herons immediately distinguished by much longer legs.

Forage in smooth and sheltered waters; rest and nest in trees and bushes over water. Short stout legs set well back, give upright stance when perched; walk with clumsy waddle; bill used to assist in clambering over obstacles. Swim on surface moving feet alternately; body may be submerged with only head and neck showing, appearing like swimming snake. During take off and when diving, feet used together. Feed by stalking fish underwater; wings may be spread for hydrostatic balance, or to provide shade to attract fish, or both. Fish stabbed in lower flank by tips of partly opened bill; tips of bill also used as forceps to pick insects off water and plants. Long neck, wings and tail give Darters appearance of flying crosses as they spiral up on thermals to great heights and then glide down towards next updraft. Mainly solitary and intolerant of conspecifics, but readily intermingle with cormorants, herons and ibises. Call with ratchet-like clicking; also hiss and caw when near nest. Often clamber onto snags and low trees to dry plumage, spreading wings and tail. Gular flutter on warm and hot days. Scratch parts of head and neck from under wing; balancing on one foot and sometimes resting tip of a wing on substrate.

HABITAT Wide distribution on terrestrial wetlands and in sheltered coastal waters, but most often recorded in Tropics and Subtropics (Aust. Atlas). Require smooth, open water for feeding, and fringing or projecting tree trunks, branches, stumps or posts for perching and to dry wings (Vestjens 1975; Fjeldså 1985); inhabit lakes, reservoirs, rivers, pools, billabongs, swamps, estuaries. Most common on permanent waterbodies with extensive sheets of open water at least 0.5 m deep, such as lakes, estuaries and large rivers (Vestjens 1975; Corrick & Norman 1980; Gosper 1981; Jaensch *et al.* 1988; Morton *et al.* 1989). May occasionally be seen at sea near shore in calm conditions, spearing fish (Whiter 1989). Also feed in deeper parts of other wetlands, shallow vegetated edges of large lakes, semi-permanent and seasonal freshwater swamps, mangrove swamps, tea-tree (*Melaleuca*) swamps and dams (Vestjens 1977; Gosper 1981). At vegetated wetlands, forage where emergent and aquatic vegetation sparse (Corrick & Norman 1980; Morton *et al.* 1989), probably because swimming and diving unobstructed; nature of shoreline vegetation not important provided perching sites available (Fjeldså 1985). Unaffected by fluctuations in transparency and salinity of water (Fjeldså 1985). Regularly use artificial impoundments where habitat suitable; in aerial survey in e. Aust., 46% estimated population in survey area on artificial waters (Braithwaite *et al.* 1985a); but absent from artificial wetlands that are narrow, deep, steep-banked, turbid, seasonally drained, and fringed with weeds (Namoi Valley, NSW; Broome & Jarman 1983). In aerial survey in e. Aust., 86% estimated population on wetlands of >100 ha (Braithwaite *et al.* 1985a).

Nest in trees or tall bushes growing in or over water (Vestjens 1975; Jaensch *et al.* 1988). If water level falls during breeding, birds may move to deeper water (Vestjens 1975). In Booligal, NSW, breed in swamps with climax vegetation of ribbonweed and abundance of fish; if swamps dry and refill, breeding inhibited until climax reached (Crome 1988).

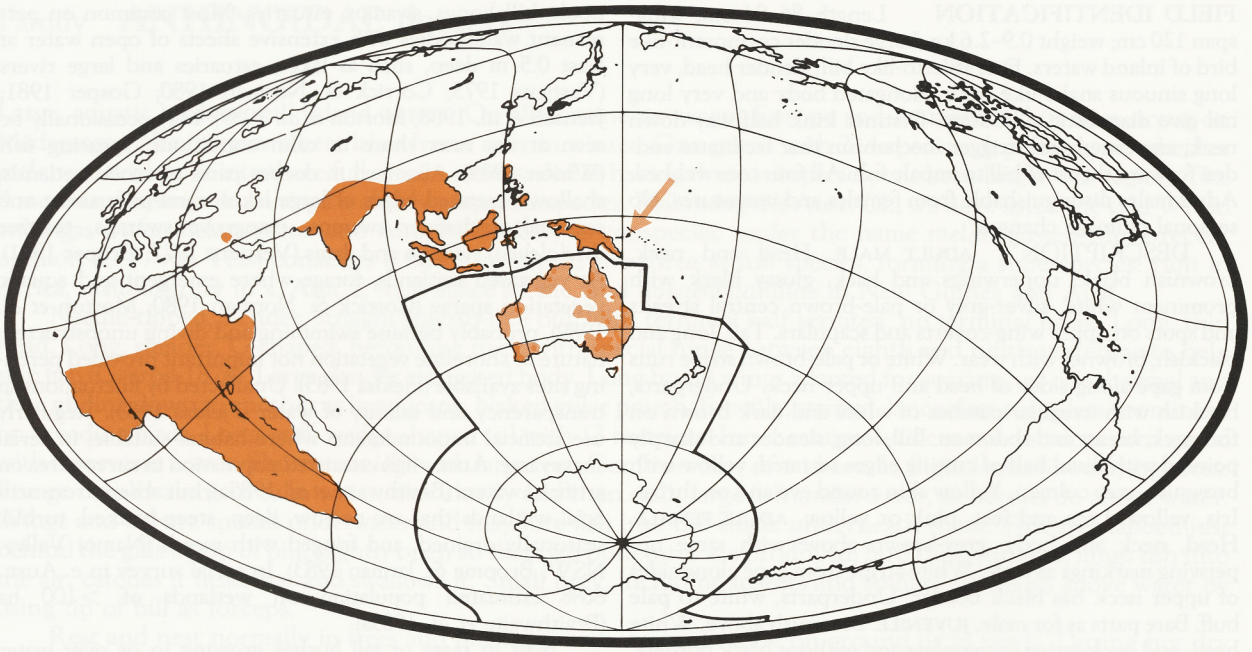
Dive well. Capture benthic fish, but can also take prey from middle and surface layers of water (Dostine & Morton 1989). Soar in thermals, particularly at dusk (Masters & Milhinch 1974).

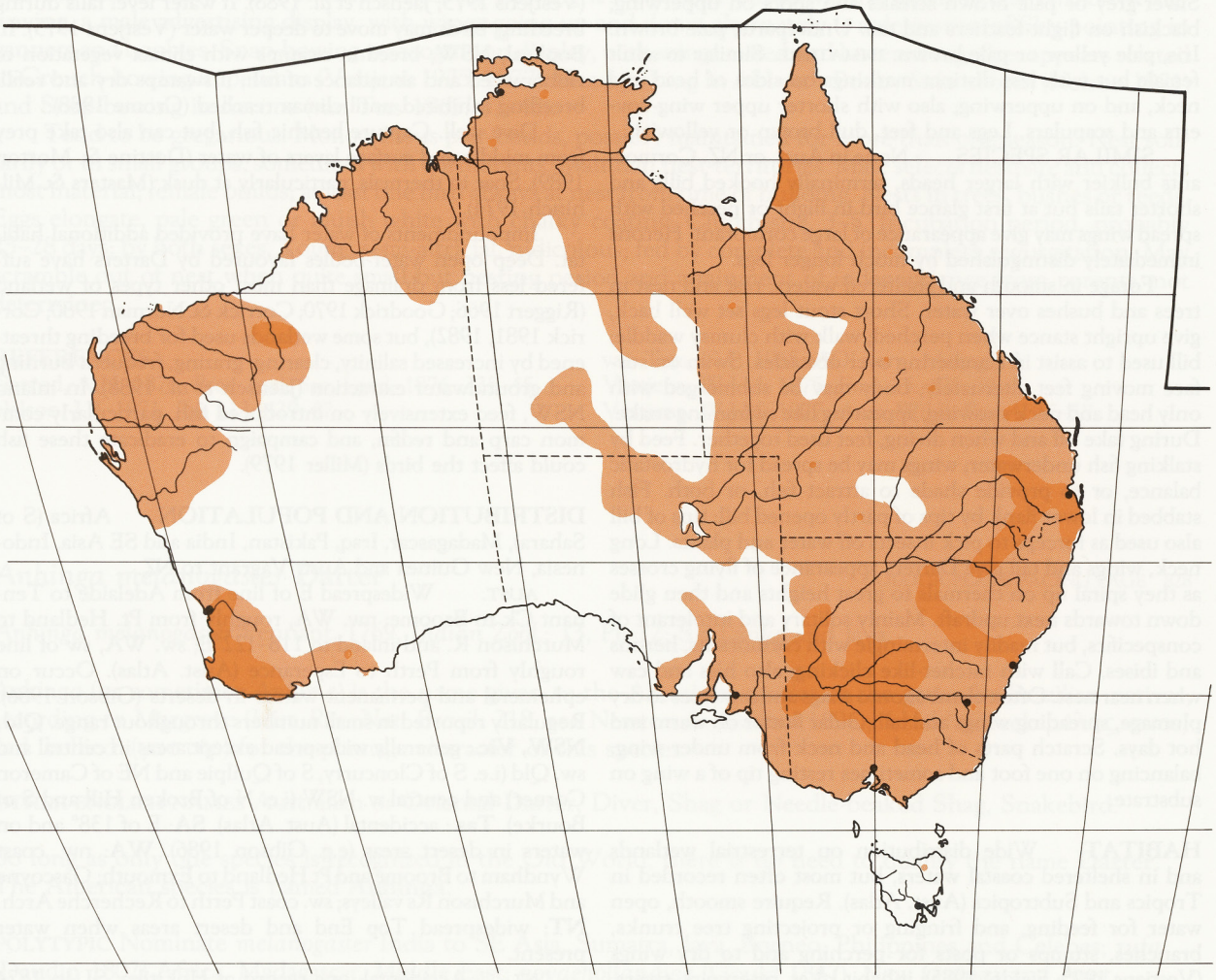
Impoundments of water have provided additional habitat. Deep open water-bodies favoured by Darters have suffered less from drainage than most other types of wetland (Riggert 1966; Goodrick 1970; Corrick & Norman 1980; Corrick 1981, 1982), but some wetlands used for breeding threatened by increased salinity, clearing, grazing, frequent burning and groundwater extraction (Jaensch *et al.* 1988). In inland NSW, feed extensively on introduced fish, particularly common carp and redfin, and campaign to eradicate these fish could affect the birds (Miller 1979).

DISTRIBUTION AND POPULATION Africa (S of Sahara), Madagascar, Iraq, Pakistan, India and SE Asia, Indonesia, New Guinea and Aust. Vagrant to NZ.

AUST. Widespread E of line from Adelaide to Tennant Ck to Broome; nw. WA, roughly from Pt. Hedland to Murchison R. and inland to 118–122°E; sw. WA, sw of line roughly from Perth to Esperance (Aust. Atlas). Occur on ephemeral and permanent waters in deserts (Gibson 1986). Regularly reported in small numbers throughout range. **Qld, NSW, Vic.**: generally widespread except areas in central and sw. Qld (i.e. S of Cloncurry, S of Quilpie and NE of Cameron Corner) and central w. NSW (i.e. N of Broken Hill and S of Bourke). **Tas.**: accidental (Aust. Atlas). **SA**: E of 138° and on waters in desert areas (e.g. Gibson 1986). **WA**: nw. coast Wyndham to Broome and Pt Hedland to Exmouth; Gascoyne and Murchison Rs valleys; sw. coast Perth to Recherche Arch. **NT**: widespread Top End and desert areas when water present.

NZ Accidental: one record at Hokitika, SI, in 1874





(Oliver; van Tets & Scarlett 1972).

BREEDING Probably throughout main range. Records in Aust. Atlas and Aust. NRS suggest breeding occurs widely in e. areas from Townsville district to Vic., W of Great Dividing Ra., and inland to Barcaldine and Cunnamulla, Qld, and Darling R., NSW; elsewhere only a few recently recorded nesting localities (Aust. Atlas). Qld: Coleman R. area, w. coast C. York Pen. N. SA: Pedirka district. WA: Perth, S to Albany and near Esperance, de Gray R. area, Wyndham. NT: Darwin area and Fitzmaurice R.

POPULATION No estimates of total population. Annual indices of abundance from aerial survey of e. Aust. wetlands 1983–88 were: 658; 1251; 529; 445; 412; 173 (Braithwaite *et al.* 1985a,b, 1986, 1987; Kingsford *et al.* 1988, 1989).

MOVEMENTS Poorly known. Adults and juveniles apparently dispersive when not breeding, sometimes over long distances (over 2000 km; see Banding), but almost entire population contracts to breeding areas during summer though extent of philopatry unknown. Fewest at L. Cowal, NSW, in June; most abundant when breeding Dec.–Feb. (Vestjens 1975) corresponding to scarcity sw. NSW, Nov.–Jan. (Hobbs 1961) but no evidence of seasonal movements in or out of Vic. (Vic. Atlas). Regularly visits Avon R., sw. WA, Nov.–May but breeding status there unknown (Masters & Milhinch 1974); on Magnetic I., n. Qld, non-breeding birds recorded all months except Jan.–Feb. (Wieneke 1988). In n. NT congregates in Alligator Rs region in winter dry season, leaving for breeding sites in wet (Morton *et al.* 1989). Numbers recorded during Oct. counts near Brisbane, Qld, positively correlated with local rainfall (Woodall 1985). Irruptive movement to coast may occur at times of inland drought (Nicholls *et al.* 1919).

BANDING All returns ABBBS:

32S142E 02 P U 9	374 119
33S139E 11 P U 4	174 093
33S147E 03 P U 1	130 036
33S151E 02 P U 53	2423 333
34S140E 01 P U ?	154 214
34S140E 01 P U 5	274 042
34S141E 11 P U 11	155 115
34S142E 05 P U 23	282 253
34S143E 11 P U 5	992 031
34S146E 01 P U 9	331 034
34S146E 01 P U ?	150 216
34S146E 12 P U 69	507 045
35S144E 01 P U 6	147 352
35S144E 12 P U 4	396 335

FOOD Mostly fish, some insects and other aquatic animals such as tortoises; occasionally take vegetable matter. BEHAVIOUR. Food captured by diving under water in depths ≥60 cm. Body usually submerged while swimming with head and neck above water. Paddle with feet though wings partly expanded and used for steering (North). Fish pierced through ventral region by tip of slightly open bill (Serventy 1939), tips being held 5–25 mm apart (Vestjens 1975), and brought to surface where fish flicked off onto water surface, retrieved and swallowed head first (Vestjens 1975). Occasionally, fish tossed into air and caught before hitting water (Barnard 1925). Smaller items swallowed under water and large fish carried to tree or log where they may take up to 20 min to be swallowed. Dives last 30–60 s with a few seconds between each dive. Usually feed alone on smooth water but mixed flocks ≤12 birds form Mar.–Apr. (Vestjens 1975).

ADULT On **Magela floodplain, NT** (14 stomachs; Dostine & Morton 1989) Plotosidae predominated: 89.0% dry wt., 38.4% no.fish, 86%+ freq., 10.5 cm length (2.4, 6.8–16.1, 28) incl. *Neosilurus rendahli* 29.5, 16.4, 50, 10.8 (2.8, 6.8–16.1, 12), *N. ater* 17.8, 5.5, 29, 13.0 (1.2, 11.7–14.1, 4), unident. 12.6, 42.9, 50; other fish were *Nematolosa erebi* 4.4, 1.4, 7, 10.2, *Melanotaenia splendida* 0.2, 1.4, 7, 3.9, *Ambassis* 3.7, 28.8, 14, 3.3 (0.5, 2.7–4.8, 2), *Leiopotherapon unicolor* 6.6, 1.4, 7, 9.6, *Glossamia aprion* 9.8, 1.4, 7, 12.3, *Morgunda* 5.6, 21.9, 14, 4.5 (1.1, 2.8–6.9, 16), *Oxyeleotris nullipora* 0.3, 5.5, 14, 3.1 (0.3, 2.7–3.5, 4) with plant material 9.1% wt., 86% freq. (vegetative parts of *Hydrilla verticillata, Najas tenuifolia*, aquatic grasses; small numbers seeds *Nymphaea macrosperma, N. iolacea, Coldenia procumbens, Heliotropium indicum, Caldesia oligococca, Oryza*) and Porifera Spongilidae 0.1, 14.

In **sw. WA** (9; Serventy 1939) diet all fish *Cnidoglanis macrocephalus* 1% no., 11% freq., max. no. per stomach 1, *Sillaginodes punctata* 1, 11, 1, *Gerres ovatus* 24, 22, 5, *Aldrichetta forsteri* 52, 67, 5, *Mugil* 4, 11, 1, *Haletta semifasciata* 12, 11, 3.

In **inland Vic.** (43 stomachs; McNally 1957) various fish including *Nematolosa erebi* 8.5% no., 20.9% freq., *Retropinna semoni* 53.7, 18.6, *Gallaxius, Carassius auratus* 6.0, 20.9, *Nannoperca australis, Perca fluviatilis* 7.5, 34.9, *Philypnodon.*

In **n. Qld** (6; Lavery & Haysom 1963) all contained *Leiopotherapon unicolor*, two had *Glossamia aprion.*

In **ne. NSW** (1; McKeown 1944) one *Acanthopagrus australis.* Has also been recorded taking shrimps and water weed (Burrell 1925).

NESTLING At L. Cowal (six adults, 13 nestlings; Vestjens 1975) largely fish (13 cm, 9–19.8) *P. fluviatilis* 63.2 freq., *Carassius auratus* 52.6, *P. grandiceps* 5.3, also small tortoise *Chelodina longicollis* 5.3, insects bugs Belostomatidae 5.3, Notonectidae 5.3, Corixidae 21.1, beetles Dytiscidae 10.5, Hydrophilidae 5.3 and some fragments of plants 15.8.

SOCIAL ORGANIZATION Solitary, but congregate where food is copious. Do not form feeding flocks.

BONDS At least seasonally monogamous. No information from banded birds on start and duration of pair-bond. No co-operative breeding. Both parents incubate and tend young until contact lost a few weeks after fledging.

BREEDING DISPERSION Nesting, solitary or in loose colonies with other tree-nesting waterbirds. Colonies of 4–100 nests recorded (Aust. Atlas; Aust. NRS). TERRITORIAL. Area within several metres of nest-site defended against conspecifics. No other territories.

ROOSTING Solitary or communal roosts in trees and bushes and on rocks and stumps near water near feeding and nesting areas. No systematic information available on times of arrival and departure from roosts.

SOCIAL BEHAVIOUR Based mainly on Vestjens (1975). Displays easy to observe, except when in willows, and resemble those of American Anhinga *Anhinga anhinga* (*c.f.* van Tets 1965). Distances between individuals maintained at several metres; flocks not integrated.

AGONISTIC BEHAVIOUR Selection of nest-site by male, either previously used nest or a new site, and territory established round it, which may include entire tree, branch on which nest located or area round nest-site. THREATS vary in intensity. **Mild Threat** by incubating or brooding birds con-

sists of pointing closed bill at intruder; as intruder gets closer, bill opened and bird may hiss. **Chase-threats** by non-incubating birds consist of hopping from branch to branch towards intruder with bill open, wings raised and calling loudly. If there is no retreat, **Snap-threat**: bill snapped shut close to head and neck of intruder; no physical contact between birds and lasts only 2–5 s. Territorial holders sometimes chase intruders. FIGHTING occurs if intruder does not leave after Snap-threat, male may stab intruder on head and neck and opponents may grab each others' bills; of nine fights, six times intruder left tree and three times birds held each other and fell from tree to water where they separated and intruder left. No submissive displays.

SEXUAL BEHAVIOUR Males decorate nest-site with 4–11 fresh, green leafy twigs; then display to attract mate and to advertise ownership of site. Female selects mate and builds nest with material delivered by male. Males ADVERTISE using Wing-waving and Twig-grasping. **Wing-Waving** (Fig. 1): tips of partly folded wings alternately raised and lowered by humeral rotation at varying speeds, silver-grey patches on wing producing flashing effect; if sitting on nest-site or old nest, tail and stretched head and neck raised *c.* 60° from horizontal; if given while perched, neck S-shaped, tail tilted up at *c.* 45° and bill pointed upwards; continues for *c.* 20 s. If female attracted, duration shorter but speed of wing-movement increases. Performed when females fly over nest-site; occasionally when immatures fly over; in area of 200 m^2 up to seven males observed displaying at same time. **Twig-grasping** (Fig. 2): birds grab nearby stick with bill and shake it vigorously; tail raised *c.* 60° from horizontal. Wing-waving and Twig-grasping performed almost exclusively by males; sometimes performed during copulation; ceases after laying. PAIR-FORMATION. When selecting mate, female circles over displaying males before alighting on branch where she may watch male or group of males displaying; sometimes leaves and returns before approaching a male. Approaches cautiously, hopping from branch to branch then stops and watches male from few metres away and performs **Darting** (Fig. 3): moves head back and forth, horizontally, with bill open or closed. Then moves closer to male, calling softly. Male calls and gives **Pointing** (Fig. 4): head and neck stretched out and either held 20° above horizontal and waved in slow sideways motions, or held vertically up with or without head-waving; feathers on back of head and upper neck raised and throat flattened; closed or fanned tail raised 20° above horizontal; bill sometimes open. Only performed by males and before laying. Female stands next to male and, after male gives Pointing display, **Neck-rubbing** takes place; necks of both birds held fully extended and rubbed together for a few seconds. Male continues to display and gives Snap-Bow which is copied by female and often given by both birds in synchrony. **Snap-bow** (Fig. 5): bill closes with snap while directed vertically downwards with neck in tight S-curve; tail spread and raised *c.* 80° from horizontal and partly folded wings raised and vibrated rapidly; lasts for few seconds and ends with ruffling of feathers and repeated. Only performed at nest-site; most often by male but partners may Snap-bow together during pair-formation. Not performed after laying. Males may **Circle-fly** after displaying to female or remain at nest or hop to another branch. RECOGNITION (=Greeting) consists of Pointing, Snap-bow, Gaping and Wing-lifting; performed on or near nest-site. **Gaping** (Fig. 6): opens bill and shakes head up and down and sideways; display directed towards male who nibbles bill of female and sometimes puts his bill inside female's; performed

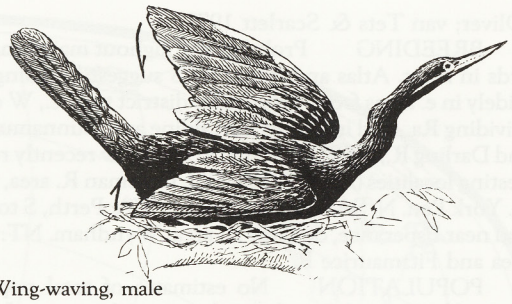


Fig. 1 Wing-waving, male

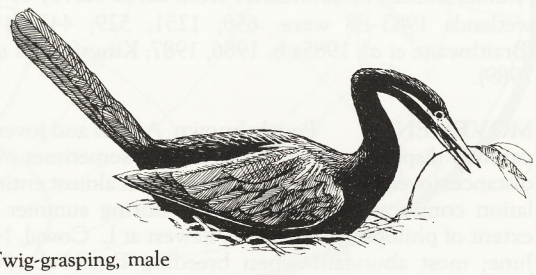


Fig. 2 Twig-grasping, male

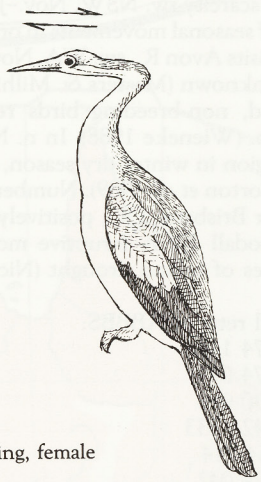


Fig. 3 Darting, female

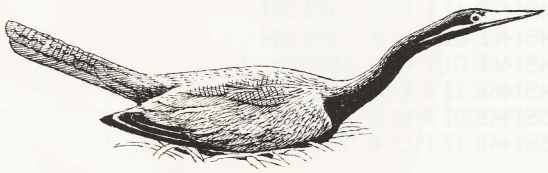


Fig. 4 Pointing, male

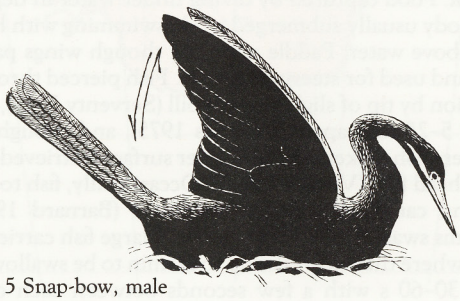


Fig. 5 Snap-bow, male

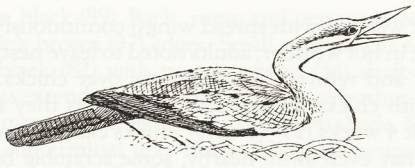


Fig. 6 Gaping

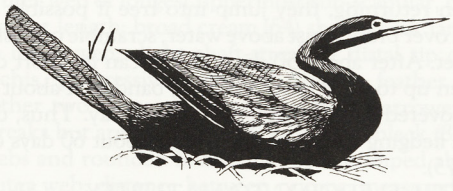


Fig. 7 Wing-lifting

by females sitting on nest, often just before copulation. **Wing-lifting** (Fig. 7) (=Greeting of Vestjens 1975): folded wings raised 2–8 times by slight humeral rotation, with neck in tight S-curve; at high intensity, tail raised *c.* 45° from horizontal. Greeting display by incubating bird when mate arrives at nest. Returning bird utters loud calls before landing; makes ticking sounds and extends neck as approaches nest and sometimes calls loudly. Beside nest, **Low-pointing Posture** adopted, with head and neck held low and horizontal. **Wing-flicking**. Incubating birds rapidly lift tips of wings with bill and tail horizontal; function not clear. ALLOPREENING not observed but paired birds observed nibbling each other's bills beside nest-site for up to 2 min. COPULATION. Female crouches and lowers neck; male, with partly spread wings, hops on her back and grabs her bill, pulling her head up and back; female opens wings slightly and both birds lift tails, opening and closing them during copulation. Of 18 observations, male twice placed his head alongside female's and three times male held green twig in bill, beside or below head of female. Lasts 4–9 s; only at nest-site, occurs several times during first 2–8 days after pair-formation.

RELATIONS WITHIN FAMILY GROUP Male and female co-operate from pair-formation to dispersal of offspring. During hot, sunny weather, eggs and small chicks depend on parental shade for survival. When required, webbed feet used to warm eggs and small chicks. Begging chicks reach up with neck stretched and closed bill directed towards parent's head; hyoid bones moved up and down to produce alternate squeaking and clicking sounds. In response, parent arches neck with head upside down and upper bill resting on nest rim at 45° to horizontal resulting in flow of partly digested fluid down inside of upper bill and into mouths of chicks. Larger chicks take food directly from parent's throat. When begging for water, chicks hold bill wide open. In response, parent flies down to water, fills its throat and, on return to nest, pours water into open bills of chicks. Not recorded as being fed by parents after 60 days old.

VOICE Not well known; some descriptions for L. Cowal, NSW (Vestjens 1975). Generally quiet; away from nest, mainly clicks; at nest, variety of loud to quiet caws, clicks and hisses. Sexual differences in form, quality and vocabulary but not well known. No information on individual differences or geographical variation. NON-VOCAL SOUNDS: males and females snap bills closed during Snap-bow display and as Threat when not incubating.

ADULT **Clicks**. Both sexes produce ratchet-like call, up to 4 s long, which is a series of *clicks*. Sonagram A shows clicks are two-note syllables blurring into longer single note at end of call; interval between clicks 0.2 s, reduced to 0.1 s towards end. At nest, often given as bird hops closer to nest from where it landed, part of greeting. **Krrr**. Rapidly repeated, rattling *krrr*; sequence ending with *kururah*. Similar for both sexes; given before and after landing and during pre-mating behaviour. **Hiss**. Adults and immatures utter a hissing *ssssst* directed at threat; given when incubating, apparently as Threat Call. **Kah**. A rolling *kah* repeated 3–15 times, decreasing in volume after a few repetitions; calls of males quicker, harsher than those of female. Used as threat call when not incubating, greeting at nest and sometimes just before landing (see also Khaah).

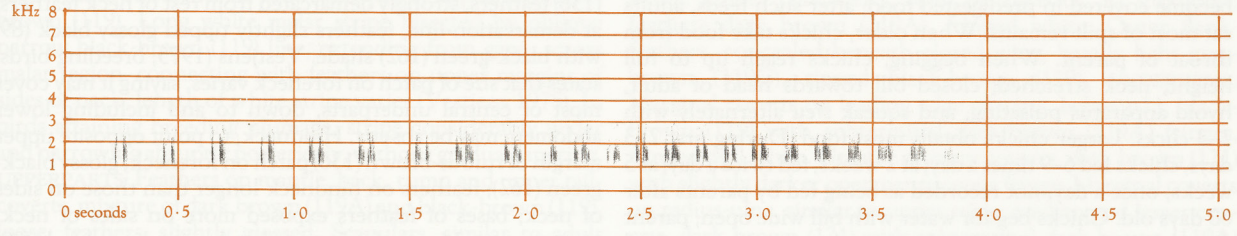
ADULT MALE **Khaah**. Loud, explosive *Khaah*; given only by males; during pair-formation, courtship and pre-mating behaviour.

ADULT FEMALE **Kah**. Like male, but apparently slower and less harsh. **Tjeeu**. Repeated *tjeeu*, uttered 1–4 times.

YOUNG Beg with squeaky *treu* calls, alternated with 2–3 *clicks*. No further information.

BREEDING Fairly well known. Studied at L. Cowal, NSW, by Vestjens (1975). Information contributed by G.F. van Tets. Breeds solitarily (up to 1 km apart) or in small (<10 nests) loose colonies, often associated with cormorants, spoonbills, ibises; over water in lakes, swamps and along rivers.

SEASON North gave the usual breeding season in se. Aust. as Nov. to 'very early months of year' but had records in Apr. in nw. Vic. Campbell reported eggs near Grafton, NSW, on 18 Sept. In Qld and NT, North recorded eggs taken from Feb. to June and in Nov. on Dunk I., Qld. In general, apparently erratic and irregular breeder, disappearing from some areas for long periods and capable of nesting at any time of year, e.g. L. Cowal, according to state of water and availability of food and shelter.



A L. Gillard; P43

SITE In forks of branches of live or dead trees away from main trunk, standing in at least 0.3 m of water; if water level falls at L. Cowal, birds move to sites in deeper water. Nesting trees usually with base or branches that enable birds to scramble up from the water. Average 3.5 m above water (0.6–5.7; 178; Vestjens 1975), but North gives a range of 2-*c.* 20 m.

NEST, MATERIALS Cup-shaped structure of about 25 green twigs, *c.* 40 cm long, as flat base; built up with about 150 dry sticks, <10–40 cm long, into cup *c.* 40 cm across and 30 cm deep inside; lined with green leaves. Some nests so insubstantial that eggs can be seen from below. Old nests may be used as base and sites may be used for several years. Male selects site; before mating, collects soft green material, needed for firm holdfast on slippery branches, and afterwards continues to collect material even from several hundred metres distance. Female adds some material collected near nest but male brings most, which female builds in with quivering motions of her bill. Adults take turns guarding nest and building may occur whenever both at nest, even during incubation and nestling periods.

EGGS Elliptical; thick white chalky coating, generally blood-streaked; coating wears off during incubation to reveal green, pale blue or greenish-white underlying colour; becoming polished and stained.

MEASUREMENTS: 59 (57–63; 17) x 37 (36–39) (North); 58 (56–63; 26) x 37 (35–38) (Schönwetter 1967); 59 (53–64; 47) x 38 (35–43) (Vestjens 1975).

WEIGHT: 44 (35–50; 17) (W.J.M. Vestjens).

CLUTCH-SIZE Av. 4 (2–6; 122) (Vestjens 1975).

LAYING First egg laid 2–3 days after pair-formation; later eggs at intervals of 24–72 h. No further information.

INCUBATION By both sexes, starting with first egg; in stints of 2–6 h with longer stints more common; reliefs usually between 07:00 and 08:30, 13:00 and 14:00, and 18:30 and 19:30. Partners not fed on nest. Hatching asynchronic; under domestic hen, first egg of C/3 hatched 4 days before third (Vestjens 1975). INCUBATION PERIOD: 28 days (26–30; 9). No disposal of egg-shells. Incubating birds alert, watch other birds, man, boats, aircraft intently with neck just above rim of nest and head held sideways, while bird flicks its wings, perhaps as sign of distress.

NESTLING Altricial, nidicolous; naked when hatched, brownish; eyes closed; bill, dark brown; head, flesh-coloured; legs and feet, light brown; gular pouch, pinkish. Remiges and rectrices appear at about one week old and are *c.* 25 mm long at about three weeks; at 4 weeks, these feathers well developed and chicks about size of adults but bills much shorter and yellow. Fed by both parents by incomplete regurgitation. When chicks still small, adults rest upper mandible upside down on nest at 45° from horizontal and food runs down inside of upper bill towards tip where is taken by chicks; adults seem unable to control flow and sometimes chicks become covered in predigested food; after such feeds, adults eat most of spilt remains. When older, chicks take food from throat of parent. When begging, chicks reach up to full height, neck stretched, closed bill towards head of adult, hyoid apparatus pulsating, and squeak *treu* alternately with 2–3 *clicks*. Larger chicks obtain most food. During first 2–3 days, chicks fed 6–9 times a day; at 2 weeks, fed twice a day; at 5 weeks, once a day; not recorded as being fed by parents after 60 days old. Chicks beg for water with bill wide open; parent flies down to water, fills its throat and returns to nest and pours water into open bills of chicks. Chicks brooded (or shaded in hot weather with spread wings) continuously until one week old; in hot weather, adults noted to leave nest, swim about nearby and return to shake water over chicks. Both adults stay with chicks during night so long as they stay in nest. At about 4 weeks (25–40 days), chicks clamber and hop out of nest, may even swim nearby; some scramble back to nest; others may stay on lower branches of nesting or nearby trees with young from other nests. When leaving nest, chicks drop over rim, swim submerged, and surface after less than a minute; when returning, they jump into tree if possible or, looping neck over branch just above water, scramble out using wings and feet. After about 50 days, chicks can fly short distances or even up to 1500 m. One chick, banded at about 27 days old, recovered 47 days later *c* 120 km away. Thus, dispersal or full fledging may occur before or about 60 days old (Vestjens 1975).

GROWTH, FLEDGING TO MATURITY No information.

SUCCESS No systematic information. At L. Cowal, 38 (31%) nests *ex* 122 lost their eggs, 21 losses attributed to disturbance by humans during two duck-shooting seasons. If disturbed by humans, incubating birds will not return until humans have left, by which time Australian Ravens *Corvus coronoides* may take eggs. Average of three young fledged from 64 nests, each with 2–5 nestlings. In nests (n=12) with chicks of greatly different sizes, smallest chick never survived for more than 1 week. Even chicks 1 week old may plunge out of nest; six that did so in Dec. were alive 3 weeks later; four that did so in June were found dead 2 days later. Some chicks (n=14) were fatally injured when plunging out of nest. Adults, immatures, nestlings and fledgelings shot during opening days of duck-shooting seasons; adults also drowned in fishing nets. Marsh Harrier *Circus aeruginosus* has been known to attack immature (Vestjens 1971).

PLUMAGES

Subspecies *novaehollandiae*.

ADULT BREEDING MALE HEAD AND NECK. Crown, black (89) with tips of feathers shaded glossy black-green (162); distal edge of feathers, brown (121C); concealed bases, light brown (239). Loral skin, bare. Outer margins of throat, white; inner, glossy black (89). Feathers on inner throat extend onto gular pouch in sharp inverted V extending narrowly along along edge of gular pouch, across malar region to base of eye and continues as narrow white stripe down sides of upperneck, tapering sharply; stripe, about one-quarter length of neck. White stripe strongly demarcated from rest of glossy-black (89) foreneck; stripe bissected by oblique narrow glossy-black (89) line, extending from gape, across malar region, connecting with rest of foreneck. White stripe, 75–80 mm long. In birds attaining breeding plumage, stripe considerably wider and narrows abruptly posteriorly, without gradual tapering. At mid-foreneck, patch of rufous-brown (136) feathers, strongly demarcated from rest of neck feathers; at demarcation-line, feathers slightly tipped glossy black (89) with black-green (162) shade. Vestjens (1975; breeding birds) states that size of patch on foreneck varies, saying it may cover most of central underparts, down to and including lower abdomen; may be absent. Hindneck, to point opposite upper margin of rufous-brown (136) patch on foreneck, glossy black-green (162); feathers on hindneck longer than those on sides of neck; bases of feathers exposed more on sides of neck. UPPERPARTS. Mantle feathers rather loose, glossy black (89) with black-green (162) shade and distally edged brown (37);

rachis, black (89). Back, rump and upper tail-coverts, similar, but lack brown (37) edges. Small scapulars at edge of mantle, grey-black (82) with narrow cream (54) shaft-streaks; shaft-streaks extend three-quarters length of feather, but absent on basal quarter, and have slight buff (124) shade. Small scapulars have subterminal grey-black (82) open pennaceous fringes, finely edged buff (124). Scapulars, lanceolate, progressively becoming longer towards lower margins; rachis, basally broad, shiny and black (89), narrowing at beginning of shaft-streak. Outer web of longest uppermost sub-scapular, crimped along feather length; broad cream (54) shaft-streak largely confined to inner web; slight shaft-streak at distal tip of outer web; rachis, progressively thinner distally; feather tip, pointed. Other two longest subscapulars have narrower distal shaft-streaks but are not crimped. TAIL, grey-black (82) with glossy webs and rounded feather tips. T1, crimped along length of outer web; distance between crimps, measured near base of feather, *c.* 5 mm apart; crimps, shallower in profile distally. Rachis, broad at base becoming thinner distally; rachis on underside of rectrices, deep in profile. UPPERWING. All feathers, grey-black (82) with cream (54) shaft-streak. On humerals, shaft-streak mostly on outer web; on smallest humeral, narrow and confined to outer web; all tips of humeral feathers, pointed. Secondaries lack shaft-streaks and have rounded webs; tips pointed on primaries. S12, first tertial, smallest, or innermost tertial, have shaft-streak on outer web only; other tertials have slight distal shaft-streaks extending from outer web to tip of inner web. Alula and greater primary coverts, long and lanceolate. All coverts, lanceolate with narrow shaft-streaks; shaft-streaks broaden from marginal coverts towards greater coverts, tertial coverts and humeral coverts. UNDERPARTS. Concealed bases, light brown (239) for three-quarters of feather length; distal quarters of feathers have open pennaceous fringes, of glossy black (89) with black-green (162) shade; occasionally, bases of feathers exposed. UNDERWING. Greater coverts, glossy dark-brown (121) with open pennaceous fringes of slightly darker colour. Marginal coverts along edge of wing, at base of p11, have very narrow cream (54) shaft-streaks, but otherwise similar to marginal upper wing-coverts. Median and lesser coverts similar to marginal coverts, but shaft-streaks more conspicuous. All coverts along radius-ulna, similar to feathers of underparts.

ADULT BREEDING FEMALE HEAD AND NECK. Crown and hindneck, black-brown (119); feathers, finely edged dull white or buff (124), imparting streaked appearance; concealed bases of feathers, light grey-brown (119C); at base of hindneck, feathers long and loose, edged dull white. Throat and foreneck, dull white, often with slight pink-buff (121D) shade. Feathers on throat extend on to gular pouch in sharp inverted V. From malar region to quarter way down sides of neck, narrow white stripe; tapers sharply. White stripe less strongly demarcated from rest of sides of neck than in male. Upper margins of sides of neck, similar to hindneck, but largely lack dull-white or buff (124) edges, appearing black-brown (119). Long white malar stripe bisected by oblique narrow black-brown (119) line, extending from gape, across malar region, connecting with feathers on upper margins of sides of neck; length of white stripe varies (Vestjens 1975). In birds attaining breeding plumage, stripe considerably wider and narrowing abruptly posteriorly, without gradual tapering. UPPERPARTS. Feathers on mantle, back, rump and upper tail-coverts, mixture of dark brown (119A) and black-brown (119), loose; feathers, slightly glossed. Scapulars, similar to adult breeding male. UNDERPARTS, dull white or with pink-buff (121D) shade, slightly glossy. Feathers on outer flanks, concealed when wing closed, mixture of dark brown (119A) and black-brown (119); similar feathers found on hind thighs, connecting with outer flanks. UPPERWING AND UNDERWING, as in adult breeding male.

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

DOWNY YOUNG At hatching, chicks, naked with eyes closed. Within 2 days, body covered in pale-buff down, darkening on dorsum. Upper margins of neck in some chicks, light brown, in others, darker, with or without white malar stripe. At *c.* 1 week old, primaries, secondaries and rectrices appear; at *c.* 20 days, these are *c.* 25 mm long. At 4 weeks old, wing and rectrices, well developed; upper wing-coverts evident and colour of down changes from buff to pale buff. At 40–60 days, most down replaced by feathers. Fledge at *c.* 50 days. (Vestjens 1975).

JUVENILE HEAD AND NECK. Crown to hindneck, dark brown (119A), feathers, edged distally, dull white; imparts streaked appearance; at lower margins of hindneck, feathers almost black-brown (c119); at base of hindneck, dark brown (119A) tipped glossy black-green (162), fringed dull white. Throat to base of foreneck, dull white. Feathering round throat and proximal gular pouch, sparse. Dull-white malar-stripe, short and indistinct; no bisecting oblique line. Sides of neck, dull white; light grey-brown (119C) bases of feathers often exposed. Demarcation from feathers of hindneck, moderately strong; at demarcation-line, feathers dark brown (119A), fringed white. UPPERPARTS. Feathers on mantle, back and rump, loose and dark brown (119A); mantle feathers, narrowly tipped white; slight tips on rump feathers. Upper tail-coverts long, with subterminal open pennaceous black-brown (119) fringes, tipped dull white. Feathers on outer rump, similar. Mantle feathers, scapulars and subscapulars, lanceolate; smallest subscapulars, black-brown (119) with prominent subterminal dark-brown (119A) fringes, tipped dull white; feathers have cream (54) shaft-streaks on distal third of feather; all other scapulars similar in pattern, tipped dull white. Longest subscapular has shaft-streak confined to inner web; other longer two subscapulars, lack shaft-streaks. Uppermost subscapular, lacks crimps. TAIL, grey-black (82), slightly glossy on webs, tipped dull white; t1 lacks crimps. UPPERWING. Humerals, grey-black (82) without shaft-streaks. Marginal coverts, almost black-brown (c119), with subterminal dark-brown (119A) fringe, fringed dull white; shaft-streak, cream (54). Greater coverts, similar to adult but fringed dull white; dull-white fringe connects with cream (54) shaft-streak, particularly on outer web. On s12, or first tertial, shaft-streak narrow on outer web; other tertials also have narrow shaft-streaks. All remiges, greater primary coverts and alula, grey-black (82), tipped dull white. UNDERPARTS, entirely dull white. Concealed bases of feathers, light grey-brown (119C); rachis, from base for half length of feather, brown (119B); rest, white. Under tail-coverts, open pennaceous. At shoulders, feathers dark brown (119A), fringed white. Outer flank-feathers, concealed beneath closed wing, basally light grey-brown (119C), tipped black-brown (119). UNDERWING. Marginal coverts on leading edge of wing, below p11, black-brown (119) with subterminal dark-brown (119A) fringes, fringed dull white. Greater primary coverts, dark brown (121) with slightly darker open pennaceous fringe. Marginal coverts on radius-ulna, similar to upper wing; median and lesser coverts, dark brown (121) with subterminal dark-brown (119A) fringes, tipped dull white.

IMMATURE MALE Plumage varies and represents gradual acquisition of adult male plumage. HEAD AND NECK. Feathers on crown to mid-hindneck, glossy black-green (162), tipped light brown (239). Sides of neck, dark brown (119A) edged light rufous-brown (139). Loral skin, bare. White malar stripe, *c.* 90 mm long. Below malar stripe, at demarcation, feathers black-brown (119), tipped brown (119B); some white feathers tipped black-brown (119); oblique narrow bissecting line on malar region, not distinct. Throat, dull white interspersed with pink-buff (121D) feathers. At mid-foreneck, some feathers, dull white, others rufous-brown (139), merging to rufous-brown (340) near base of foreneck; at base, some rufous-brown (340) feathers tipped black (89) or black-green (162) at demarcation from underparts. UPPERPARTS. Mantle, similar to adult, rest similar to juvenile. TAIL, UPPERWING, similar to juvenile, primaries often retaining worn dull-white tips. UNDERPARTS, dull white, irregularly patched with white or black-brown (119) feathers. Feathers, largely white along centre of breast. Flanks, similar to juvenile. At shoulder, feathers basally brown (119B), white merging to rufous-brown (139), tipped black (89). UNDERWING, similar to juvenile, primaries often retaining worn dull-white tips.

ABERRANT PLUMAGES Underparts of birds often stained with ferrous oxide; particularly noticeable on juveniles and adult females.

BARE PARTS

ADULT BREEDING MALE In courting birds, upper mandible and tip of lower mandible turn light green; colours fade soon after laying, (Vestjens 1975). Label data on spirit specimen at MV, colours recorded 1 min after death: Iris, broad outer ring, olive-yellow; narrow inner, orange-brown; further moderately broad innermost ring, brown-spotted light grey. Gular pouch, orange-yellow. Bill, olive-yellow. Legs and feet, buff-yellow; outer leg, dark brown. Claws, black. Webs and soles, dark brown.

ADULT BREEDING FEMALE Colours recorded 1 min after death: iris, broad outer ring, yellow-orange; further moderately broad inner ring, grey, speckled light-grey; further thin solid black ring; innermost ring, cream. Gular pouch, pale orange-yellow. Facial skin, orange-yellow round eye. Tip of lower mandible, pale buff merging gradually to deep pale orange-yellow proximally. Upper mandible, greenish-olive. Legs, pale horn; pale-blue veins on inside of leg noticeable, less so on outer margins. Webs, pale orange-yellow. Bare skin under wing, between feathers on radius-ulna, indigo-blue. Vestjens (1975): iris, naked skin round eyes and throat, yellow. Bill, brown above, yellow below. Legs and feet, fleshy yellow. In courting birds, bill colour as adult breeding male.

ADULT NON-BREEDING In males, olive-yellow bill fades. Females lack greenish-olive upper mandible. Further study required to ascertain changes of bare parts after breeding.

DOWNY YOUNG Iris, dark brown. Bill, black-brown. Bare skin on crown and malar region, pink. Thin black line extends through eye to ear-coverts. Legs and feet, dull pink. Within 2 days, gular pouch, pinkish. At 4 weeks old, colour of bill changes to yellow (Vestjens 1975).

JUVENILE Vestjens (1975): iris and naked skin round eyes, pale yellow or orange. Upper mandible, black or brown; lower, grey-brown, yellow or fleshy. Throat, fleshy yellow or yellow-orange. Legs and feet, pink, grey, light brown or dark brown.

IMMATURE Undescribed.

MOULTS ADULT Flight-feathers shed simultaneously after post-breeding moult (White 1975). Tail moult, irregular (photo in NZRD). Duration and onset of moult, unknown. Anhinga *A. anhinga* has complete post-breeding moult and partial pre-breeding moult, in which all body plumage replaced (Palmer 1962).

POST-JUVENILE Undescribed.

MEASUREMENTS (1) Adult skins; methods unknown (AM, MV, WAM, ANWC, Museum Zoologicum Bogoriense; G.F. van Tets). (2) Adult skins (MV, SAM, ANWC).

		MALES	FEMALES
WING	(1)	351 (11; 329–373; 46)	344 (17; 304–375; 26)
BILL	(1)	74 (4; 61–81; 45)	73 (7; 54–85; 27)
TARSUS	(1)	49 (3; 46–58; 45)	49 (3; 42–53; 26)
TAIL	(1)	215 (11; 183–240; 46)	215 (13; 177–238; 25)
TOE	(2)	80.1 (2.97; 74.7–83.5; 12)	81.1 (3.31; 76.8–85.4; 6)

Additional measurements in Rand (1938).

WEIGHTS Label data from adult skins (MV, SAM, ANWC): males 1759 (211.14; 1450–2100; 9), females 1790 (317.7; 1300–2077; 4). Adult skins (MZB, MV, WAM, AM, ANWC; G.F. van Tets): 1600 (300; 1200–2100; 16); females 1700 (900–2600; 18). Morris (1978) gives average weight: 1025–1750.

STRUCTURE Wing, long and broad. Eleven primaries: p8 longest, p10 16–27 mm shorter p9 2–6, p7 1–10, p6 20–36, p5 51–67, p4 75–92, p3 88–109, p2 100–121, p1 113–137, p11 minute. P10 emarginated on inner web; p9 on outer and inner, slight p8-p7. Sixteen secondaries, four of tertial form. Seven humerals. Tail, long and wedge-shaped; 12 rectrices, t1 longest, t6 34–50 mm shorter. Neck, long and thin. Crimps on innermost tail feathers and outermost subscapular in adults. Ridge at base of culmen. Upper and lower mandibles extend to gape; no pronounced bill-flange, as in cormorants. Bill, pointed and slender; small, sharp backward serrations on distal halves of cutting edges. Bill, smooth in adults, flaky in juveniles. Tarsus, short and rounded. Feet, totiplamate. Claws, strongly curved; middle claw slightly serrated on inner margin. Outer toe *c.* 111% of middle, inner *c.* 71, hind *c.* 39.

GEOGRAPHICAL VARIATION Aust. birds regarded as distinct subspecies *novaehollandiae* on basis of more pronounced sexual dimorphism in plumage (BWP). Subspecies *novaehollandiae* does not show differences in length of bill between sexes as found in other subspecies and, further, appears to have shorter bill and tail, and longer tarsus (G.F. van Tets). Peters and Aust. CL submerge *novaehollandiae* in subspecies *rufa*, claiming differences too slight to justify separation. On the other hand, Vaurie (1965) considered *melanogaster*, *rufa* and *novaehollandiae* as three full species.

RMO

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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