

## Order CICONIIFORMES

Medium-sized to huge, long-legged wading birds with well developed hallux or hind toe, and large bill. Variations in shape of bill used for recognition of sub-families. Despite long legs, walk rather than run and escape by flying. Five families of which three (Ardeidae, Ciconiidae, Threskiornithidae) represented in our region; others — Balaenicipitidae (Shoe-billed Stork) and Scopidae (Hammerhead) — monotypic and exclusively Ethiopian. Related to Phoenicopteriformes, which sometimes considered as belonging to same order, and, more distantly, to Anseriformes. Behavioural similarities suggest affinities also to Pelecaniformes (van Tets 1965; Meyerriecks 1966), but close relationship not supported by studies of egg-white proteins (Sibley & Ahlquist 1972). Suggested also, mainly on osteological and other anatomical characters, that Ardeidae should be placed in separate order from Ciconiidae and that Cathartidae (New World vultures) should be placed in same order as latter (Ligon 1967).

### REFERENCES

Ligon, J.D. 1967. *Occas. Pap. Mus. Zool. Univ. Mich.* 651.

Meyerriecks, A.J. 1966. *Auk* 83: 683-4.

Sibley, C.G., & J.E. Ahlquist. 1972. *Bull. Peabody Mus. nat. Hist.* 39.

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

## Family ARDEIDAE bitterns, herons

Medium-sized to large or very large wading birds with long necks and long legs. Various placed in 61-69 species in 10-17 genera (Bock 1956; Curry-Lindahl 1971; Payne & Risley 1976; Hancock & Elliott 1978; Peters) according to choice between many, mainly monotypic genera and a few large genera. Treated here in few large genera, particularly merging *Egretta* into *Ardea* because there is no clear distinction between the two (Mock 1977; van Tets 1977). Two sub-families: Ardeinae (herons) and Botaurinae (bitterns). In our region, 19 species in four genera; all breeding except three accidentals.

Body, slim; neck, long with kink at sixth vertebra. Male larger than female. Wings, long and broad. Flight strong with regular wing-beats, neck retracted. Eleven primaries: p7-p10 longest, p11 minute. Fifteen to twenty secondaries; diastataxic. Tail, short, square or slightly rounded; 8-12 feathers. Under tail-coverts, nearly as long as tail-feathers. Bill, long, straight and sharply pointed, except in *Cochlearius*; often serrated with notch near tip. Nostrils, long slits. Lores, bare. Legs, long; lower part of tibia, bare. Toes, long; small web between middle and outer. Hind and inner toes, broadened at base; claw of middle, pectinate. Stance upright, neck retracted when at rest; gait striding. Perch in trees adeptly (herons) and climb about expertly in reeds (bitterns). Oil-gland small, often with short tuft (longer in night herons *Nycticorax*). Aftershaft well developed. Plumage, loose; feather tracts, narrow; down confined to apteria. Two to four pairs of powder-down patches; down soft and friable, producing fine particles used in care of plumage. Ornamental plumes on head, back or chest in many species; usually more highly developed in breeding season. Bare parts, yellow, brown or black; usually more colourful in season of display and pair-formation. Seasonal differences in plumage, small. Moults, poorly known; mostly two per cycle, but pre-breeding moult often restricted. Moult of primaries irregular or outwards. Young, semi-altricial and nidicolous; single coat of sparse down, white, grey or pale brown. Clamber out of nests when large but unable to fly. Except in *Nycticorax* and *Ixobrychus*, juveniles like adult or duller. Reach adult plumage when 2-4 years old.

Cosmopolitan, with main area of adaptive radiation in Tropics. Absent from Arctic and Antarctic areas; rare vagrants to subarctic and subantarctic regions. Adapted to catch medium-sized prey in shallow water and damp places with short grass, thus rather restricted in habitat. Avoid areas far from marine and inland waters. Otherwise widely distributed from temperate latitudes through Subtropics and Tropics wherever suitable feeding habitat occurs, including forest, mountain and agricultural areas. Usually found at water's edge, especially where gentle slopes and unobstructed bottom makes fishing easy, but some taller, longer-legged species may feed in deeper water. Some smaller species, however, largely arboreal: Cattle Egret *Ardea ibis* now mainly a commensal of large herbivores. Some species (e.g. reef herons *A. sacra* and *A. gularis*) adapted to littoral habitats; others (notably bitterns *Botaurus* and *Ixobrychus*) habitually haunt tall dense vegetation such as reedbeds.

Main breeding and roosting sites, reedbeds, islands, trees and shrubs along banks of rivers, billabongs and lakes (Fullagar & Davey 1983), from which they forage over wide areas. Formerly plumage trade almost annihil-

ated populations of egrets, which have recovered after protection. In Aust. and NZ mainly dispersive, especially those that depend on freshwater habitats.

Food mostly fish, amphibians and insects and their larvae; also, for some species, molluscs and crustaceans, reptiles, small birds and mammals, and their young. Indigestible material ejected as pellets. Prey grabbed by bill; sometimes speared. Feeding methods: (1) stand and wait for prey; (2) wade or walk slowly while stalking prey; (in both methods strike out with neck and bill when within range); (3) movements serving to uncover or startle prey (e.g. foot-shuffling accompanies method 2, at least in Ardeinae); (4) disturb-and-chase technique, in which bird runs and dashes about in shallow water, flushing prey; (5) swimming in deeper water and surface-diving; (6) hovering above water and plunge-diving; (7) plunge-diving from perch (Meyerriecks 1960). Feeding usually diurnal or crepuscular or both (e.g. *Ardea* spp); or crepuscular or nocturnal or both (e.g. *Nycticorax*). Most species solitary feeders, some territorially; where food plentiful may congregate in feeding flocks. Voice, mostly harsh guttural croaks or grunts, unspecialized. With partial exception of some Botaurinae, monogamous pair-bond typical; usually of seasonal duration and not evident away from nest-site or nearby; birds rarely if ever meeting as mates elsewhere. When breeding, both colonial and solitary species typically defend nest-site only. Most species roost communally, often conspicuously at traditional and protected sites; roosts mainly nocturnal but in some species diurnal.

Comfort-behaviour generally similar to other marsh and waterbirds. Bathe while standing in shallow water. Liberal use made of powder-down and oil-gland while preening, with frequent use of pectinate claw in scratching head, neck and bill. In some species, underwing preened by extending wing at right-angle to body. Heat dissipated by gular-fluttering; characteristic sunning posture with upright stance and wings held, shieldlike, out at sides but not fully spread.

In many, specially in colonial species, onset of breeding protracted. Seasonal breeders in coastal and temperate areas but prolonged in inland Aust. if wet conditions prevail. Nest in dense vegetation or in trees. Colonial, often with other Ciconiiformes and Pelecaniformes, or solitary. Displays when forming pairs use long neck and large bill in various distinct ways resembling those of long-necked Pelecaniformes, and birds bob up and down, bending and straightening long legs (Daanje 1950; Meyerriecks 1960). Nest, piles of available vegetation, in tree-nesting species of interlocked twigs; built wholly or mainly by female with material brought by male. Eggs blunt oval, light blue or green, smooth. Clutches 3–5 (1–10). Normally single brood. Replacements laid after loss of eggs or even young. Eggs laid at intervals of 1–3 days. Incubation, 22–30 days; typically by both sexes in roughly equal spells. Single median brood-patch. Incubation starts with first or second egg, so hatching asynchronous. Eggshells removed from nest. Young cared for and fed typically by both parents, by complete and partial regurgitation. Brooded continuously when small; then and later, sheltered from strong sun or rain by parents spreading wings. Older young often guarded by parents in turn. May leave nest before fledging, though often return to be fed. Nestling period 30–55 days; young may become independent soon after, but prolonged periods of post-fledging semi-dependence probably more typical, especially in larger species. Age of first breeding usually 1 or 2 years, occurring in some species before adult plumage attained.

## REFERENCES

- Bock, W.J. 1956. *Am. Mus. Novit.* 1779.  
 Curry-Lindahl, K. 1971. *Ostrich* 9 (Suppl.): 53–70.  
 Daanje, A. 1950. *Behaviour* 3: 48–99.  
 Fullagar, P., & C.C. Davey. 1983. Pp. 39–42. In: Haigh 1983.  
 Haigh, C. 1983. *Parks and Wildlife: Wetlands*. NSW NPWS.  
 Hancock, J., & H. Elliott. 1978. *The Herons of the World*.  
 Meyerriecks, A.J. 1960. *Publs Nuttall orn. Club* 2.  
 Mock, D. 1977. *Bird-Banding* 48: 81–4.  
 Payne, R.B., & C.J. Risley. 1976. *Univ. Mich. Mus. Zool. Misc.*  
 Publ. 150.  
 van Tets, G.F. 1977. *Emu* 77: 156–7.

## *Ardea novaehollandiae* White-faced Heron

COLOUR PLATE FACING PAGE 980

*Ardea novae Hollandiae* Latham, 1790, *Index orn.*: 706 — New Holland = New South Wales, *vide* Mathews 1912 *Novit. zool.*, 18: 231.

OTHER ENGLISH NAMES Blue Crane, White-fronted Heron.

### MONOTYPIC

**FIELD IDENTIFICATION** Length 66–68 cm, standing about 66 cm tall, body about half total length; wingspan 106 cm; weight 550 g. Medium-sized glaucous blue-grey heron with white face and upper-throat and yellow legs. The heron that is most likely to be seen by most people in Aust. In flight, dark flight-feathers contrast with paler upper and under wing-coverts. Sexes similar, but male larger. When breeding, plumes on back and breast brighter and more numerous; changes in colour of bare parts not established. Immature similar to adults, slightly paler ventrally, with less white on head and no white on face; no plumes.

**DESCRIPTION** **ADULT BREEDING.** Forehead, face, chin and throat, white, extending above and behind eyes; crown, nape and neck, blue-grey; upperparts, blue-grey with long lanceolate pale-brown plumes on nape, mantle and back; tail, dark grey; wings, blue-grey. In flight, dark-grey flight-feathers contrast with paler grey coverts of upperwing and underwing. Short lanceolate pinkish brown plumes on lower foreneck and breast; lower neck, dark grey with chestnut wash; rest of underparts pale grey with chestnut wash on breast and belly; slightly paler on abdomen and undertail. Bill, black; base of lower mandible paler, grey or buff. Gape-notch (posterior) almost non-existent, below pupil of eye. Lores, green or olive yellow, grey-black during courtship and when incubating (M.N. Maddock). Iris, varying, yellow, grey, green-

ish or dull yellow or cinnamon. Legs and feet, green-yellow or orange-brown. **ADULT NON-BREEDING.** Similar to breeding plumage but lack plumes on mantle and few plumes on back; fewer plumes on foreneck and breast and paler. Bare parts probably similar to adult breeding but little information. **JUVENILE, IMMATURE.** Appear paler and duller than adults with slight brown wash on plumage and less white on head; lack white face; forehead and lores, grey-white; dorsally, grey, without plumes on back and mantle; upper wing-coverts with buff subterminal patch. Base of neck and breast, pinkish grey without plumes; rest of underparts, buff- or grey-white.

**SIMILAR SPECIES** Two-tone grey plumage with white face and upper throat of White-faced Heron should prevent confusion with other Aust. or NZ herons. Dark-morph **Eastern Reef Egrets** *Ardea sacra* have face and body uniform grey, bill more robust. **Pacific Heron** *Ardea pacifica* has all white head, neck, throat and breast with prominent black spots on forethroat, and black legs; in flight, white patches on leading edge of wings distinctive. Adult and juvenile **Pied Herons** *Ardea picata* much smaller, have all-white neck; adults also show dark crown and nuchal plumes.

Widespread; in variety of wetland and terrestrial habitats; in all shallow, fresh and marine wetlands, particularly intertidal mudflats; also grasslands, farm dams, public gardens and golf courses. In flight, typical silhouette of all herons; head

retracted on bulging neck, long broad wings and feet protruding beyond tail; often fly with head and neck not withdrawn or only partly so, giving noticeably spread-eagled appearance, but perhaps only on short flights and when disturbed suddenly by intruder. Action slow with deep flaps of bowed wings. Walk deliberately; prey taken by stealthy approach, by standing and waiting with neck extended or by crouching with head withdrawn. Generally solitary or only a few, well spaced, round edges of small water-bodies; gather in loose groups of c. 10-20 birds in damp paddocks or short grasslands, keeping individual distance of several metres. Frequently perch on dead or live trees, fence-posts and similar prominent places. Rather silent but has variety of harsh, guttural calls in flight and at nest. Solitary nester.

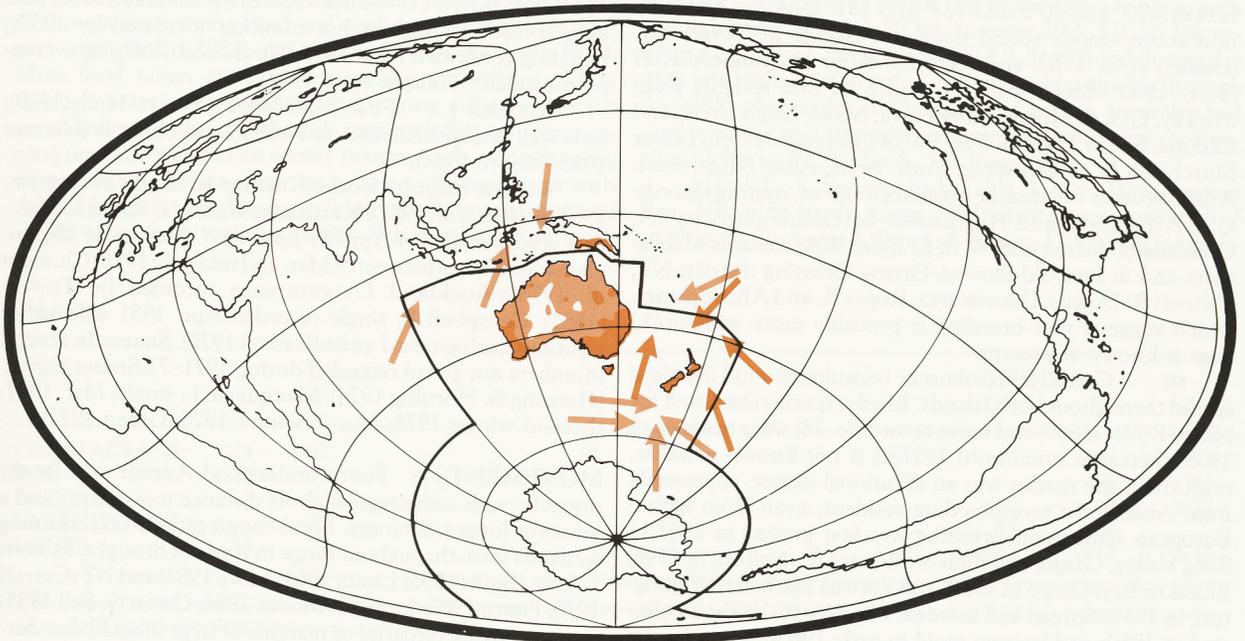
**HABITAT** In Aust., widespread in tropical and temperate littoral and estuarine habitats, and inland wetlands and grasslands. Forage in open areas over soft or firm substrate; in shallow water (rarely exceeding depth of tarsus); on shores or exposed surfaces in wetlands; regularly away from wetlands in moist or dry vegetation (Recher & Holmes 1982; Lowe 1983; Moore 1984). Occupy wider variety of habitats than other A'asian herons and egrets. Inland, prefer pools, billabongs, watercourses and floodwaters on floodplains; freshwater meadows; shallow swamps with low emergent vegetation and abundant aquatic flora or with tall emergent vegetation (e.g. *Eleocharis*, *Typha*, *Phragmites*, *Scirpus*). Also wet or dry pasture, but concentrate along drains or in low-lying areas with surface water (Lo 1982); shallow parts of permanent open lakes and reservoirs; shrubby or wooded lakes, swamps or floodwaters (e.g. *Melaleuca*, *Casuarina*, *Eucalyptus*, *Muehlenbeckia*); penetrate forested areas along rivers and creeks (Hobbs 1956, 1961; Vestjens 1977; Corrick & Norman 1980; Gosper 1981; Lowe 1981; Corrick 1982; Recher & Holmes 1982; Fjeldsa 1985). Regularly use farm dams (Corrick 1982); enter urban areas, and feed on flies at garbage tips, and round animal waste and carcasses on grazing land and road verges

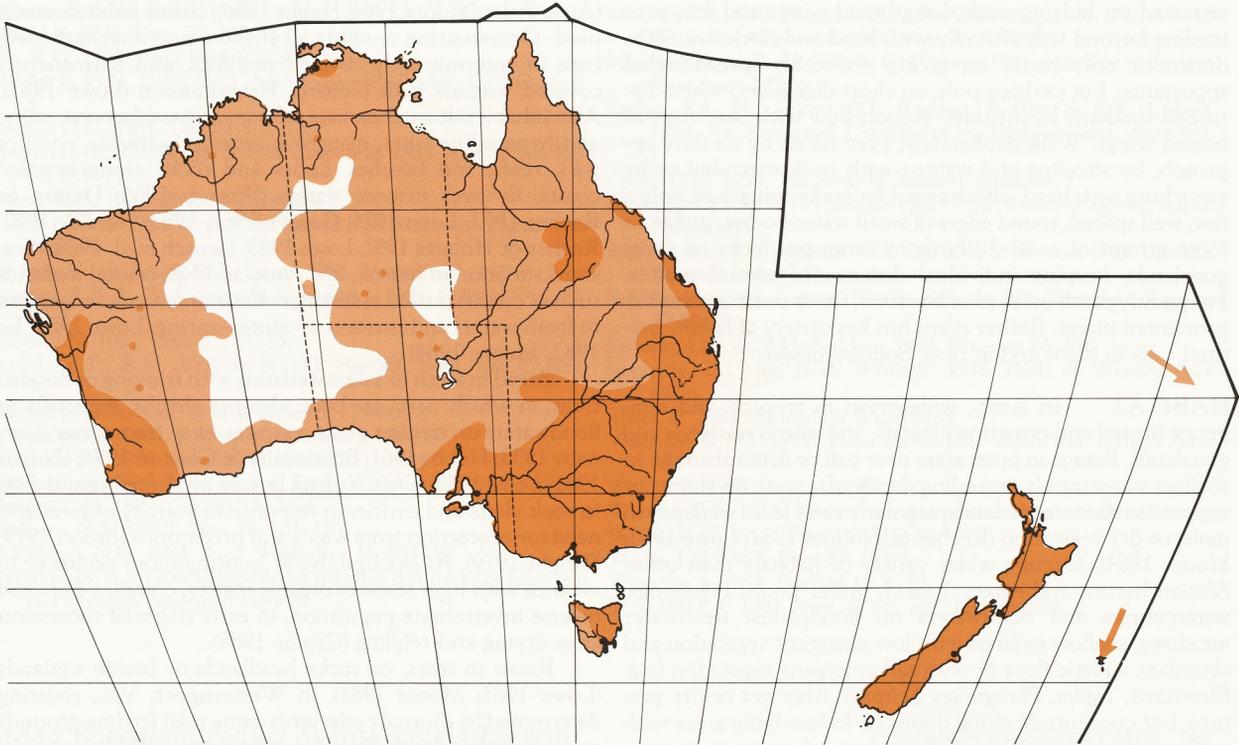
(Aust. Atlas; Moore 1984; Hobbs 1986). Saline habitats much used. On estuarine mudflats all shallow microhabitats used; bare or intermittently covered mudflats, and permanently covered seagrass beds (*Zostera*, *Heterozostera*) (Lowe 1983). Also inhabit saltmarshes, bare salt pans, coastal lagoons, saline and hypersaline lakes, mangrove swamps, saltfields, coral or rock reefs, and beaches, dunes and rocks along exposed coasts; fly over inshore waters (Watson 1955; Domm & Recher 1973; Loyn 1975; Gosper 1981, 1983; Corrick 1982; Recher & Holmes 1982; Lowe 1983; Jaensch *et al.* 1988). Seasonal variation in habitat; in s. Aust. and NZ, coastal wetlands such as estuaries used as summer-autumn refuges; movement to fresh waters and pastures in winter-spring (Lowe 1981; Lo 1982; Moore 1984).

Breed in fresh or saline wetlands with fringing or flooded trees, in which nests are built; also use shrubs, especially in floodwaters on treeless plains, or trees away from water (Carnaby 1933; Hobbs 1961; Braithwaite & Clayton 1976; Gosper 1981; Lowe 1983). On Chatham Is, nest on shoreline and cliffs in rock clefts and cavities in response to scarcity of trees and need for protection from winds and predators (Gordon 1979; Wright 1979). At Booligal, NSW, nesting more extensive in swamps with high levels of organic matter, complex flora and diverse invertebrate population, in early stages of succession after drying and refilling (Crome 1988).

Roost in trees, on rocky headlands or beside wetlands (Lowe 1983; Moore 1984). In Westernport, Vic., roosting determined by diurnal cycle; birds using tidal feeding grounds move elsewhere to feed at high tide (Lowe 1983).

In Aust. and NZ, favoured by clearing of wooded lands, conversion to pasture, irrigation schemes and construction of farm dams and reservoirs; little affected by loss and modification of natural wetlands (Lo 1982; Corrick & Norman 1980). Regularly occur and breed in pastoral land and beside artificial wetlands; occasionally in urban areas; use introduced trees and artificial structures for roosting and nesting (Falla *et al.* 1981; Lowe 1983; Pescott 1983).





**DISTRIBUTION AND POPULATION** Moluccas, Lesser Sunda Is, Christmas I. (Ind.), New Guinea, Aust., Tas., Lord Howe and Norfolk Is, New Caledonia, Iles Loyauté, NZ and NZ islands. Vagrant to Cocos-Keeling Is, Sulawesi (once Oct. 1893), Macquarie I., Solomon Is (Ndendi, Santa Cruz Is).

**AUST.** Widespread throughout mainland and Tas., but apparently rare or absent in driest areas of WA, NT and SA (Great Sandy, Gibson and Great Victoria Deserts) roughly between 20° and 30°S and 123° and 131° E (Aust. Atlas); on near-shore islands round coast, on islands in Torres Str. (Draffan *et al.* 1983) and recorded as far as Ashmore Reef (Storr 1980). Breed widely E and S of line roughly from Mackay, Qld, to Moree, Tibooburra, NSW, Leigh Creek and Ceduna, SA; in Tas.,; in WA, SW of line roughly from Lower Murchison R. to Esperance (Aust. Atlas; Aust. NRS). Aust. Atlas has other isolated, or isolated groups of, nesting records: Qld, Ayr-Bowen and Hughenden-Barcardine districts; SA, Oodnadatta district and W of L. Eyre; WA, towards Meekathara and in Leopold-Downs-Fitzroy Crossing district; NT, Victoria R. Downs, Darwin area, Roper R. and Alice Springs; which suggests that breeding is probably more widespread than is known at present.

**NZ** Carroll (1970) must be consulted for full details of spread throughout both Islands. Briefly, species first listed for NZ by Buller (1868) and more records (c. 23) were made until 1905; thereafter none until 1937; it is not known whether, until then, the species was an occasional visitor, supposedly from Aust., or a rare breeding resident, even from before European settlement. Breeding was first proved in 1941 in Shag Valley, Otago, and then on Wainui R., Nelson, in 1946; Blueskin Bay, Otago in 1950; and Porirua Harbour, Wellington, in 1952. Spread and increase was slow in 1940s, accelerated in 1950s and became rapid in early 1960s. Coastal areas

were generally colonized first; birds spread inland later, so that now the species is widely spread on both Islands, up to 500 m asl but rare above (NZ Atlas). Breed widely throughout both Islands.

**CHATHAM IS.** Small resident population since about 1966 (Carroll 1970).

**CHRISTMAS I. (IND.)** First reported (two specimens, Nov. 1940) (Gibson-Hill 1947); now common and probably resident (Stokes *et al.* 1987).

**LORD HOWE I.** First record by Ramsay (1888) and long considered vagrant but numbers increased by 1930s; breeding confirmed Nov. 1938 (Hindwood 1940); now common resident (Fullagar *et al.* 1974).

**NORFOLK I.** First recorded by Basset Hull (1909); now well established; also on Nepean and Philip Is (Hermes 1985; Moore 1984).

Vagrant records: **Cocos-Keeling Is:** single during Jan. 1982 (Stokes *et al.* 1987). **Kermadec Is:** single, Raoul I., Mar.-Apr. 1965; single, 14 Apr.-27 June 1969 (Merton 1970); singles several times between 9 Mar. and mid-July 1978 (Clunie *et al.* 1978). **Auckland I.:** occurrence recorded by Travers (1882). **Campbell I.:** single recorded Apr. 1951 with other sightings during next 7 years (Carroll 1970). **Snares Is:** several (numbers not given) recorded during 1971-73 Snares Exped. (Horning & Horning 1974). **Macquarie I.:** single, Mar. 1957; three in winter 1975; four in winter 1976 (Green 1977).

**MOVEMENTS** Poorly understood. Appear to be locally nomadic with some regular short distance movements and a few over longer distances. Local congregations on remaining wetlands form throughout range in times of drought. In both s. Aust. (Binns 1953; Lamm 1964; Lowe 1983) and NZ (Carroll 1970; Pierce 1980; Lo 1982; Moore 1984; Owen & Sell 1985) move to coastal estuaries or margins of large inland lakes dur-

ing summer after breeding (Lo & Forham 1986). In w. (Missen & Timms 1974) and s. Vic. (Watson 1955), sw. NSW (Hobbs 1961) and sw. Aust. (Heron 1970), congregate in flocks round permanent water during autumn when surrounding swamps dry. In areas of predominantly summer rainfall congregate during winter on coastal mudflats (ne. NSW, Gosper 1981; Magnetic I., Wieneke 1988; Torres Str., Draffan *et al.* 1983) or perennial inland swamps (Darwin, Crawford 1972). Although there may be some movement to NT from s. Aust. (Morton *et al.* 1989), reporting rates in Vic. suggest no long-distance seasonal movements (Vic. Atlas). Numbers at six wetlands in n. NSW correlated with rainfall in nw. NSW (Gosper *et al.* 1983) but no necessary relation because White-faced Herons use wetlands other than those censused. Annual fluctuations in Oct. counts in se. Qld small (Woodall 1985) but records of vagrants in autumn and winter 1973 suggested movement E at that time (Kermadec Is, see Distribution; Fiji, 19 July, Clunie *et al.* 1978). Similar emigration from Aust. could have resulted in successful colonization of NZ (see Distribution). Apart from coastward movement in winter, NZ population generally considered sedentary although there may also be shift N in winter (NZRD). Sporadic records from Christmas I. (Ind.) up to 1974 (van Tets 1974) have also resulted in colonization (Stokes *et al.* 1987). Local flocks may move 10–20 km in a day between feeding and daytime resting sites (Sedgwick 1971).

**BANDING** All returns ABBBS: eight recoveries show birds may be near banding site several years after banding.

Recoveries >100 km: banded near Barham, NSW, Jan., aged 1 year, recovered Great Western, Vic., 229 km distant, after 9.8 months; banded Acton, ACT, Nov., aged 1 year, recovered Baulkam Hills, NSW, 249 km distant, after 4.8 months; banded Merbein, Vic., as pullus, recovered Purnong, SA, 232 km distant after 9.5 months.

**FOOD** Wide range of aquatic invertebrates and vertebrates. **BEHAVIOUR.** Food taken by standing and waiting, gleaning, walking slowly, scanning, walking quickly, wing-flicking, foot-raking (Recher *et al.* 1983), false-striking (lunging at water with bill opened abnormally wide; Moore 1984), neck-swaying (moving head and neck from side to side after prey sighted; Lo 1982) and taking carrion (Baldwin 1975). Most food taken either when wading or walking slowly through water or by standing and waiting either with neck extended or crouched with neck retracted. Pursue prey, running up to 20 paces in an erratic twisting path, wing-flapping when running across water or in series of short hops with dangling legs. Avoid glare by walking rapidly towards sun and slowly away from it (Davis 1986). When taking flies, walk

slowly in crouched position with neck half retracted taking prey with final bill thrust (Hobbs 1986). When foot-stirring, extends foot forward and slowly rakes it back or vibrates it (Leach 1928; Hobbs 1957; Lo 1982). Wing-flicking, rapidly extending then closing wings, uncommon (Spurr 1967; Louisson 1972). At Pauatahanui Inlet, NZ (621 feeding observation periods; Moore 1984), 62.3% observations birds feeding without active prey disturbance with 50.7 ± 25.3% success, 12.6% observations false-striking with 46.4 ± 20.5% success, 15.3% observations foot-stirring with 40.3 ± 19.9% success and both methods in 9.8% observations with 39.6 ± 19.9% success. At Hawkesbury R., se. Aust., stationary 32.5 ± 0.7 s/min, walking 0.9 ± 0.01 steps/s when moving for 5.3 m/min, making 1.6 strikes/min with 46.1% success (521 min observations; Recher *et al.* 1983); when feeding alone (92.6 min observations) took 34.7 steps/min making 2.4 strikes/min with 61.9% success; when following Australian White Ibis *Threskiornis molucca* took 24.0 steps/min, made 0.8 strikes/min with 39.2% success, though energy intake similar when Ibis followed for more than 90 s. Though little apparently gained by association, Herons defended their Ibis against conspecifics, sometimes switched Ibis and once recorded pecking an Ibis when it stopped foraging (Davis 1985). Feeding method varies with prey: slow prey taken with head held vertically; fish approached in crouch, head plunged rapidly into water ahead of Heron. Food swallowed after tossing back into throat with rapid backward motion of head. Large food positioned first; crabs often dismembered by shake of head; fish usually taken ashore and subdued on land. One eel pecked 425 times in 9 min before swallowing (Moore 1984). If not swallowed, prey may be picked clean of flesh (Cole 1908). Most feeding solitary, congregations occurring only when food at high density. In pasture near Palmerston North, NZ, foraging recorded during 68.7% observations (38,011 observations, 668 h; Lo & Fordham 1986), with proportion increasing from about 60% in summer to 82% in spring, most feeding occurring early morning or late afternoon or evening except in spring when feeding remained high all morning. Took 38.8 steps/min making 5.2 strikes/min of which 67.3% successful with all three variables changing with season (spring 34.8, 6.2, 68.1%; summer 29.6, 5.9, 76.2%; autumn 41.0, 4.0, 72.3%; winter 44.8, 4.9, 52.6%) and during day (step rate highest in morning, other variables similar through day; 4813 observations). Over part of period, juveniles had similar strike- and step-rate to adults but had lower capture-rate (53.9% to 69.5%; Lo & Fordham 1986).

**ADULT** Summarized Table 1. On **Westernport Bay, Vic.** (786 items; Lowe 1983) crustaceans consisted of amphipods *Orchestia* 0.5% wt., 6.4% no., 12.5% freq., isopods

Table 1.

	weight			number			frequency			
	1	2	3	1	2	4	1	2	3	5
CRUSTACEANS	74	32		91	85	30	100	50	29	≥22
FISH	13			8			88		53	44
INSECTS		36	≤12		9	67		≥50	≥69	≥78
EARTHWORMS		27			3			33	29	
OTHER	13	7		2	3	1	38	≥17	≥43	≥44

(1) Westernport Bay, Vic., estuarine, eight stomachs (Lowe 1983); (2) Westernport Bay, pasture, six stomachs (Lowe 1983); (3) NZ, 93 stomachs (Carroll 1967); (4) Pukepuke, NZ, pasture, pellets (Lo 1982); (5) L. Cowal, NSW, nine stomachs (Vestjens 1977).

*Crabzyos* 0.1, 0.1, 12.5, shrimps *Alpheus euphrosyne* 1.2, 1.3, 25.0, *Macrobrachium intermedium* 23.1, 25.2, 87.5, *Pontophilus intermedius* 5.2, 9.0, 50.0, *Chlorotocella leptorhynchus* 8.0, 21.4, 50.0, crabs *Litocheira bispinosa* 0.2, 0.3, 25.0, *Brachynotus spinosus* 0.9, 0.9, 25.0, *Paragrapsus gaimardi/laevis* 5.0, 0.9, 37.5, *Halicarcinus ovatus* 1.1, 3.7, 37.5, *Nectocarcinus tuberculatus* 1.3, 0.1, 12.5, *Macrophthalmus latifrons* 26.4, 21.0, 87.5, *Pilumnus fissifrons* 0.7, 0.4, 12.5; the fish Sygnathidae 0.7, 0.5, 25.0, Clinidae 0.9, 0.3, 25.0, Gobiidae 9.5, 7.0, 87.5, Monacanthidae 2.1, 0.1, 12.5; other foods cephalopods Sepioidae. Samples from nearby pastures (884 items) crustaceans were notostracans; insects orthopterans Tettigoniidae 1.1, 1.0, 33.3, Gryllidae 32.7, 3.4, 33.3; beetles Dytiscidae 0.9, 1.9, 50.0, Hydrophilidae 0.4, 0.9, 50.0, Scarabaeidae <0.1, 0.1, 16.7; lepidopterans <0.1, 0.1, 16.7; flies 0.5, 1.7, 50.0; other foods spiders Lycosidae 0.1, 0.5, 16.7, gastropods 6.4, 2.4, 16.7.

In samples from **both Islands, NZ** (93 stomachs; Carroll 1967) fish included *Anguilla* 2.3% freq., *Salmo* 13.5% wt., 11.2% freq., *Retropinna* 2.3, 20.2, *Galaxius* 2.1, 15.7, *Carasius* 1.1% freq., *Gobiomorphus* 49.2% wt., 34.9% freq.; crustaceans were ostracods, notostracans, shrimps, freshwater crayfish, crabs; insects mayfly ads. 1.1% freq., larv. 5.6, odonatan ads. 10.2, larv. 17.9, stoneflies 1.1, 3.5, orthopterans 15.7, hemipterans 32.5 (Corixidae), lacewing ads. 3.5, larv. 1.1, beetles ads. 59.5, larv. 24.7 (largely *Rhantus suturalis*), caddisflies ads. 4.5, larv. 32.6 (numerous small *Oxyethira* probably ingested accidentally), lepidopteran larv. 11.4, flies ads. 68.5, larv. 20.1 (largely *Calliphora*), hymenopterans 2.3; earthworms when present very numerous; other foods: tadpoles *Litoria* 1.1; spiders 35.9; centipedes & millipedes 2.3; molluscs 28.1 (*Potamopyrgus*, *Isidorella*, other Planorbidae, minute bivalves); plants Caryophyllaceae seeds 4.5, Polygonaceae seeds 4.5, Fabaceae *Trifolium* leaves 17.9, seeds 6.7, Lemnaceae 3.3, Juncaceae seed 11.2, Poaceae leaves 42.7, Azollaceae 4.5, Salviniaceae 4.5.

At **Pukepuke, NZ** (805 g dry pellet; Lo 1982) insects: odonatans 0.8% no.: *Xanthocnemis zealandica* 0.2, *Austrolestes colenensis* 4.3; orthopterans 0.7: *Phaulacridium marginale* 0.6, *Metioche maorica* 0.1; bugs 6.7: *Sigara* 0.7, *Anisops* 5.6, Lygaeidae 0.4, *Cermatulus nasalis* <0.1, unident. Pentatomidae <0.1; beetles 49.2: *Neocincindela tuberculata* <0.1, *Clivina rugithorax* <0.1, *Hypharparx aereus* 0.1, *Notagonum submetallicum* 0.1, unident. Carabidae 0.1, *Antiporus* <0.1, *Lancetes lanceolatus* 0.7, *Rhantus suturalis* ads. 38.1, immms. 7.4, *Homeodytes hookeri* 0.6, *Enochrus tritus* 0.2, *Onthophagus granulatus* <0.1, *O. posticus* 0.1, *Saprosites communis* 0.1, *Costelytra zealandica* 0.2, *Odontria* 0.1, *Pyronota festiva* 0.3, *Pericoptus truncatus* 0.1, *Conoderus exsul* 0.1, unident. Elateridae larv. <0.1, *Coccinella undecimpunctata* <0.1, Tenebrionidae <0.1, *Thelyphassa* <0.1, *Xylotoles* <0.1, *Catoptes* <0.1, *Ceryropa* <0.1, *Graphognathus leucoloma* <0.1, unident. Curculionidae 0.1; lepidopterans 2.3: *Wisana* 1.2; flies 7.3: Stratiomyidae larv. 1.6, *Eristalis tenax* 0.4, *Lucilia sericata* <0.1, *Hybopygia varia* 4.5, unident. Calliphoridae <0.1, unident. Muscoidea 0.3; hymenopterans 0.2: *Apis mellifera* <0.1, *Epipompilus* <0.1; crustaceans notostracans *Lepidurus apus viridus* 29.8, decapods <0.1; spiders 0.7. In **another sample** (two reurgitations, one stomach, 243 food items) insects 56.2% no.: odonatans Zygoptera nymphs 31.2; bugs *Anisops* 1.2, *Sigara* 0.4; beetles *Rhantus suturalis* ads. 5.8, larv. 15.2, *Odontria* 0.4, *Homeodytes hookeri* 0.8; flies Stratiomyidae 0.4, Calliphoridae 0.8; spiders 0.4; earthworms 9.1; frogs 32.1: *Litoria ewingi* ads. 3.3, tadpoles 28.8. Also observed feeding directly on earthworms and frogs *Litoria raniformis*. Beetles

occurred more frequently in pellets in spring, flies in summer and notostracans spring and summer. Earthworms made up 18.5% of observed swallows in winter, 4.1 spring, 5.1 spring and 1.0 summer and were taken at decreasing frequency through day.

At **L. Cowal** (Vestjens 1977) crustaceans: shrimps 11% freq., freshwater crayfish 22; insects: odonatans dragonfly nymphs 11, damselfly ads. 11, nymphs 11; earwigs 22; orthopterans long-horned grasshoppers 11, crickets 67, mole-cricket 11, short-horned grasshoppers 33; bugs water-boatmen 67, backswimmers 33; beetles ground beetles 11, water beetle ads. 78, larv. 44, leaf beetles 11; fly larv. 22, caterpillars 22, sawfly larv. 11; ants 11; fish *Gambusia affinis*; other foods: freshwater snails 33; spiders 44; frogs 22.

**Other records. NZ:** shrimps (Buller 1873), crabs, insects, frogs and fish incl. whitebait, smelt (Oliver). **Aust.:** gastropod molluscs (van Tets *et al.* 1977); crustaceans clam shrimps *Limnadopsis* (McKeown 1934), amphipods <1.0 cm (Recher *et al.* 1983), isopods (Barker & Vestjens 1989), prawns Penaeidae, shrimps Alphaeidae (Cleland 1911; North; Cleland *et al.* 1918), freshwater crayfish (Mantingley 1908; Cole 1908) incl. *Astacopsis bicarinatus* (Lea & Gray 1935), *Cherax tenuimanus* (.5 cm), *C. quinquecarinatus* (8.5 cm; Serventy 1939) *C. sp.*, *Euastrac armatus* (Hobbs 1957), crabs (Cleland 1911; North; Cleland *et al.* 1918) <2.5 cm (Recher *et al.* 1983) incl. *Brachynotus spinosa* (Lea & Gray 1935), *Holoecius cordiformes* (van Tets *et al.* 1977); spiders (Serventy 1939) incl. Lycosidae (Rose 1973); millipedes (Lea & Gray 1935); insects odonatans (Serventy 1939); earwigs (Lea & Gray 1935); orthopterans (Berney 1903; 1907; Butler 1907; Mathews 1910) incl. Tettigoniidae, Gryllidae (van Tets *et al.* 1977) *Teleogryllus commodus* (Ellis 1958), Gryllotalpidae (van Tets *et al.* 1977) *Gryllotalpa* (Rose 1973), Acrididae (van Tets *et al.* 1977) *Acrida turrata* (Serventy 1939), *Chortoicetes* (McKeown 1934), *Gastrimargus musicus* (Serventy 1939); bugs (Lea & Gray 1935; Serventy 1939) incl. *Agraptocorixa* (van Tets *et al.* 1977); beetles (Serventy 1939) incl. *Eretes australis* (Lea & Gray 1935), *Macrogyrus oblongus* *laticornis* ads, larv., *Enochrus*, *Berosus*, *Hydrophilus* (McKeown 1934), Dynastinae (van Tets *et al.* 1977); lepidopterans (Lea & Gray 1935; Lord 1956); flies (Hobbs 1986); fish (Cole 1908), ≤10 cm (Recher *et al.* 1983) incl. *Galaxias* (McGarvie & Templeton 1974) *Tandanus tandanus* (≤2.5 cm; Rose 1973), Sygnathidae (North), Gobiomorphidae (Rose 1973); frogs (Mathews 1910) incl. *Litoria* (3 cm; Serventy 1939), *Heleioporus eyrei* (Storr 1964); lizard (Mathews 1910) incl. *Lampropholis guichenoti* (van Tets *et al.* 1977); mice (Rose 1973). One confirmed record of carrion feeding, bird tearing flesh from dead Galah *Cacatua roseicapilla* (Baldwin 1975); others (e.g. Immelmann 1960; Klapste 1982) may have been taking flies (Hobbs 1986).

**NESTLING** Only records freshwater crayfish (Chandler 1923), marine worms, shrimps, crabs, aquatic insects (Sharland 1926).

**INTAKE** Mean weight of stomach contents in NZ, 21.7 g (89; Carroll 1967); at Westernport Bay, 23.9 g (19.8; 5.0-54.7; 8; Lowe 1983).

**SOCIAL ORGANIZATION** Little information. Based mainly on Lo (1982), Moore (1984) and information supplied by K.W. Lowe and M.N. Maddock. On marine and intertidal mudflats, usually feed singly in Aust. (K.W. Lowe), independently in scattered flocks in NZ (Moore 1984); generally solitary when feeding in terrestrial and aquatic habitats, but occasionally flocks of up to 60 birds observed in Aust. (Lowe

1983) and 20+ birds in NZ (Lo 1982); feeding flocks of 10–15 observed often in lower Williams R. valley, NSW, on small shallow swamps and on margins of receding floodwaters. Sometimes territorial on intertidal mudflats outside breeding season, but this varies from day to day (possibly according to weather) (K.W. Lowe); in NZ, aggressive; maintain individual distances but do not consistently defend feeding territories (Moore 1984).

**BONDS** No information. No co-operative breeding. Both parents incubate; no observations of adult behaviour during nestling period. Birds in adult plumage seen feeding fledged young away from nest up to 10 days after fledging.

**BREEDING DISPERSION** From thorough search of Phillip I., Vic., 1978–81, and casual observations elsewhere, nest solitary; closest distances between four nests were 2, 3.5 and 2 km. All-purpose territory defended only in breeding season. Possibly maintain territories or fixed home-ranges outside breeding period; one colour-banded bird seen repeatedly on mudflat over several months. Feeding birds range over large areas: on mudflats birds forage over several hectares each day; during spring, will fly 2+ km between feeding sites and breeding birds may feed more than 2 km from nests (K.W. Lowe).

**ROOSTING** Outside breeding season, communal or solitary, in mangroves, clumps of trees and in freshwater marshes; occasionally solitary. Roosting usually nocturnal; following marine feeding, some birds roost at farm dams during high-tide periods where they drink freshwater. As breeding season progresses, birds observed roosting for c. 1 h and then feeding on grasshoppers and crickets in pastures before returning to mudflats later in day. During breeding season, one observation of both parents roosting at nest; no further information. In NZ, during day in summer, roost singly or in small groups (up to 21 birds) either beside rushes next to feeding areas or on nearby beach; at night, roost in kanuka *Kunzea ericoides* or macrocarpa *Cupressus macrocarpa* in groups of 16–18 birds; arrive singly 21 min (15.1; 44) after sunset, depart 26 min (17.1; 93) before sunrise. One family group roosted together away from these communal roosts (Moore 1984).

**SOCIAL BEHAVIOUR** Based mainly on Lo (1982), Lowe (1983), Moore (1984) and unpublished information supplied by K.W. Lowe and M.N. Maddock. Little known, especially at breeding colonies; displays may be few and subtle. From time-budgets on feeding grounds, most time spent foraging, followed by 'looking' (which included resting) and maintenance and comfort behaviour (Lo 1982). Peak of 'looking' between mid-morning and early afternoon; maintenance and comfort behaviour peaked early in morning and decreased through rest of day. Social behaviour on feeding grounds studied at Pauatahanui Inlet, NZ (Moore 1984).

**AGONISTIC BEHAVIOUR** Agonistic interactions when in feeding flocks said to be rare and usually of low intensity (Lo 1982; Lowe 1983; K.W. Lowe); but persistent agonistic behaviour to drive away another bird observed when intruder entered feeding territory near nest (M.N. Maddock). Visits to nests by humans do not provoke reaction from parents who usually move off or perch quietly nearby, especially at nests where eggs measured and chicks banded (K.W. Lowe). In NZ, agonistic behaviour recorded only 0.3% of time (Lo 1982); most interactions settled quickly, and only on occasions would aggressor persistently drive away another bird. Agonistic behaviour described in NZ at feeding grounds:

included Forward Display, Upright Display and Chasing (Moore 1984); Lo (1982) classified behaviour into Chase, Head-up Bill-up, Run and Jump-up-and-down. **THREAT DISPLAYS.** **Forward Display:** ordinarily, feathers of chest and plumes on back raised in response to close approach of another bird, which could be <1 m at roost or >10 m when feeding; at high intensity, breast held further forward and downward, neck curved back over body with bill pointed forward, usually toward intruder. Intruder normally raised feathers of head before moving off; if intruder did not move off, aggressor walked towards or parallel to intruder, maintaining Forward Display; sometimes intruder adopted Forward Display and both birds would start slow strutting run, parallel to each other, displaying (Moore 1984); probably equivalent to **Head-up Bill-up** of Lo (1982). **Upright Display:** neck extended upwards without raising feathers, bill pointed forward; if nearby bird does not move away, movement may be repeated several times (Moore 1984). Another form of Upright Display used during high-intensity interactions, particularly between two birds that appeared to be equally aggressive: both birds extended necks fully with bills pointed upwards, and stepped backwards and forwards; once, two birds ran parallel to each other in Upright Display before one began running in small circles and began Forward Display and possibly displacement foraging behaviour (Moore 1984). Similar to and possibly ritualized version of Alert Posture. **Chase:** between two or more herons with attacking bird extending neck forwards, flapping wings and running at second bird; aerial chases often occurred, attacking bird flying with neck extended, relentlessly pursuing fleeing bird (Lo 1982; Moore 1984) or pursuing for several seconds before returning to previous feeding site (Lowe 1983). **FIGHTING:** rare; two Herons faced each other, wings flapping and lifting them a metre or two into air, and jabbed at each other with bills, apparently without making contact (**Jump-up-and-down** of Lo, 1982); roosting birds sometimes jab at neighbours (Moore 1984). **ESCAPE BEHAVIOUR.** Attacked birds may run or fly from threatening bird; in aerial chases, fleeing bird flies with neck retracted and tries to evade aggressor by turning and circling (Lo 1982; Moore 1984). **Alert Posture:** like Upright Display with body feathers raised; given in response to Australian Magpies *Gymnorhina tibicen* or Swamp Harriers *Circus approximans* flying close by or to man (Lo 1982; Moore 1984). **SUBMISSIVE POSTURE: Withdrawn Crouch** observed once, in response to aggressive Heron swooping over group of feeding birds (Moore 1984).

**SEXUAL BEHAVIOUR** **COURTSHIP.** **Courtship Display** in tree observed by Moon (1967); he suggested that pair-formation may take place away from feeding areas. In Aust., courtship behaviour takes place in area round nest tree as well as at nest-site: pair observed in weaving and swooping pursuit flights with neck outstretched and slow wingbeats, uttering harsh high-pitched *kar-kar-kar* calls; after alighting on branch, birds **Twig Shake** and **Back-bite**, making soft clucking *crook-crook-crook* call; Bill Quiver observed at nest-site. At Pauatahanui Inlet, probable courtship observed, including **Twig Shake:** pair consistently foraged together and displays observed when birds roosting (c. 40% of day). One Heron raised plumes on back when close to other, then moved away a few steps; occasionally other bird gently snapped bill at back or tail of other; first Heron once picked up twig and dropped it at feet of other, which also grasped twig (Moore 1984). Possible **GREETING CEREMONY** described by Lo (1982): members of pair circled each other with bodies

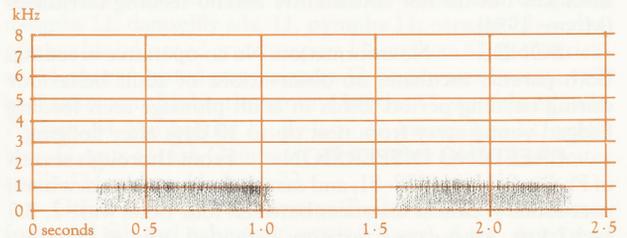
lowered and horizontal, bill pointed at partner's tail. In Aust., at change-over member of one pair observed with neck folded back, head touching back, and plumes raised; soft clucking *crock-crock-crock* uttered, followed by Back-bite; one brief Greeting or Change-over Ceremony observed where both birds stood at nest and called *grak*; relieved bird immediately collected sticks from just below nest and brought them to nest, three times in 4 minutes (K.W. Lowe). In two observations of change-over, incubating bird was not fed by relieving mate.

**RELATIONS WITHIN FAMILY GROUP** Nest building for up to 12 days before sitting began; more building occurred during incubation and raising young. One bird (presumed male) gathered sticks, returned to nest and passed them to mate; both placed sticks with tremble-shove movements. Adults Back-bite at intervals during building. At first, chicks fed throughout day and constantly brooded by one parent. As chick grows, fed less frequently and guarded but not brooded. Left unattended after 3–4 weeks; one pair left young unattended after 9 days; fed only in morning and evening in last week (Moon 1967). Lo (1982) did not observe fledgelings being fed; in Aust., few observations of juveniles being fed by adults; fledged young observed pursuing parent round trees near nest-tree, begging for food and being fed (M.N. Maddock); feeding of juvenile by adult observed on mudflats (K.W. Lowe); in NZ, juveniles continued to be fed over summer (Moore 1984). Begging action of fledged young: neck feathers erected, wings drooped, body and wings moved in wagging action (M.N. Maddock). Bathing behaviour described by Vestjens (1979): body is tilted c. 20° to horizontal and then moved back to horizontal position while bird sags on legs so that thighs and lower part of abdomen submerged in water; bill sloped down slightly until surface of water touched; position held for c. 30 s. Bird totally submerged by fast forward and downwards movement of head and upper body; wings partly opened, raised and flapped. Dipping movement repeated three or four times. Followed by sitting posture whereby body at 45° to horizontal and legs folded so that bird sitting on feet and tarsus and only head and shoulders above water; posture maintained for 60–90 s. Followed by gaping when bird held bill 60° above horizontal and opened it wide two or three times. Sequence of dipping, sitting and gaping may be repeated several times. May then shake feathers, jump out of water and fly onto perch to hold out wings to dry for 4–6 min. Followed by feather-drying, where side of bill used to remove water from feathers, shaking and then preening. Bathing may be cooling behaviour along with gular-fluttering, as well as cleaning after feeding.

**VOICE** Little known. No detailed studies; some information for NZ in Moore (1984) and for Aust. from M.N. Maddock. Generally quiet; loud, guttural calls and high-pitched chattering and shrieks when alarmed or interacting with other herons; at breeding site, few observations and only one call reported. No information on sexual differences or individual differences though differences within and between calls reported, depending on circumstances and individual calling (Moore 1984). Alarm Call similar to that of other herons. No information on geographical variation.

**ADULT** Loud repeated guttural *graaw* or *griaaw* was main call noted in NZ and used during interactions between herons (Moon 1967; Moore 1984). Repeated, loudly, 3–4 times when arriving at feeding grounds, particularly at dawn; softer versions given when leaving herony. Bird land-

ing near another at roosts usually uttered extended version: *griaaw griaaw bock bock bock* (Moore 1984). Loud grating *graak* reported during aerial chases in Aust. (Lowe 1983). **Alarm Call.** Away from nest, loud guttural *oooooaaark*, repeated several times as birds fly off (P.J. Higgins); sonagram A shows two of these calls. When flushed at short distance, loud



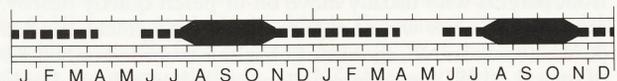
A H. & A. Crouch; P19

strident *aaaaarrgh* of about 1 s duration, repeated as bird flew off (J.M. Peter) and birds heard uttering latter call repeatedly, up to 25 times, in flight (P.J. Higgins). In NZ, loud strangled cries, as described above, when flying off after fight or disturbance (Moore 1984). **Contact Call.** At roosts, Herons waking at dawn uttered high-pitched *garik* calls; probably function as contact calls (Moore 1984); harsh, croaking *grak* recorded at change-over at nest in Aust. possibly the same (K.W. Lowe). **Chattering.** Short, high-pitched chattering notes uttered by both birds after arrival of one at roost (Moore 1984). **Courtship Calls.** Loud harsh high-pitched *krark-krark-krark* uttered during pursuit flight. **Greeting Call,** at nest, during building or changeover: soft clucking *crock-crock-crock*; also reported from pair in tree together during Courtship. **Other Calls.** High-pitched screech sometimes uttered when bird, returning to roost, driven away by another bird (Moore 1984). Perched bird twice uttered quiet nasal *orrk*, c. 0.5 s duration, before take-off (not flushed) (J.M. Peter).

**YOUNG** No information.

**BREEDING** Badly known. No detailed studies. Some information supplied by K. Lowe and M.N. Maddock; much from Aust. NRS (286 records to 1988). Breeds solitarily, mostly in rather open country with groves, clusters and isolated trees along water-courses but not necessarily near water; even in urban areas.

**SEASON** **AUST.** Details of start of laying poorly known because contents of nests hard to record until eggs hatched. Approximate ageing of nests recorded in Aust. NRS (n=158) shows that 109 (69%) started in Aug., Sept., Oct.; earliest nests (two) in June (WA) and latest (15) in Jan., Feb., Mar. (NT, Qld, SA, WA, NSW); Apr., May only months in which no nests started, yet Lavery *et al.* (1968) and Lavery (1986) gave clutches as started in ne. Qld in those months. This agrees reasonably with data in Campbell and North, and suggests that nesting may be earlier, later or more prolonged in n., w. and inland areas than in se. Aust. Timing may be much influenced by water-conditions and climatic fluctuations; one nest started in July in very wet winter at site where nest in previous season started Oct. (Glenoak, NSW). **NZ.**



(se. Aust.)

Eggs laid June–Dec. (Falla *et al.* 1981); at Pukepuke, Aug. and Dec. (P. Lo).

**SITE** AUST. Throughout range almost anywhere with trees in rather open country, and tree-lined waterbodies, but not in large areas of closed forest and extensive woodlands; not always near water, being recorded in places 0.2–4 km from nearest water ( $n=7$ ; Aust. NRS). Generally isolated and solitary but in Aust. NRS two records of two and three nests in adjacent trees and one of eight in colony at Goondiwindi, Qld, but spacing not recorded; one pair nested in isolated location c. 100 m from active breeding colony of several hundred egrets (Shortland Wetlands Centre). Favoured areas are partly cleared pastures with dams and isolated trees, small clumps of trees or trees at edge of larger woodlands; roadside reserves, golf courses, suburban areas with trees, parks in cities (e.g. Albert Park and Kew, Melbourne) and open woodland areas at edge of towns recorded. Large *Eucalyptus* trees usually chosen; nests in forks near top of tree but commonly (69 Aust. NRS records) on horizontal branches well out from trunk. Also in paperbarks *Melaleuca*, *Casuarina*, mangroves, willows *Salix* spp, pines and on mistletoe clumps. Once recorded on platform of tower in dam (Wall 1986). Old stick nests ( $n=4$ ) of ravens and cormorants sometimes used. On average 10.1 m high (2–25; 177) and c. 4.5 m below treetop (2–12; 28) but this does not take into account those areas where the trees are not tall in any case. Sites may be used from year to year ( $n=12$ , NRS; North; M.N. Maddock); possibly for second broods (see below), certainly for replacement layings (North; Campbell); one observation of site used 2 years in succession, shift of c. 20 m to new site, used 2 years in succession. NZ. Sites in many sorts of trees, usually high to 22 m and often well out from trunk (Moon 1967, 1979; P. Lo); recorded on beached ferry (Falla *et al.* 1981). On Chatham I., on ledges on cliffs and among boulders (Gordon 1979; Wright 1979).

**NEST, MATERIALS** Rather flat flimsy structure of coarse sticks lined with finer twigs (Campbell), through which it may be possible to see contents (North); may include green sticks pulled from living tree; becomes much fouled by white excreta; c. 40 cm across, 10 cm thick (Campbell). Sticks collected from close to base of nest tree up to distances of several hundred metres; turn-around time up to 1.5 min. Building observed up to 12 days before sitting began; additions during incubation and raising young. Material brought by one bird (presumed male) and given to other, which builds it into nest; both observed placing sticks with tremble-shove movements.

**EGGS** Elliptical to oval and elongated oval; close grained, smooth, not glossy; pale bluish green, often with traces of lime; varying much in size (North).

**MEASUREMENTS:**

Aust.: 47.7 (44.2–51.6; 20 from five clutches) x 34.7 (34.3–36.3) (North; Campbell; K.W. Lowe)

NZ: 45.5 (2.3; 41.2–48.8; 21 from nine nests) x 33.4 (1.4; 31.2–37.5) (P. Lo)

Chatham I.: 47.9 x 36.1 (Wright 1979).

**CLUTCH-SIZE** AUST. Acceptable Aust. NRS clutches 3xC/2, 7xC/3, 9xC/4, 7xC/5 (mean 3.77;  $n=26$ ) but one brood of six young noted. Generally claimed to be 4–5 (North; Campbell). NZ. At Pukepuke: 2xC/3, 2xC/4, 1xC/5 (P. Lo). Falla *et al.* (1981) say 3–5. Two Aust. NRS cards imply that, after successful fledging about 25 Sept. another brood was successfully reared in same nest from Oct. to 14 Jan. but it is not made absolutely plain that nest was same and it was not

known whether pair was same; second pair could perhaps have taken over nest in Oct. Replacements laid after loss of eggs at an early stage, up to five times (North; Campbell).

**LAYING** No information.

**INCUBATION** By both sexes (Lowe 1983). Period not known. One approximate determination (Aust. NRS) for  $26 \pm 4$  days; two records of period from first consistent sitting to time eggshells found beneath tree after hatching, 24 and 26 days; in former case, probable feeding of young by parent observed on twenty-first day. Claimed as c. 25 days without support (Falla *et al.* 1981). Lowe (1983) observed one stint of 5 h 25 min between dawn and 13:00. No further information.

**YOUNG** Semi-altricial, nidicolous. Covered with long grey down (North; Campbell). Brood-stage, when chicks small, followed by guard-stage, and then unattended by day, except for feeding, after 3–4 weeks old but no details (Moon 1967; P. Lo); one record of young being left unattended 12 days after parental activity suggested young present, 9 days after eggshells found below nest tree (M.N. Maddock). Feeding by both parents observed; by incomplete regurgitation (Aust. NRS) but no details. If alarmed, young will regurgitate food (North) and adopt bittering pose (Aust. NRS). **NESTLING PERIOD.** No precise information. One nestling observed clambering to branches adjacent to nest 10 days after estimated hatching date based on appearance of eggshells on ground under nest; at 43 days, flew to adjacent tree; at 46 days, pursued parent round neighbouring trees, begged for food and was fed.

**FLEDGING TO MATURITY** After fledging, young use nest site as base for feeding excursions of several hundred metres. One record of juveniles near nest-site 18 days after first observed flying. No further information.

**SUCCESS** Based on known clutch-size and outcome of nest ( $n=4$ ; three success, one failure), seven young fledged from 11 eggs (Aust. NRS). Nests destroyed or contents blown out by high winds, storms. **PREDATORS.** Laughing Kookaburra *Dacelo novaeguinae* seen to harry adults and cause them to abandon nest (Aust. NRS). Nests robbed by Harriers *Circus* spp and Australian Magpies *Gymnorhina tibicen* (CSN 19; M. Edwards; B. Sexton).

**PLUMAGES**

**ADULT BREEDING** Age of first breeding unknown. **HEAD AND NECK.** Feathers of crown, excluding forehead and outer margins of crown, short, dark blue-grey (78); feathers longer on hindcrown, c. 55 mm, forming nuptial crest; extent and shape of grey on crown varies (M.N. Maddock). Forehead, outer margins of crown, ear-coverts, and from chin to mid-foreneck, white. At mid-foreneck, white feathers taper in V-shape, apex basally. Rest of neck, dark grey (83). **UPPERPARTS.** On mantle, long lanceolate pink-brown (219C) plumes, varying in length, 82–91 mm long and sometimes very short. Some, but few, birds may have plumes at base of hindneck. On back, long pale brown-grey (80) lanceolate plumes. When wing closed, plumes almost extend to wing tips, but not beyond tail, ending c. 27 mm short of tip; plumes 157–204 mm long in males, 82–161 in females. Rump and upper tail-coverts, brown-grey (79). **TAIL.** Dark grey (83). **UPPERWING.** Alula, primaries, secondaries and tertials, very dark grey (83), almost grey-black (82). Basal inner webs of primaries and secondaries, white. Rachis of primaries, black-brown (119); rachis at base of secondaries, light grey-brown (119D). Greater coverts, dark grey (83), with brown-grey (80) shade.

Median, lesser and marginal coverts, brown-grey (80) with light-grey (85) shade. **UNDERPARTS.** Partly at base of foreneck and mostly on breast, long lanceolate plumes similar those on mantle, but shorter; in males, plumes 80–90 mm long; females, 47–86. Rest of underparts, light grey-brown (119D) and slightly paler on abdomen; under tail-coverts pale grey-white. Concealed bases of feathers of body, white. **TAIL.** Dark grey (83). **UNDERWING.** Greater primary coverts, light grey (85); webs basally white, mottled white half way along length. Median and lesser primary coverts, pale light grey-brown (119D). Greater and median coverts, dull white with faint light grey-brown (119D) shade. Lesser and marginal coverts, brown-grey (80) with light grey-brown (119D) shade. Remiges particularly subject to wear (Amadon 1942).

**ADULT NON-BREEDING** Similar to adult breeding, differences described only. **HEAD AND NECK.** Feathers of hindcrown, short; no nuptial crest. **UPPERPARTS.** Lacks pink-brown (219C) plumes on mantle; lanceolate plumes on back, shorter. **UNDERPARTS.** Lanceolate breast plumes, fewer and mixture of dirty pink (4) and dull pink (5).

**NESTLING** Largely naked at hatching, down brown-grey (79); down erect on crown, thin on neck, thicker on body. Birds fledge at c. 6 weeks (Falla *et al.* 1981).

**JUVENILE** Similar to immature (described below) but **HEAD AND NECK:** crown feathers narrowly tipped white; caused by retention of down follicle. *Contra* Stonehouse (1968) and Oliver, juveniles do not have more white on head and neck than adults (Lo 1982). **UPPERWING.** Median and lesser coverts have less distinct pink-buff (121D) subterminal patches. **UNDERPARTS.** Upper breast, grey (84).

**IMMATURE HEAD AND NECK.** Crown and sides of head, grey (84) with strong brown-grey (79) shade. Forehead and lores, grey-white. Chin to mid-foreneck, white. At mid-foreneck, demarcation of white feathers occurs in sharp V, continuing as narrow line of pink-buff (121D) feathers to base of foreneck and continuous with breast. Sides of neck and hindneck, grey (84). **UPPERPARTS,** grey (84) with brown-grey (79) shade. No lanceolate plumes on back. **TAIL.** Dark grey (83). **UPPERWING.** Primaries, alula and secondaries, dark grey (83); tertials grey (84). All coverts, grey (84); median and lesser coverts have prominent pink-buff (121D) subterminal patches. **UNDERPARTS.** Breast, pink-buff (121D) with scattered grey (84), speckled pink-buff (121D), feathers; no lanceolate plumes. Rest of underparts, white with pink-buff (121D) shade; thighs and flanks, grey-white, former with pale pink-buff (121D) tips. **TAIL.** Dark grey (83). **UNDERWING.** Similar to adult, but paler.

**ABERRANT PLUMAGES** Albinistic and partial albinistic birds recorded (Heather 1983; M.N. Maddock).

**BARE PARTS** Colour of iris and other bare parts varies but correlations between these and age or breeding status have not been determined. Based on photos in Wade (1975), Pringle (1985) and label data on skins (NMNZ).

**ADULT** Iris, yellow, lead-grey, greenish or dull yellow, light brown (123A). Loral skin, blue-grey, olive-yellow, dark brown (219). Bill, grey-black (82); base of lower mandible, pale grey, pink-buff (121D) at tip. Legs and feet, yellow-brown (123B), greenish-yellow to reddish (Hancock & Kushlan 1984); several birds known with pink or light red legs (Oliver), but age not mentioned. Claws, pale brown.

**NESTLING** Iris, dark brown (219). Lores and bare skin above eye, light blue-grey (88). Bill: upper and lower mandibles, pink-buff (121D) tipped grey-black (82); upper

mandible, grey (87) at base and subterminally behind grey-black tip. Legs and feet, yellow-olive (52). Body skin, straw yellow (57).

**JUVENILE** Iris, dark brown. Bill, black. Loral skin, black. Eyelid, bluish-grey. Legs and feet, yellowish-green. Claws, olive-horn.

**IMMATURE** Iris, light yellow. Bill, black; lower mandible, pink with black cutting edge and tip. Legs and feet, olive yellow. Soles, bright yellow. Claws, brown.

**MOULTS** Largely undescribed. Some information from museum skins.

**ADULT POST-BREEDING** Complete; late summer. Remiges, moult irregularly and outwards.

**ADULT PRE-BREEDING** Partial; development of breast and back plumes.

**POST-JUVENILE** Few data; presumably complete.

**MEASUREMENTS** (1) Adults, skins (NMNZ). (2) Adults, recently dead (K.W. Lowe).

		MALES	FEMALES
WING	(1)	326.6 (8.43; 316–341; 9)	313.4 (6.94; 305–323; 5) *
	(2)	320, 328, 333	303 (10.9; 282–315; 8)
TAIL	(1)	130.2 (5.15; 124–140; 9)	126.7 (6.29; 120–137; 4)
BILL	(1)	79.3 (4.40; 73.8–86.9; 9)	71.8 (2.55; 67.2–74.2; 5) *
	(2)	72.5, 74.6, 80.9	76.0 (3.31; 69.7–80.6; 9)
TARSUS	(1)	96.7 (3.53; 91.2–100.9; 9)	90.5 (3.06; 84.7–93.1; 5) *
	(2)	82, 89, 92	83 (2.2; 80–87; 9)
TOE	(1)	67.9 (2.90; 62.2–72.1; 9)	64.1 (2.03; 62.1–67.8; 5) *

Unsexed birds: (3) Adults, recently dead (K.W. Lowe).

WING	(3)	305, 340
BILL	(3)	72.4, 78.6, 87.4
TARSUS	(3)	84, 95, 99

Amadon (1942) gives a series of standard measurements, and mean wing-length of males as c. 330, and of females c. 318. Additional measurements in Oliver.

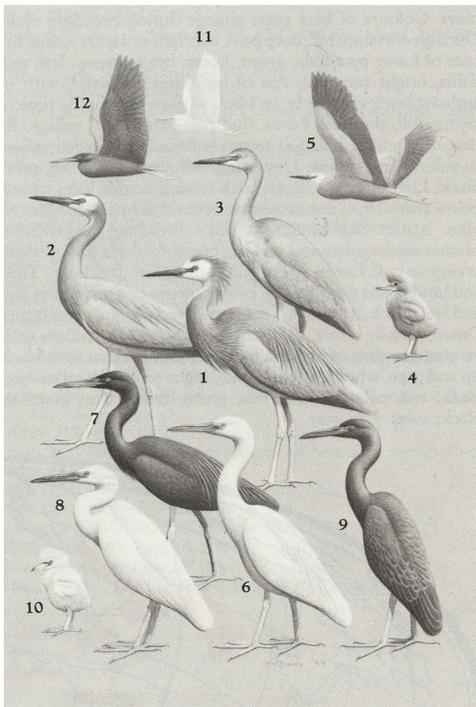
**WEIGHTS** Adults, skins (NMNZ): males 599.2 (54.77; 505–693; 7); females 521.2 (37.09; 462–559; 4); males significantly heavier ( $P < 0.05$ ). Adults, recently dead (K.W. Lowe): males 500, 680, 710; females 450–630; 7); unsexed 550, 650, 880. No data on seasonal changes.

**STRUCTURE** Wing, long and broad. Eleven primaries: p8 longest p10 6–9 mm shorter, p9 1–8, p7 1–7, p6 13–21, p5 33–42, p4 54–64, p3 72–83, p2 89–96, p1 103–111, p11 minute. P10–9 emarginated on inner webs, p9–8 slight on outer. Fourteen secondaries; four of tertial form. Tail, square; 12 rectrices: t3 usually longest, sometimes t1; t6 3–5 mm shorter, from t3; t1 5–7. Bill long, narrow and pointed; high at base, with deep nasal groove. Lower half of tibia bare. Tarsi scutellate. Legs and feet slender. Claw of middle toe, pectinate. Outer toe c. 82% of middle, inner c. 81, hind c. 45. In nestlings, post-gape loral notch is before eye (photo in Wade 1975).

RMO

## REFERENCES

- Amadon, D. 1942. *Am. Mus. Novit.* 1175.
- Baldwin, M. 1975. *Emu* 75: 113-20.
- Barker, R.D., & W.J.M. Vestjens. 1989. *The Food of Australian Birds*. 1.
- Basset Hull, A.F. 1909. *Proc. Linn. Soc. NSW* 34: 636-93.
- Berney, F.L. 1903. *Emu* 3: 123-4.
- Berney, F.L. 1907. *Emu* 6: 106-15.
- Binns, G. 1953. *Emu* 53: 211-21.
- Braithwaite, L.W., & M. Clayton. 1976. *Ibis* 118: 584-6.
- Buller, W.L. 1868. *Trans NZ Inst.* 1: 49-57.
- Buller, W.L. 1873. *History of Birds of New Zealand*.
- Butler, A.L. 1907. *Emu* 7: 88-9.
- Carnaby, J.C. 1933. *Emu* 33: 103-109.
- Carroll, A.L.K. 1967. *Notornis* 14: 11-17.
- Carroll, A.L.K. 1970. *Notornis* 17: 3-24.
- Chandler, L.G. 1923. *Emu* 23: 71.
- Cleland, J.B. 1911. *Emu* 11: 79-95.
- Cleland, J.B., J.H. Maiden, W.W. Froggatt, E.W. Ferguson, & C.T. Musson. 1918. *Dept. Agric. NSW Sci. Bull.* 15: 1-112.
- Clunie, F., F.C. Kinsky, & J.A.F. Jenkins. 1978. *Notornis* 25: 118-27.
- Cole, C.F. 1908. *Emu* 8: 76-78.
- 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.
- Crawford, D.N. 1972. *Emu* 72: 131-48.
- Crome, F.H.J. 1988. *Emu* 88: 243-8.
- Davis, W.E. 1985. *Colonial Waterbirds* 8: 129-34.
- Davis, W.E. 1986. *Corella* 10: 65.
- Dommm, S., & H.F. Recher. 1973. *Sunbird* 4: 63-77.
- Draffan, R.D.W., S.T. Garnett, & G.J. Malone. 1983. *Emu* 83: 207-34.
- Ellis, R. 1958. *Emu* 58: 312.
- Falla, R.A., R.B. Sibson, & E.G. Turbott. 1981. *The New Guide to the Birds of New Zealand*.
- Fjeldså, J. 1985. *Emu* 85: 141-9.
- Fullagar, P.J., J.L. McKean, & G.F. van Tets. 1974. Pp. 55-72. In: Recher & Clark 1974.
- Gibson-Hill, C.A. 1947. *Bull. Raffles Mus.* 18: 87-165.
- Gordon, A. 1979. *Notornis* 26: 46.
- Gosper, D.G. 1981. *Corella* 5: 1-18.
- Gosper, D.G. 1983. *Corella* 7: 7-13.
- Gosper, D.G., S.V. Briggs, & S.M. Carpenter. 1983. *Aust. Wildl. Res.* 10: 319-27.
- Green, R.H. 1977. *Birds of Tasmania*.
- Hancock, J., & J. Kushlan. 1984. *The Herons Handbook*.
- Heather, B.D. 1983. *Notornis* 30: 341-3.
- Hermes, N. 1985. *Birds of Norfolk Island*.
- Heron, S.J. 1970. *Emu* 70: 155-8.
- Hindwood, K.A. 1940. *Emu* 40: 1086.
- Hobbs, J.N. 1956. *Emu* 56: 61.
- Hobbs, J.N. 1957. *Emu* 57: 216.
- Hobbs, J.N. 1961. *Emu* 61: 21-55.
- Hobbs, J.N. 1986. *Aust. Bird Watcher* 11: 209-210.
- Horning, D.S., & C.J. Horning. 1974. *Notornis* 21: 13-24.
- Immelman, K. 1960. *Emu* 60: 237-44.
- Jaensch, R.P., R.M. Vervest, & M.J. Hewish. 1988. *RAOU Rep.* 30.
- Klapste, J. 1982. *Aust. Bird Watcher* 9: 171-2.
- Lamm, D.W. 1964. *Emu* 64: 115-28.
- Lavery, H.J. 1986. *Emu* 86: 111-13.
- Lavery, H.J., D. Seton, & J.A. Bravery. 1968. *Emu* 68: 133-47.
- Lea, A.M., & J.T. Gray. 1935. *Emu* 34: 275-92.
- Leach, J.A. 1928. *Emu* 28: 83-99.
- Lo, P.L. 1982. Unpubl. M.Sc. thesis, Massey Univ.
- Lo, P., & R.A. Fordham. 1986. *Notornis* 33: 233-45.
- Lord, E.A.R. 1956. *Emu* 56: 163-4.
- Louission, V.M. 1972. Unpubl. B.Sc.(Hons) thesis, Canterbury Univ.
- Lowe, K.W. 1981. *Vict. Ministry Conserv. Env. Stud. Rep.* 347.
- Lowe, K.W. 1983. *Corella* 7: 101-108.
- Loyn, R. 1975. *Report on the Avifauna of Westernport Bay*. Rep. to Vic. Ministry Conservation.
- Mathews, G.M. 1910. *Emu* 10: 103-109.
- Mattingley, A.H.E. 1908. *Emu* 7: 152-5.
- McGarvie, A.M., & M.T. Templeton. 1974. *Emu* 74: 91-6.
- McKeown, K.C. 1934. *Rec. Aust. Mus.* 19: 113-35.
- Merton, D.V. 1970. *Notornis* 17: 147-99.
- Missen, R., & B. Timms. 1974. *Aust. Bird Watcher* 5: 128-35.
- Moon, G.J.H. 1967. *Refocus on New Zealand Birds*.
- Moon, G.J.H. 1979. *The Birds Around Us*.
- Moore, P.J. 1984. *Notornis* 31: 285-99.
- Morton, S.R., K.G. Brennan, & M.D. Armstrong. 1989. *Dist. Abund. Waterbds Alligator Rs*, NT. Report to ANPWS.
- Owen, K.L., & M.G. Sell. 1985. *Notornis* 32: 271-309.
- Pescott, T. 1983. *Birds of Geelong*.
- Pierce, R.J. 1980. *Notornis* 27: 21-44.
- Pringle, J.D. 1985. *The Waterbirds of Australia*.
- Ramsay, E.P. 1888. *Tabular List of All the Australian Birds*.
- Recher, H.F., & S.S. Clark (Eds) 1974. *Environmental Survey of Lord Howe Island*.
- Recher, H.F., & R.T. Holmes. 1982. *Tech. Memo 4 Superv. Scient. Alligator Rs*.
- Recher, H.F., R.T. Holmes, W.E. Davis, & S. Morton. 1983. *Colonial Waterbirds* 6: 1-10.
- Rose, A.B. 1973. *Emu* 73: 177-83.
- Sedgwick, E.H. 1971. *West. Aust. Nat.* 11: 191-2.
- Serventy, D.L. 1939. *Emu* 38: 510-12.
- Sharland, M.S.R. 1926. *Emu* 26: 40-4.
- Spurr, E.B. 1967. Unpubl. B.Sc.(Hons) thesis, Canterbury Univ.
- Stokes, T., D. Merton, J. Hicks & J. Tranter. 1987. *Aust. Bird Watcher* 12: 1-7.
- Stonehouse, B. 1968. *Birds of the New Zealand Shore*.
- Storr, G.M. 1964. *Emu* 64: 105-13.
- Storr, G.M. 1980. *Spec. Publ. West. Aust. Mus.* 11.
- Travers, W.T.L. 1882. *Trans. NZ Inst.* 15: 178-87.
- van Tets, G.F. 1974. Pp. 39-43. In: *Conserv. Endangered Sp. Christmas I. Rep. Senate Standing Comm. Sci., Tech. Env.*
- van Tets, G.F., W.J.M. Vestjens, A.H. D'Andria, & R. Barker. 1977. *Guide to the Recognition and Reduction of Aerodrome Bird Hazards*.
- Vestjens, W.J.M. 1979. *Emu* 79: 142-3.
- Vestjens, W.J.M. 1977. *Tech. Memo Div. Wildl. Res. CSIRO Aust.* 12.
- Wade, P. (Ed.) 1975. *Every Australian Bird Illustrated*.
- Wall, L.E. 1986. *Aust. Bird Watcher* 11: 237.
- Watson, I.M. 1955. *Emu* 55: 224-48.
- Wieneke, J. 1988. *Sunbird* 18: 1-22.
- Woodall, P.F. 1985. *Aust. Wildl. Res.* 12: 495-506.
- Wright, A. 1979. *Notornis* 26: 349-52.



**Volume 1 (Part B), Plate 71**

White-faced Heron *Ardea novaehollandiae*

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

Eastern Reef Egret *Ardea sacra*

- 6. Adult breeding, white morph
- 7. Adult breeding, dark morph
- 8. Juvenile, white morph
- 9. Juvenile, dark morph
- 10. Downy young
- 11. Adult non-breeding, white morph
- 12. Adult non-breeding, dark morph

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