

Order GRUIFORMES

Diverse assemblage of small to very large wading and terrestrial birds. Morphologically diverse, with few unifying characters within the Order. Anatomical details are summarized by Sibley & Ahlquist (1990). Possibly polyphyletic, though DNA comparisons indicate that the Order is monophyletic, composed of highly divergent groups that are more closely related to one another than to members of any other order (Sibley & Ahlquist 1990). The boundaries of the Order and relationships with other Orders and between families in this Order are uncertain (Sibley 1960; Sibley & Ahlquist 1972, 1990; Cracraft 1973; G.F. van Tets).

Peters, Wetmore (1960) and Storer (1971) recognized 12 families: Eurypygidae (monotypic Sun-bittern of tropical America); Otididae (bustards); Gruidae (cranes); Heliornithidae (finfoots of tropical Old and New World; three monotypic species); Aramididae (monotypic Limpkin of tropical and subtropical America); Psophiidae (trumpeters of tropical America; three species in single genus); Cariamidae (seriemas of central S. America; two monotypic genera); Rhynochetidae (monotypic Kagu of New Caledonia); Rallidae (crakes and rails); Mesitornithidae (mesites of Madagascar; three species in two genera); Pedionomidae (monotypic Plains-wanderer of Aust.); and Turnicidae (button-quails).

The Plains-wanderer is now recognized as being a charadriiform on evidence of morphology (Olson & Steadman 1981) and DNA-DNA hybridization (Sibley *et al.* 1988). Sibley *et al.* (1988) and Sibley & Ahlquist (1990) placed the Turnicidae in a separate Order, the Turniciformes *incertae sedis* (which we follow here; q.v.) and included Aramididae within the Heliornithidae but otherwise retained a similar arrangement of families. The Mesitornithidae, Rhynochetidae and Otididae have also been regarded as separate Orders.

Only Gruidae, Rallidae and Otididae occur in our region; other families are not considered further here.

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Family GRUIDAE cranes

Large to very large, long-necked and long-legged terrestrial and wading birds, superficially like the storks Ciconiidae. Divided into two groups or subfamilies: crowned cranes *Balearica* of Africa (1–2 species) and white, wattled or blue cranes *Grus*, *Bugeraus* and *Anthropoides* (13–15 species); Sibley & Monroe (1990) included *Bugeraus* and *Anthropoides* in *Grus*. On all continents except South America and Antarctica; also absent from Madagascar, Malayan and Polynesian islands and NZ (though Brolga recorded as vagrant there and Sarus Crane formerly recorded Malaysian Pen. and vagrant to Indonesia). Two breeding species in Aust. Centre of distribution (seven species) in central and e. Asia.

Bodies somewhat elongated; upright stance when resting or alert. Males often smaller than females. Neck, long; 19–20 cervical vertebrae. Wings, long and rather broad; 11 primaries (except in *Balearica*, which has ten); 19–25 secondaries; diastataxic; tertials and tertial coverts, long, dense and ornate, often curved. Fly strongly with head and neck stretched forward and legs trailing. Tail, short and rather broad, square-ended; 12 rectrices. Bill, longer than head, straight, compressed and pointed; nostrils, pervious in long deep nasal groove. Bare patches on crown and face in *Grus* and *Bugeraus*, with warts, wattles and lappets in some species, e.g. *Balearica*. Tongue, long. Legs, long; toes, short; hind toe (digit I), short and raised; claw of inner toe (digit II) elongated and used for fighting. Oil-gland, large, bi-lobed, feathered. Caeca, rather long. Tracheae, straight in *Balearica*, convoluted between clavicle and sternum in other genera. Feathers with aftershaft.

Adult plumage in various shades of grey or black and white; juveniles generally brown or brownish grey, without bare skin on head. Elaborate ornamental feathers on crown in *Balearica*; plumes on head and breast in *Anthropoides*; bare skin on head and wattles of *Grus* and *Bugeraus*, red, orange or black. Sexes and seasonal plumages alike. Moulting simultaneous with flightless period, except in *A. virgo* and *Balearica*; some species of *Grus*, perhaps all, unusual in replacing primaries and most secondaries once every 2 years or even longer intervals. Adult plumage attained in 1.5–3 years.

Typically associated with aquatic habitats and widely but locally distributed in undisturbed open country with wetlands; also on grasslands, pastures and even arid steppes with shrubs. Generally nest in open freshwater habitats. Many species have

declined in number this century, chiefly because habitats have been changed, disturbed or lost. Most species breeding at high latitudes in n. hemisphere are long-distance migrants; regular long-distance migration not reported in Brolga *Grus rubicundus* and Sarus Crane *G. antigone* in Aust. and not reported in African species (Urban *et al.* 1986). Movements usually diurnal, in flights of V-formation or in oblique lines, often at great heights; can travel long distances without assistance of thermal currents and, unlike storks, can cross large stretches of water. Omnivorous, taking all sorts of vegetation and a wide variety of animals, from invertebrates to small birds and mammals. Gregarious when not breeding; roost communally and retire to secluded areas for moult of remiges and flightless period. Pair-bond monogamous and probably lifelong. Both sexes probably defend territories but dispersal of breeding pairs is often so wide and sites of nests traditional that aggression between neighbours reduced. Antagonistic, pair-bonding and dancing displays often elaborate and spectacular. Voice, typically loud trumpeting with rolling guttural elements; often given in flight; also clatter with bills. Sleep with head and bill tucked into feathers at base of folded wings. Often at rest on one leg. When bathing, dip head to shoulders in shallow water, ruffle wings, then preen and oil. Scratch head directly, using middle claw. Rarely sunbathe. Pant (possibly gular flutter) to reduce heat; true yawning.

Breed seasonally. Nest, substantial pile of vegetable material on ground in open; often use same nest from year to year. Both sexes build. Eggs, ovate; smooth, slightly glossy; ground-colour usually dull; heavily blotched darker. Clutch-size, normally two. Replacements laid after loss of eggs. Lay at intervals of 1.5–4 days. Incubation starts with first egg; hatching asynchronous. Both sexes incubate but female most; both sexes have two large lateral and one small central brood-patches. Incubation period, 27–35 days. Both parents tend young, feeding bill-to-bill. Young hatched in down, precocial, nidifugous, walking and swimming soon after hatching; gradually learn to feed themselves. Parents may take charge of one chick each. Fledging period, 55–75 days; age of independence not known but young of migratory species accompany parents and may stay with them for first winter. First breed when 2–5 years old.

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Grus rubicundus Brolga

COLOUR PLATE FACING PAGE 456

Ardea rubicunda Perry 1810, *Arcana* 6: Pl. (22) — Botany Bay, New South Wales.

Grus is Latin for a crane; *rubicundus*, for 'red' or 'ruddy', referring to the colour about the heads of these birds.

OTHER ENGLISH NAMES Australian Crane, Native Companion.

MONOTYPIC

FIELD IDENTIFICATION Length: male, 105–134 cm, female 77–113 cm; wingspan 1.7–2.4 m; weight: male, 4.7–8.7 kg, female, 3.7–7.3 kg. Large light-grey crane with red head; similar in size and appearance to Sarus Crane *G. antigone*. Bill, long with blunt tip; head small in proportion to bill and rest of body; and neck and legs very long. Sexes similar; female smaller on average with smaller dewlap; separable when together. Juveniles and immatures separable.

Description Adult Most of head, bare, orange-red to red, with greyish-green cap, extending from forehead, over eye to hindcrown, and contrasting feathered blue-grey ear-spot; small but obvious dewlap tinged darker by black bristles. Neck and body, blue-grey with pale edging to feathers of upperparts, especially folded wings and mantle. Tertiaries, grey with darker shafts, dense and elongate, drooping over tail and primaries of folded wing. Upperwing: innerwing, mostly grey with broad pale-grey wing-bar across greater secondary coverts; outerwing, black. Underwing,

pale grey with thin blackish trailing-edge to secondaries and inner primaries, and black outer primaries, forming dark wing-tip. Bill, olive-grey. Iris, yellow to reddish orange. Legs, dark-grey to blackish. **Juvenile** Head, feathered, pale grey, sometimes with buff tinge; tertiaries shorter than in adult. Bill, buff with olive-grey tinge that spreads from tip with age. Large orbital ring, pale yellow. Iris, dark brown becoming dark orange in older birds. Legs, dark grey. **Immature** From second to third year, gradually assume adult features. Differ from adults in paler, more orange skin on head; feathering of head gradually lost. Attain adult colour of bill and iris before all feathers lost from head. Slowly assume reddish cap, though rest of head slightly feathered and grey. Cap then turns grey and rest of head, reddish, dewlap developing and increasing in size. Bill darkens from light brownish to adult colour. Iris lightens from grey to honey-colour.

Similar species Can be confused only with slightly larger **Sarus Crane**; adult Sarus Crane differs by dark-pink legs; larger

area of red on head, extending onto lores and upper third of neck; no dewlap; pale-grey chin; underparts slightly darker than upperparts (slightly paler in Brolga); no or indistinct trailing-edge to secondaries. Juveniles and immatures differ as above, except that subadult Sarus can have less red skin on head than adults. Call of Channel-billed Cuckoo *Scythrops novaehollandiae* remarkably similar, and can mislead if bird not seen; call of Channel-billed more highly pitched and with more of a laughing quality.

Occur in open swamps, coastal mudflats, grassland, crops and in deserts close to water. In flocks before breeding season, then pair off when breeding and with attendant chicks after hatching. When pairing, flocks and pairs perform elaborate dances, which include leaping up and down, jerking neck up and backwards with wings half stretched out, and giving bugling calls throughout. Walk with slow and steady gait. In flight, bill conspicuous, drooping slightly, giving a gently decurved appearance; head small, only slightly broader than neck; long neck stretched out, sagging in centre; slow purposeful wing-beats, on very broad wings with obvious primaries and prominent fingers; legs and feet extending well beyond tail. Often fly in flocks and in 'V' formation; sometimes spiral high in thermals. Omnivorous, picking at ground for food. Voice a loud trumpeting call, very distinctive apart from Sarus Crane and Channel-billed Cuckoo.

HABITAT Terrestrial wetlands, grasslands and woodlands of tropical and temperate Aust.; less common in arid and semi-arid regions. In se. inland Aust., restricted to lowland environments. In n. Aust., most common on coastal and subcoastal plains; recorded regularly to c. 750 m asl, Atherton Tablelands (Bravery 1970; Gill 1970).

In n. Aust.: during dry season, concentrated on coastal and subcoastal swamps dominated by spikerush *Eleocharis* (Lavery 1964; Crawford 1972; Walkinshaw 1973; Garnett & Bredl 1985; Schulz 1989), feeding on tubers of Bulkuru *Eleocharis dulcis* and other sedges such as *Cyperus* and *Eleocharis* (Lavery 1964; Walkinshaw 1973). Other dry-season habitats: shallow freshwater marshes; permanent billabongs; deep water impoundments; saltpans, saltmarshes; cultivation paddocks; irrigated pastures and crops; grasslands; open woodland and swamp woodland (McLennan 1917; Lavery & Blackman 1969; Bravery 1970; Boekel 1980; Storr 1980; McKean 1985; Gowland 1989; Schulz 1989). Occasionally recorded from creeks and estuaries with mangroves (Hughes & Blackman 1973; Storr 1980). Move to different habitats as dry season progresses: at end of wet season at Townsville, found on shallow swamps, rarely on grasslands or lagoons; subsequently move to slightly deeper swamps when shallow swamps dry out; then to deep lagoons when swamps dry out, birds feeding in adjacent grasslands (Lavery 1964). In wet season, disperse to well-vegetated grasslands and shallow wetlands (Archibald & Swengel 1985; Gowland 1989). May congregate in early wet season on shallow flooded depressions to feed on tubers of emergent sedges (Archibald & Swengel 1985). Preferred breeding habitat in Gulf of Carpentaria, open wetlands 1–2 km across with shallow water and scattered trees: 12/25 nests located here; another six in slightly elevated ridge wetlands, where narrow wetlands 30–100 m wide extend for up to several kilometres between wooded ridges; six in open wetlands abutting ridges; and one next to small upland ponds (Archibald & Swengel 1985). Also recorded nesting on blacksoil plains, grasslands interspersed with ephemeral swamps, close to lagoons (Aust. NRS), floodplains, grassy ridges and beside intermittent watercourses in eucalypt woodland (Schulz 1989).

Inland populations mostly in L. Eyre Drainage Basin, where recorded from bore overflows, creeks, canegrass *Eragrostis*

australasica swamps, sedge-swamps (Terrill & Rix 1950; Condon 1962; Badman 1979), drainage channels, adjacent floodplains, shrublands (Wyndham 1978) and blacksoil plains (Aust. NRS). In Simpson Desert, claypan country with semi-permanent waterhole, at bores and waterholes (Wilson 1974). Recorded nesting near one bore in successive years (Badman 1979).

In SE, populations generally in different habitats in breeding and non-breeding seasons. In breeding season, (July–Dec.), mostly near shallow freshwater marshes or freshwater meadows: prefer shallow marshes <0.5 m deep, with emergent vegetation. Also use: freshwater meadows less than 0.3 m deep dominated by annual herbs or rushes, (e.g. *Carex* and *Juncus*), tussock-grass *Poa* and Australian Sweet-grass *Glyceria australis* and Spike-rush *Eleocharis*; freshwater meadows interspersed or bordered by River Red Gums *Eucalyptus camaldulensis* or other eucalypts; occasionally in shallow freshwater meadows dominated by Lignum *Muehlenbeckia cunninghamii*, and deep freshwater marshes with much growth of Common Sword-sedge or canegrass on n. plains, and Australian Sweet-grass on w. plains (Corrick 1982; Arnol *et al.* 1984; Bransbury 1991; M. McIntyre). During non-breeding season (late Dec. to May), congregate near deep (<2 m) permanent freshwater marshes; mostly forage in nearby fields of crop stubble, improved pastures, potato fallow or potato waste (Arnol *et al.* 1984; Bransbury 1991); occasionally forage in littoral zones of freshwater marshes; use marshes for roosting and drinking (Arnol *et al.* 1984).

Recorded throughout Aust. in shallow freshwater wetlands within eucalypt forest; shallow wetlands in open areas surrounded by pine *Pinus* plantations (Bransbury 1991); broad valleys between sandstone escarpments (Schodde 1976); infestations of Prickly Pear *Opuntia stricta* (Morse 1922); low wet heathlands (40–80 cm high) (McFarland 1988); chenopod shrublands (Sonter *et al.* 1984); estuarine sandbanks (Mayo 1931) and islands offshore (MacGillivray 1910; Smith *et al.* 1978).

Prefer to forage in moist mud for plant tubers (Lavery & Blackman 1969; Arnol *et al.* 1984; Archibald & Swengel 1985); change habitats in parts as mud dries out and food no longer available. Seasonal feeding areas in Vic.: Jan.–Mar., feed in cereal crop residues, dry pasture, permanent freshwater marsh; Apr.–June, in moist marsh bed, pasture, crop residue, permanent freshwater marsh; July–Sept., marsh and wet pasture; Oct.–Dec., marsh, moist pasture and cereal crop (Arnol *et al.* 1984). Also forced to change habitats when wetlands dry out as need to drink and bathe daily (Walkinshaw 1973). Tend to roost in shallow water (Archibald & Swengel 1985; Gowland 1989); sometimes on sandbanks or small offshore islands; during day, beneath clumps of *Melaleuca* fringing floodplains (Schulz 1989).

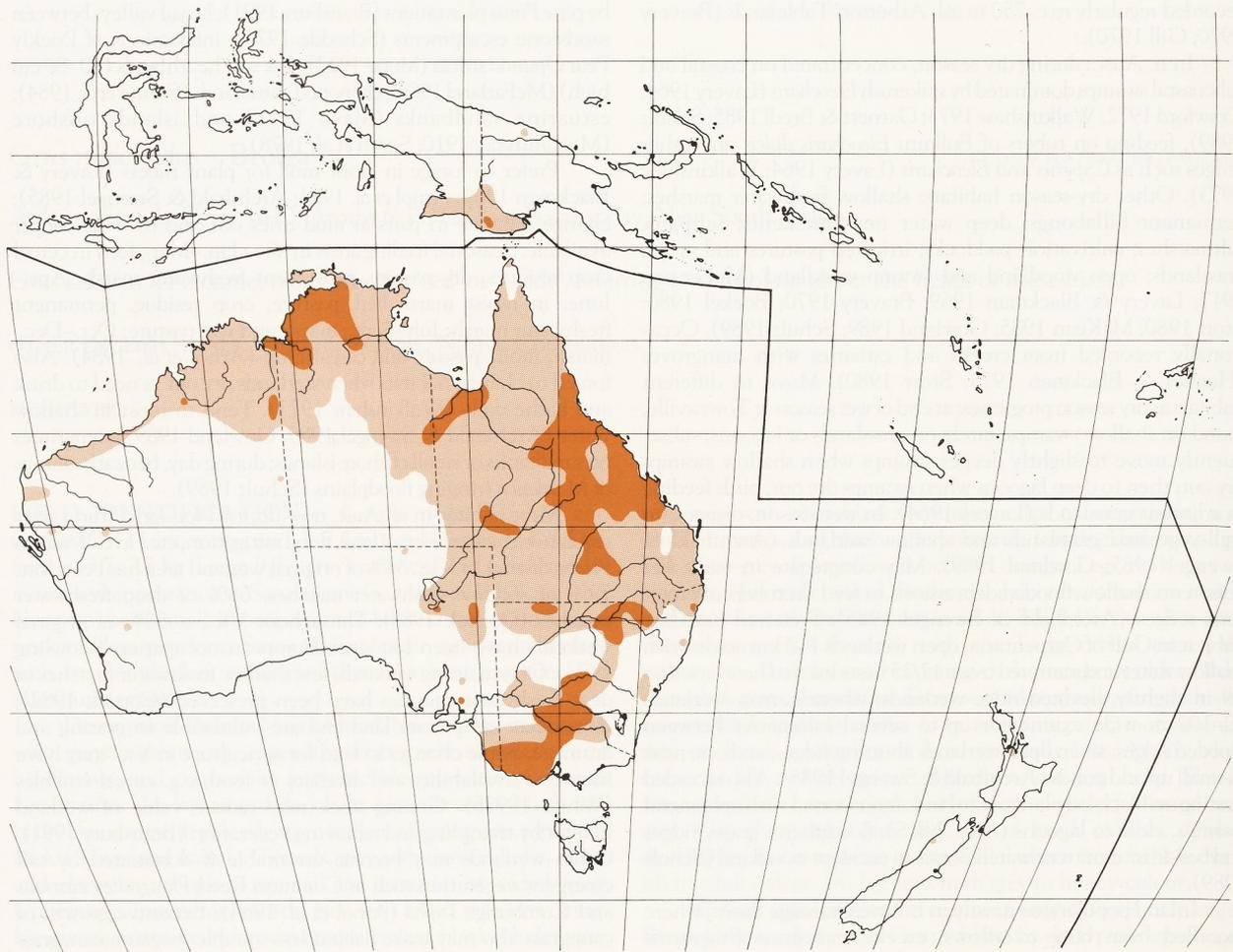
Most habitat in se. Aust. now drained for agriculture, river regulation, reclamation of land, flood mitigation, etc.; in e. Western Plains district of Vic., 34% of original wetland area has been lost, 79% of shallow freshwater marshes, 66% of deep freshwater marshes (Corrick 1982). Throughout Vic., c. 50% of original wetlands have been lost since European occupation (Cowling 1973). Of remaining wetlands, few shallow freshwater marshes or deep freshwater marshes have been preserved (Corrick 1982); most occur on private land and are vulnerable to grazing and drainage. Some changes to land for agriculture in Vic. may have increased availability and diversity of food, e.g. cereal stubbles (White 1992b). Grazing stock may reduce value of wetland habitat by trampling and removing vegetation (Bransbury 1991). Other wetlands may become unsuitable if dominated by tall emergent vegetation such as Common Reed *Phragmites australis* and Cumbungi *Typha* (Arnol *et al.* 1984). Excessive growth of canegrass also may make habitat less suitable, because canegrass

provides dense cover for foxes (Arnol *et al.* 1984). In n. Aust., impoundments may have increased area of potential breeding habitat (Lavery & Blackman 1969) but more likely that construction of impoundments has flooded areas of otherwise suitable habitat. Agriculture in n. Aust. has also led to loss of many wetlands dominated by sedges by conversion to croplands (Lavery & Blackman 1969) or other developments. Drainage for agriculture and urban development likewise result in destruction of habitat near towns along e. coast and near Darwin. Grazing by stock may be a threat in Gulf of Carpentaria.

DISTRIBUTION AND POPULATION Widespread and generally abundant in n. and e. Aust., especially ne. Qld from St Lawrence district to Princess Charlotte Bay (Aust. Atlas). Not recorded Tas. In Trans-Fly region and Sepik R., New Guinea (Rand & Gilliard 1967; Coates 1985). Accidental NZ (McKenzie & Cunningham 1952; Westerskov 1968). Unsuccessfully introduced to Fiji before 1926 (Blackburn 1971; Long 1981).

Aust. Qld Widespread throughout; less common n. C. York Pen. and SE (Roberts 1979; Aust. Atlas). Two records Torres Str. islands: Friday I., 1889; Horn I., Aug., Oct. 1978 (Draffan *et al.* 1983). Single record, Willis I., Coral Sea, Apr. 1923 (Hogan 1925). Recorded rarely Fraser, Stradbroke, Bribie and Coolooloa Is (Barry & Vernon 1977). **NSW** Along major river systems on nw. slopes of Great Dividing Ra. and Riverina. Rare E of Great Dividing Ra., S of 30°S, central district between Darling, Bogan and Lachlan Rs, and W of Darling R. Single

record Canberra, 1978 (Hobbs 1961; Gregory-Smith 1979). Erroneous record at Armidale, June 1982 (Aust. Atlas). **Vic.** W. plains, mainly S of 37°S, W of 144°E, with scattered records N to Horsham; few records Mildura district; n. plains between Kerang, Bendigo and Wangaratta; scattered ne. records (Arnol *et al.* 1984; Sonter *et al.* 1984; Vic. Atlas; J.M. Peter). **SA** Mainly in NE, S to 30°S; scattered records elsewhere in E and SE at Plumbago, Laura, Minlaton (Aust. Atlas); Adelaide (Glover 1968–69); Frances (Aust. Atlas); Bool Lagoon district between Naracoorte and Mt Gambier (Condon 1962; Bransbury 1991; Aust. Atlas); Kangaroo I. (Mellor 1920; Sutton 1926); Hindmarsh I. (Newell 1927). Dalhousie Springs in Simpson Desert: singles, May 1977, July 1977, June 1979, Jan.–June 1980 (Aust. Atlas); two, 23 July 1979 (Badman 1979). **WA** Sparse in coastal and subcoastal areas between Carnarvon and Broome (Aust. Atlas). Two (11 Aug. 1990), and three (20 Aug. 1990), recorded Lyndon R. Crossing, c. 25 km N of Minilya (Edinger 1991; Weeldenburg 1991). Widespread throughout inland Kimberley Division N of 20°S, including continental islands (Storr 1980; Aust. Atlas); common at Anna Plains and L. Gregory (Jaensch 1989). In Great Sandy Desert, flocks present 1979–80 at L. Gregory and Bulbi Plain (Start & Fuller 1983). Single, L. Mackay in Gibson Res., 22–29 July 1980 (Aust. Atlas); singles recorded Beacon in SW on 27 Aug. 1952 (Serventy 1953). **NT** Widespread N of 20°S; in E, extend S to MacDonald Downs and Arooto Bore (Storr 1977; Aust. Atlas). Few records Melville I., Gove and Groote Eylandt, Cobourg Pen., Wessel Is (Thompson & Goodfellow in prep.);



Pellew I. (Schodde 1976). Tanami Desert: singles at Rabbit Flat, 1–5 July 1980; 3–4 May 1981; at The Granites, 26 Mar.–12 Apr. 1981 (Aust. Atlas).

NZ Accidental; single, Mar.–May 1947, Clevedon (McKenzie & Cunningham 1952); single, Punakaiki, Westland, 8 Jan. 1968 (Westerskov 1968).

Occasionally recorded beyond normal range. In 1896–97, many recorded in Berrigan and Wellington districts of NSW (North). Pair recorded Wangaratta, 1919, first sighting in 16 years, possibly because inland NSW drought-stricken (Cole 1920). In 1952, after severe drought in Kimberley Division, several records from between Eighty Mile Beach and Carnarvon district, c. 1050 km farther S than previous records (Serventy 1953).

Breeding Qld Gulf of Carpentaria between Gregory and Flinders Rs (Aust Atlas): mouth of Normanby R., C. York Pen. mainly in area bounded by Cairns, Rockhampton and Charleville districts. Scattered records elsewhere in SE, S, SW and W (Aust. Atlas). **NSW** Few records scattered throughout range. **Vic.** Throughout range (White 1983; Vic. Atlas; Aust. Atlas). **SA** Most records in L. Eyre drainage basin (Aust. Atlas). Also recorded at L. Frome (McGilp 1923); Coongie Ls (Reid & Gillen 1988); near Adelaide (Glover 1968–69); Bool Lagoon (Aust. Atlas), and in area between Penola, Kalangadoo and Tarpeena (Bransbury 1991). **WA** Few records in Kimberley Division: between Broome, Ord R. mouth and Sturt Ck region (Aust. Atlas). **NT** Between Victoria R. region and Arnhem Land, and S to near Roper R. Downs (Frith & Davies 1961; Schulz 1989; Thompson & Goodfellow in prep.; Aust. Atlas).

Between 1900 and 1976 range generally stable, though now rarely reported on NSW coast (Aust. Atlas). In Vic., former distribution included: coastal plains of e. Gippsland; plains round Melbourne and Port Phillip Bay; French I. and Westernport; Rutherglen in NE (White 1983); once common on plains N of Bendigo, but reported that only a few remained by 1927 (Wilson 1927). Historical records for Wilson's Prom. (Cooper 1974). In SA, 'plentiful' 1836 in Reed Beds district in S round Adelaide, but gone by 1919 (White 1919). Formerly more widespread in se. SA (Terrill & Rix 1950; Condon 1959); contraction possibly because severe droughts occurred at turn of century (Serventy 1977).

Generally abundant n. Aust.; uncommon se. and inland Aust. (Gowland 1989). Vulnerable SA (Reid & Gillen 1988). Range reduced se. Aust. by draining wetlands for agriculture and illegal shooting (Gowland 1989). Increase in numbers recorded in Riverland and Sunraysia district Vic. and NSW, 1971–83, peaking 1980–83 (Sontter *et al.* 1984). Rare in sw. Kimberley (Johnstone *et al.* 1981).

Estimated 12,000 birds at Cromarty, Qld (Lavery & Blackman 1969); 35 pairs breeding at Morr Morr Stn, Qld (31 km²; Archibald & Swengel 1985). Estimated 600–650 birds in Vic.; as few as 50–100 in n. Vic. (White 1983). Of 635 recorded on a single-day count in Vic., 566 were in flocks, and remainder in pairs or small family groups (White 1992a). Total number flocking in se. SA, c. 150–250 birds, with breeding population of 10–20 pairs (Bransbury 1991). Between 1978 and 1981, \leq 2000 birds in 600 km² of Ord R. Irrigation Area (Gowland 1989). Flocks of 1000s occurring on Townsville Town Common reduced to c. 500 since much of freshwater swamp of Bohle Basin drained or built up (Garnett & Cox 1988). At separate sites in Bohle R. basin (453 ha), in 1959–63, maximum population c. 2650 (Lavery 1964).

Minor pest of cereal crops and improved pasture grasses (Lavery 1964). In past, many died from eating poisoned grain (Barrett 1923; Walkinshaw 1973; White 1983); large numbers

still occasionally poisoned in Ord R. Irrigation Area (Gowland 1989). Also shot illegally (Barrett 1923; White 1983). Eaten and sold as game in late nineteenth century (Campbell). Young birds taken by foxes, and reductions of some local populations have been attributed to predation (Morse 1922; White 1983). A few killed by collisions with fences and powerlines (White 1983). Prey on crop-feeding insects (Gowland 1989). Numbers in Vic. reduced through agricultural development reducing freshwater wetlands (White 1983). Single record of Brolga attacking a man, who, pecked on posterior, contracted in wound a new anaerobe, *Clostridium brolgaseptica*; attacking bird was beaten off by a half-empty bottle of Ord Ale, after which it died of a cerebral haemorrhage (Stanley *et al.* 1972).

MOVEMENTS Partly migratory; some dispersive movements. In n. Aust., regularly move between dry-season refuges and wet-season breeding sites. Populations more concentrated in dry season, as many as 3500 birds gathering at favoured sites (Gowland 1989; Jaensch 1989); disperse during wet season, moving farther inland to follow rain (Crawford 1972; Walkinshaw 1973; Schulz 1989). Scale of movements poorly known. Dry-season influxes of adult and young birds recorded from Atherton Tablelands (May–Dec.), coastal swamps near Townsville, w. C. York Pen. (June–Oct.), Gulf of Carpentaria, Top End, Ord R. Irrigation Area (May–Oct.) and coastal plains of Kimberley (Bravery 1970; Crawford 1972; Walkinshaw 1973; Garnett & Bredl 1985; Gowland 1989; Jaensch 1989; Schulz 1989). Not known where any of these populations go at start of wet. Breeding records suggest that most movements local (Garnett & Cox 1988; Gowland 1989), though populations on Atherton Tablelands thought to migrate to Gulf or inland (Walkinshaw 1973; Archibald & Swengel 1985). Some resident birds recorded from Townsville, w. Cape York Pen., Gulf of Carpentaria, Rockhampton district and the Kimberley (Schodde 1976; Longmore 1978; Garnett & Bredl 1985; Garnett & Cox 1988; Gowland 1989).

Patterns of dispersal of inland populations poorly known: probably resident within L. Eyre drainage system; birds moving locally in response to rainfall, availability of water and drought (e.g. McGilp 1923). Some populations resident (Reid & Gillen 1988); some show strong fidelity to breeding sites (Badman 1979). Perhaps move locally between bores and waterholes, pairs returning each year to traditional breeding grounds (Badman 1979).

In se. Aust., regularly move between breeding and non-breeding sites; population concentrated at two or three non-breeding localities (Arnol *et al.* 1984; Bransbury 1991). Breeding and non-breeding sites appear traditional (Arnol *et al.* 1984). However, movements partly determined by rainfall. Generally breed between July and Dec., forming flocks at non-breeding grounds late Dec. to early May; dispersal to non-breeding wetlands partly prompted by drying of shallow freshwater marshes used for breeding. Adults and young disperse if season very dry, and some non-breeding wetlands dry out; however, if season very wet, may remain at breeding grounds throughout year (Arnol *et al.* 1984; Bransbury 1991). Immatures and juveniles may disperse from non-breeding grounds before adults (Arnol *et al.* 1984); not known where they spend following season.

Patterns of dispersal strongly influenced by rainfall and drought. At Ord R. Irrigation Area, one of first species to leave area, departure correlated with onset of first wet-season storms and filling of subcoastal marshes (Gowland 1989). However, if wet season fails, as in 1968–69, birds may remain in dry-season refuges; little breeding will occur (Walkinshaw 1973). Highest dry-season and wet-season totals recorded from Townsville in 1961; one of driest years on record in n. Qld (Lavery 1964).

Elsewhere, drought may cause aseasonal movement: during severe drought in 1900–2, flocks recorded flying W and SW over Murray R.; considered to be migrating from dry inland wetlands to wetlands at mouth of Murray R. (Le Souëf 1903b; Simpson 1903). Recorded from some inland sites only after heavy rain (McGilp 1923; Johnstone *et al.* 1981); significant s. extensions of range reported from WA in 1952, after severe inland and n. drought (Serventy 1953); recent range extensions reported from Gascoyne district in Aug. 1990, after unusually dry conditions in Kimberley, very wet conditions in Gascoyne (Edinger 1991; Weeldenburg 1991); recorded from Illawarra district only in 1957, a drought year farther inland (Gibson 1977). May also move locally in response to availability of food; flocks occasionally reported from central-w. NSW, just after wheat sown (Austin 1907). On Atherton Tablelands, move between roosting site at swamp and newly ploughed cultivation paddocks (Archibald & Swengel 1985). NZ records show some birds may wander far beyond usual range.

FOOD Omnivorous. Mostly crops, especially sorghum grain *Sorghum vulgare* (Lavery 1964; Gowland 1989) and maize *Zea mays* (Lavery 1964), and tubers of Bulkuru *Eleocharis dulcis* in n. Qld (Lavery & Blackman 1969; Archibald & Swengel 1985). Also, variety of insects, spiders, freshwater and marine molluscs, crustaceans, small mammals and reptiles, and frogs, all parts of both wetland and dryland plants growing as agricultural crops and improved pastures (Gowland 1989). Drink fresh and salt water (Hughes & Blackman 1973). During drought, recorded feeding on Prickly Pear *Opuntia* (D'Ombra 1921; Morse 1922). At Ord R. Irrigation Area, sorghum main food from mid-dry season (June) to early wet season (Jan.). In wet and early dry season, main foods rice, peanuts, river-grass and grasshoppers (Gowland 1989). Main diurnal feeding begins in hour after first light; forage all day but mainly early morning and late evening (Gowland 1989). During morning, search intensely; during afternoon, search widely (Lavery & Blackman 1969). After morning feeding, sometimes congregate in flooded rice bays and eat small insects. Flocks stop roosting at midday in rice fields just before appearance of panicles (Gowland 1989). **Behaviour** Walk slowly with head down (Archibald & Swengel 1985); forage by grazing and digging, preferably on moist ground (Lavery & Blackman 1969). Dig for tubers 8–15 cm deep (Walkinshaw 1973). Use bill as hammer or spear to kill small vertebrates, e.g. snakes and frogs; also as tool to excavate roots and other vegetables (Rand & Gilliard 1967). Two birds observed knee deep in water, probing mud; heads under water for average of 7 s, once up to 20 s (Mathews). One bird in NT observed stabbing bill into shallow pool; lifted head with small fish in mandibles; put head back and swallowed fish (S.M. Clegg). Take entire panicles in standing crops of sorghum, rice, wheat and commercial millet; in stubble, forage for seeds on ground or from low panicles that were not harvested; maize usually consumed from stubble; take peanuts by probing with bill round base of recently watered, nearly mature plants; penetrate standing grain crops only where crops are neither dense nor tall; in tall dense crops, feed only at edge; occasionally reported feeding on recently sown and emerged crops by pulling out young seedlings to eat grain (Gowland 1989). Drink by taking a sip then raising head to swallow (Alexander 1923). Captive pair observed preying on wild House Mice *Mus musculus*. Male jabbed bill into grass 30 cm tall (75 jabs/min) then lifted neck to 70° angle with young Mouse impaled on bill. Shook head until Mouse fell, retrieved it, lifted head and neck to 80° and swallowed. Female stabbed ground at 55 jabs/min at same time as male. Did not move during male's predatory bout, then moved c. 1 m away from him,

lowered and turned head quickly from side to side then jabbed ground. Lifted head with adult Mouse in mandibles. Tossed prey in air, then caught it in bill before swallowing. Only incidence of predation observed, but pair spent most of their time near site of capture during next 4 days (Brown & Archibald 1977).

Adult No detailed studies. Ord R. Irrigation Area, n. WA (10,596 feeding observations in early morning, 1978–81; Gowland 1989): grain stubbles 54.3% no.; germinating and recently emerged grain crops 6.2%; ripening grain crops 25.1%; of crops, sorghum 59.1%. **Other records** **Plants** Plant remains, seeds, tubers (Barker & Vestjens); sds, fru., bulbous roots (Gould); green plant materials (McFarland 1988); swamp-grass sds (Chisholm 1944); grass (Mathews 1910; Chisholm 1944; North); *Eleocharis* bulbs (J.L. McKean); bluebush, *Chenopodiaceae* saltbush (Sontter *et al.* 1984); grain, soft ends of water-weeds and newly planted grain (North); corn, wheat, rice, peanuts (Walkinshaw 1973). **Animals** Annelids: worms (North). Molluscs: freshwater and marine (Gowland 1989). Crustaceans (Gowland 1989); Decapods: freshwater crayfish *Cherax depressus*, fiddler crabs *Uca* (Walkinshaw 1973). Arachnids: spiders (Gowland 1989). Insects (Lavery 1964; Gowland 1989; Gould; North; Barker & Vestjens); Orthoptera (Barker & Vestjens): crickets (Reid 1976); Acrididae/Tettigoniidae: grasshoppers *Atractomorpha crenaticeps* (Anon. 1926; Lavery & Blackman 1969; Walkinshaw 1973; Barker & Vestjens); Hemiptera: leafhoppers *Melampusalta* (Lavery & Blackman 1969); Coleoptera (Chisholm 1944); Lepidoptera: Noctuidae: *Spodoptera* (Barker & Vestjens); Hymenoptera: Formicidae: army ants (Roberts 1936). Fish (North; S.M. Clegg): mudskippers *Periophthalmus vulgaris* (Walkinshaw 1973). Frogs (Rand & Gilliard 1967; Gowland 1989; North; Mathews). Reptiles (North): lizards (Gould); snakes (Rand & Gilliard 1967; Campbell; North). Mammals: House Mice *Mus musculus*, in captivity (Brown & Archibald 1977). Pebbles (Mathews 1910; Chisholm 1944); teeth, bones and barbed wire (Lavery & Blackman 1969).

Young Indirect evidence suggests parents feed insects to downy young (Lavery & Blackman 1969). **Intake** About 150 g food/day; mainly grain (Gowland 1989).

SOCIAL ORGANIZATION Studied near Kununurra, Ord R. Irrigation Area, WA (Archibald & Swengel 1985; Gowland 1989); Townsville, Qld (Lavery 1964; Walkinshaw 1973; Archibald & Swengel 1985); and Normanton, Qld (Archibald & Swengel 1985). Gregarious; in pairs or flocks, occasionally solitary. Parties usually made up of 2–4 birds, often families with one or two young, though some groups thought to be unrelated (Walkinshaw 1973). In non-breeding season, large flocks may form at feeding, and communal roosting or loafing sites (e.g. Austin 1907; Walkinshaw 1973; SA Bird Reps 1968–69, 1975); these large flocks show little co-ordination and seem to be composed of small groups, e.g. families appear to remain separate, and flocks split into small feeding groups when birds leave roosts each morning (Walkinshaw 1973; Archibald & Swengel 1985; Gowland 1989). When occupying same areas as Sarus Cranes, each species seems to remain separate (Archibald & Swengel 1985). **Flocking** Generally form flocks outside breeding season, and disperse as pairs to breed, but regularity of flocking cycle also related to rainfall, availability of surface water, and distribution. In s. Aust., adults and young move to traditional flocking areas in summer–autumn, then all disperse May–June to breeding areas; immatures may disperse as separate flocks; from Aug. to Feb., young birds seen with parents at or near breeding sites; a few adults with offspring may remain near breeding sites throughout flocking season. At one flocking site in Apr., estimated that 10% of birds were immatures or juveniles (White 1983; Arnol *et al.* 1984;

Bransbury 1991). Flocking more spectacular in n. Aust. where pattern of dry (non-breeding) and wet (breeding) seasons apparent in some regions. **The Dry** With onset of the Dry, Apr.–May, shortly after chicks fledge (Archibald & Swengel 1985; Gowland 1989), parents and young start congregating in remaining, usually coastal, wetlands; in some areas, increase rapid (Lavery 1964), and in others, not so (Gowland 1989). At some wetlands, form very large concentrations of between several hundred to 1000, feeding or roosting together; largest concentration recorded, 12,000 birds (Lavery 1964; Lavery & Blackman 1969; Walkinshaw 1973; Garnett & Bredl 1985; Gowland 1989; Aust. Atlas). Though most birds congregate, some smaller groups stay inland on remaining wetlands (Walkinshaw 1973); in some regions, e.g. Kimberley Division, commonly gather into small flocks and concentrate in refuges with most favourable conditions (Storr 1980). Numbers peak in WA, Aug.–Oct. (Gowland 1989); in Qld, June–Nov. (Lavery 1964). Concentrations decline if wetlands dry out, and birds leave in small flocks (Lavery 1964; Blackman 1983); birds disperse with onset of the Wet (Archibald & Swengel 1985). **The Wet** Small scattered populations seen as single birds, pairs, family groups, or parties (Lavery 1964; Walkinshaw 1973; Storr 1980; Gowland 1989); in feeding flock of 1000 observed at start of the Wet, most birds seemed paired; flock did not include juveniles; pairs later dispersed to establish territories (Archibald & Swengel 1985). Some non-breeding subadults remained together in small flocks (Gowland 1989); some mixing of these with Sarus Cranes (q.v. for details) (Archibald & Swengel 1985). **Other records** **Qld** Generally 5–8 (Alexander 1923; Crossman 1910; North); late Oct. to early Nov., usually pairs, family, or small groups, but up to 40, and early Jan., up to c. 700 (Walkinshaw 1973); often 8–10, but up to 40–50 (Berney 1907); disperse in summer, though flocks of 150+ recorded (Longmore 1978). **NSW** 30–50 (Gould; North); up to 16 (Hobbs 1961); 25 in Oct. and 82 in Feb. (NSW Bird Reps 1976, 1983). **Vic.** At flocking sites, up to 200 (Arnol *et al.* 1984). **SA:** in past, usually c. 80, up to 500 (Bransbury 1991); occasionally 150+ (Attwill 1972), also see Bransbury (1991). **WA** Pilbara region, small parties up to 15, and rarely up to 100 in late July and early Nov. (Storr 1984); in NW, in Aug., generally 2–3, occasionally 12–15, and one of 100 (Serventy 1953); 2–25 (Start & Fuller 1983). **NT** In Kakadu, up to 550 in the Dry (Schulz 1989). See below for flock-sizes at roosts.

Bonds Lifelong monogamy (Arnol *et al.* 1984). Able to breed in third year (Lavery & Blackman 1969; Gowland 1989); pair-bond forms when 3–4 years old, and new pairs seek breeding territories when 4–5 years old (Arnol *et al.* 1984). Pair-formation and Courtship possibly occur within flocks (White 1983), particularly just before birds disperse to nesting territories; near Normanton many seemed paired by about mid-Jan., though behaviour of some suggested they were still soliciting partners (Archibald & Swengel 1985). **Parental care** Pairs share nest-building, incubation and rearing young (Walkinshaw 1973; Fisher 1980; Arnol *et al.* 1984); in captivity, female appears to take greater share of incubation, particularly in early stages (Astley 1901; Campbell).

Breeding dispersion Solitary nesting in territories (Gowland 1989; Schulz 1989; NRS); one record of large colony containing 193 Brolga nests and 114 Sarus Crane nests (Aust. NRS). In n. Aust., nests concentrated in suitable locations (Archibald & Swengel 1985), but not considered colonial. In s. Aust., nesting density depends on availability of suitable wetlands during breeding season (Arnol *et al.* 1984); in past, not uncommon for two pairs to build in same swamp, and once three nests with eggs found in swamp c. 0.5 km² (Campbell). **Territories** During breeding

season male defends tight territory against intruders; results in low numbers of breeding pairs per unit area of wetland in some areas (Astley 1901; Archibald & Swengel 1985; Gowland 1989); in Vic., appear to maintain territories up to 256 ha, including several marshes (Arnol *et al.* 1984).

Roosting Available information refers only to non-breeding season, particularly at communal roosts. Nocturnal, but also loaf about midday. Number of birds in roost ranges from small family groups to large flocks of over 1000 (e.g. Austin 1907; MacGillivray 1914; Walkinshaw 1973; Gowland 1989; Schulz 1989); during the Dry in Ord R. Irrigation Area, birds tend to form one or two large flocks, though a few families remain apart (Gowland 1989). Arrive and depart communal roosts singly or in groups of 2–8; occasionally larger groups of 10 or 20–33 (e.g. MacGillivray 1914; Walkinshaw 1973; Gowland 1989; Campbell). Sites always associated with wetlands, fresh or saline; type of wetland used may vary throughout year; usually in shallow water (Hughes & Blackman 1973; Arnol *et al.* 1984; Gowland 1989). Sites include: among grass in shallow freshwater wetlands; muddy and intertidal flats, sometimes covered with a few centimetres of salt water (Walkinshaw 1973); swamps; sandbars; flooded growing rice crops (when crop matures, no longer used); flooded irrigated pastures or stubble (Gowland 1989); round dams (Austin 1907). Departure: at Townsville, Qld, in Dec., began calling 04:40, usually pairs giving Unison Call; started leaving 04:45; most walked to a feeding area c. 1 km away, though some flew out; occasionally bird or pair Danced or called on leaving; most left by 05:40 (Walkinshaw 1973). In n. WA, groups start to fly out about first light, c. 40 min before sunrise; leave rather quickly and most gone before sunrise (Gowland 1989). Arrival at roost: at Townsville, Qld, in Nov., birds moved to feeding area near roost-site; groups of 2–16 started flying into roost-site about 30 min before sunset and stopped 30 min later; many called on and after arrival (Walkinshaw 1973). Loaf in groups during middle of day and feed in morning and afternoon; diurnal loafing most obvious late in the Dry, when temperatures high (Walkinshaw 1973; Archibald & Swengel 1985; Gowland 1989; Schulz 1989). In n. WA, feed for only about an hour after leaving roost then congregate again (Gowland 1989); at other locations after morning feeding, each family walks or flies back to roost-site, and birds immediately wash mud off bills (Walkinshaw 1973). Sites other than nocturnal roosts may be used for loafing; under melaleucas fringing dry open floodplain (Schulz 1989); in late dry season in Ord R. Irrigation Area, mainly use flooded rice-bays (though these used less as rice crop matures), flooded pasture-bays, or low-growing irrigated crops; preference for flooded sites more apparent in hotter seasons than in cooler ones (Gowland 1989).

SOCIAL BEHAVIOUR No detailed studies; only anecdotal material. Flocks fly in distinctive V-formation (Le Soeuf 1903b; Simpson 1903; North) and periodically single bird may call (Walkinshaw 1973); also recorded flying single file (NSW Bird Rep. 1975). If disturbed, often Dance (see below) while walking away from intruder (Alexander 1923; Mayo 1931; Walkinshaw 1973; Coates 1985); if flock disturbed, calling spreads throughout; seems that only one bird in each family calls (Walkinshaw 1973). At midday, if hot, may ride thermals to high altitudes for several hours or bathe in lakes (Archibald & Swengel 1985); calling often heard from soaring birds (Berney 1970; Lavery & Blackman 1969).

Agonistic behaviour Within family groups, individuals roost or feed 1.5–2 m from others; within flocks, each family group 2–7.5 m from closest neighbours (Walkinshaw 1973). Male defends territory, mate and young, and will attack intruding



Fig. 1 Unison Call



Fig. 2 Dancing Display

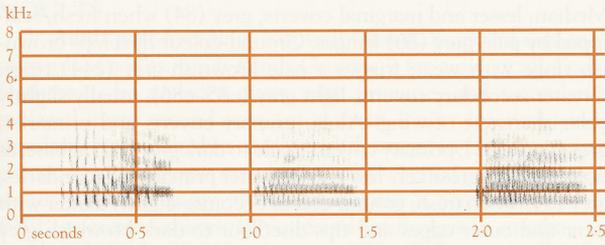
single birds or groups (Walkinshaw 1973; Gowland 1989). **UNISON CALL** (Fig. 1; see Voice): both territorial threat and sexual display; given by mated pairs from breeding territories in early morning and late afternoon; pairs will answer calls of neighbours (Archibald & Swengel 1985). Male stands with head up, neck fully stretched vertically, and bill pointing slightly backward; raises secondaries over back, holds primaries at side, and calls; when female joins in, keeps wings by her side (Walkinshaw 1973). **Threat, Attack** Male threatens by flapping wings; usually attacks by running toward intruder(s) with wings spread, and head and neck arched upward and forward; usually conspecific intruders leave straight away by running or flying a short distance; occasionally intruder remains too close and attacker chases for 6–15 m or more (Walkinshaw 1973); when incubating, male can be very savage (Campbell). **Triumph ceremony** When defending male returns after attack, often stands erect, arches neck, and points bill toward ground; may call; may give Unison Call with mate (Walkinshaw 1973). Apparent hierarchy within flock, with males of each family competing for Dominance (Walkinshaw 1973). Also recorded threatening and attacking stilts *Himantopus* (Walkinshaw 1973), dogs and horses (Elliott 1938) and, when in captivity, humans (Astley 1901). Brolgas and Sarus Cranes sometimes interact when defending breeding territories; Brolgas appear to be submissive to Sarus Crane (q.v.).

Sexual behaviour Pair-formation and Courtship possibly occur within flocks (White 1983). Brolgas well known for **DANCING DISPLAY** (Fig. 2), which can be seen at any time of year, but more often early in breeding season (Lavery & Blackman 1969; Walkinshaw 1973; Archibald & Swengel 1985; Coates 1985). Dance often starts with bird picking up grass, and tossing and catching it with bill; then repeatedly jumping about a metre into air with wings outstretched; also involves stretching, bowing, bobbing heads, walking and calling. Sometimes birds display singly, or groups (e.g. 10–14) display together, birds lining up roughly opposite each other before starting; when Dancing in pairs, one of pair may Dance round mate, or both birds may bring throats close together and move necks sideways (McGill 1923; Mayo 1931; Hood 1934; Lavery & Blackman 1969; Walkinshaw 1973; Coates 1985; North). Said that birds often Danced, then tumbled on ground, at times with feet uppermost, and finished by rolling like a dog (Mathews), though no other records of Dance finishing this way. Unison Call (see Agonistic Behaviour) also

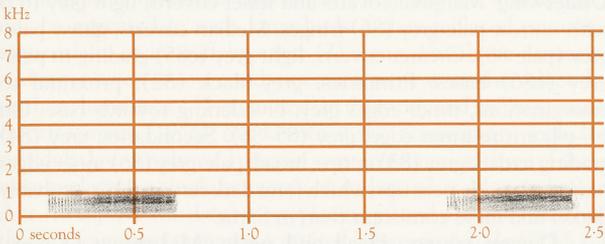
sexual display; near beginning of breeding season, in one flock where many seemed paired, nearly 10% of Unison Calls given by unmated females that were possibly soliciting mates (Archibald & Swengel 1985). In captivity, female recorded taking short morning flights when her mate was courting her (Astley 1901). One observation of a member of a flock circling high into sky calling continually then descending in circles and landing near where it started (North). One observation of Brolga and Sarus Crane behaving as pair (Archibald & Swengel 1985).

Relations within family groups Usually partner of incubating bird remains nearby (Campbell). Newly hatched birds move away from nest to shelter in vegetation (Gowland 1989); family feeds close together (Aust. NRS). Young will beg for food from adult; downy young attract attention of parents by purring softly (Lavery & Blackman 1969). **Anti-predator behaviour of young** When still downy, if approached, squat and remain still and quiet (Elliott 1938; Aust. NRS). When older, adults move in one direction, calling loudly, while chick lowers neck to horizontal, hunches body and sneaks off in another direction (Boekel 1980). **Parental anti-predator strategies** Before incubation, pair shows little concern if nest approached (Campbell). Later, attack when nest approached (see Agonistic Behaviour); may also Dance, run with drooping spread wings in Distraction Display, walk slowly away, occasionally turning round and calling, or remain at a distance, calling occasionally (Elliott 1938; Walkinshaw 1973; Campbell). Young independent when 1 year old but family may remain together for another year if adults do not re-nest (Walkinshaw 1973; Arnol *et al.* 1984); young may remain with parents into third year (Lavery & Blackman 1969; Gowland 1989).

VOICE Not well known. No detailed studies. Sonagram of Unison Call in Archibald (1976). Vocal inventory of three congeners in Archibald (1975) and summarized by Johnsgard (1983); eight adult calls listed. Sonographic analysis of Unison Calls of Brolga and of all but one congener used to derive taxonomic relationships (Archibald 1976). Known since sixteenth century that lengthened trachea is responsible for loud and penetrating calls of genus; intrasternal tracheal coiling found only in most species of swans and cranes (Johnsgard 1983). Only species of *Grus* to have dewlap as aid to voice (Johnsgard 1983). Calls are loud trumpeting, shrill notes and croaking, grating and guttural



A R. Buckingham; Mackay, Qld, Aug. 1985; P36



B H. Pollock; Yeppoon, Qld, 1961; P36

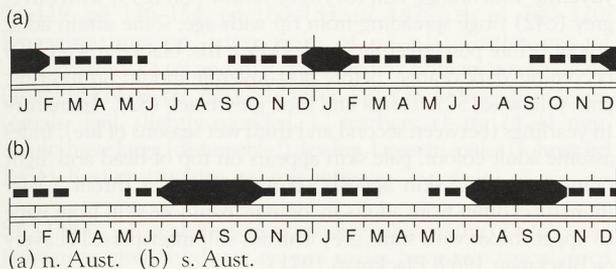
sounds (Walkinshaw 1973; Gould; North). Individual differences and regional variations, not known. Unison Call of Sarus Crane similar but more highly pitched (Archibald 1976).

Adult (1) **UNISON CALL**: loud bugling; given in duet by members of pair, female initiating call. Calls different for each sex; calls of female: introductory call, rapid series of very short calls, longer series of short calls; calls of male: introductory call, longer broken call, longer series of calls. Dewlap of male inflated towards end of sequence and one or two calls of very low pitch uttered (Archibald 1976). **Unison Call** of one pair often stimulates calling from other pairs (Walkinshaw 1973). Can carry up to 5 km in right conditions (Anon. 1992b). **FLIGHT CALL** (sonagram A): hoarse croaking (Gould); harsh grating noise (North); low guttural *graaaaw* (Walkinshaw 1973). **CONTACT CALL**: low guttural *purrr*; contact call between adults and also used when calling chick (Walkinshaw 1973). Probably snoring sounds described by Elliott (1938) and Sedgwick (1947). **ALARM NOTE**: shrill goose-like *garraw* (Walkinshaw 1973). **SINGLE TRUMPETING** (sonagram B): shrill *garooooo* (Walkinshaw 1973).

Young Chicken-like *peep* from downy chick (Walkinshaw 1973). Soft purring from downy chick to attract attention of adult (Lavery & Blackman 1969).

BREEDING Fairly well known. Comprehensive summary by Walkinshaw (1973); studied in Vic. by Arnol *et al.* (1984), SA by Bransbury (1991); 61 records in Aust. NRS up to Dec. 1991. Pair for life.

Season At start of wet season in n. Aust.; after winter rains in s. Aust. In n. Qld: laying, mid- to late Jan., mean date of laying



(a) n. Aust. (b) s. Aust.

first egg, 22 Jan. (Archibald & Swengel 1985); Sept.–June (Frith & Davies 1961). NT: laying Sept., Oct, and Mar. (Frith & Davies 1961); eggs, Jan.–June (Walkinshaw 1973; Aust. NRS). SA: eggs, early July to late Oct. (Bransbury 1991; Aust. Atlas). In n.w. NSW: eggs, May; small young, early July; large young, early Oct. (Lawler & Briggs 1991). Vic.: eggs, early July to mid-Nov.; breeding may extend into Mar. in years of high rainfall (Arnol *et al.* 1984; Aust. NRS). Fresh eggs in Feb. and Mar. in NSW and Qld (North).

Site In shallow wetlands or shallows of deep wetlands, up to 40 cm deep but usually less than 30 cm; among tussock-grass, sedge or canegrass or in grassy tidal flat, in rice crop, occasionally on plains up to 1.6 km from water; usually on ground, on small islet surrounded by water, occasionally floating (Barnard 1914; McGilp 1923; Dennis 1933; Walkinshaw 1973; White 1983; Arnol *et al.* 1984; Bransbury 1991; Aust. NRS; QNPWS). In n. Aust., for 25 nests: 12 in open wetlands with shallow water and scattered trees, seven on bare ground away from water; six beside trunk of tree; 12 within shade of tree, seven in open. Of 18 nests in water, seven on mounds elevated above water (Archibald & Swengel 1985). Nest near site of previous year (Elliott 1938; Walkinshaw 1973; Aust. NRS); re-layed in new nest c. 100 m away (Aust. NRS); may use same site for up to 20 years (White 1983; Arnol *et al.* 1984). One nest in ibis colony (Aust. NRS). Distance between nests, two estimations: 0.7 and 1.0 km (QNPWS).

Nest, Materials Varies from raised knoll, mound or platform, floating structure to trampled grass or practically no nest at all; occasionally lay eggs in depression in bare ground or on banks or islands with little or no vegetation (Le Souëf 1903a; Dennis 1933; Arnol *et al.* 1984; North; QNPWS). Usually composed of grass, sedge, rushes, sticks and leaves, lined with dry grass or with little or no lining (Le Souëf 1903a; Lavery & Blackman 1969; Aust. NRS; QNPWS); knolls possibly form during construction of nest because mud adhering to roots of grasses used makes nest more solid (Dennis 1933). Both sexes build (Arnol *et al.* 1984). Constructed from material round nest-site, vegetation cleared round nest for up to 5 m; appear to heap up earth, grass and other vegetable matter; coarse grass pulled up by roots (Lavery & Blackman 1969; Aust. NRS; Campbell); if vegetation not available, construct nests from clay and roots of vegetation unearthed from marsh beds (Arnol *et al.* 1984). Sometimes use old nests of swans (Aust. NRS). **MEASUREMENTS**: average diameter, 86 cm (57–142; 7); two nests: 5–6 cm thick, nest cavity c. 80 cm across (Walkinshaw 1973).

Eggs Oval to elongate oval, sometimes compressed or pointed at one end; coarse, minutely pitted all over, slightly lustrous; dull white, greyish white to creamy buff, spotted and blotched with shades of chestnut and dull purplish-brown or purplish-grey, latter often appearing beneath surface. Markings may be regular and evenly distributed, or form dashes, short streaks and irregular patches, often confined to one end; some eggs pale bluish-white, completely unmarked (Campbell; North; QNPWS). In n. Aust., some eggs uniform dull white without markings (Campbell). May become stained during incubation (Walkinshaw 1973). **MEASUREMENTS**: 94.6 (6.09; 87.6–99.8; 4) x 59.3 (2.17; 56.4–61.2) (North); 92.0 x 60.5 (n=26) (Walkinshaw 1973); 90.6 (85.0–99.8; 63) x 60.9 (56.4–67.3) (Walkinshaw 1973); 94.7 (5.79; 85.4–107.4; 21) x 61.0 (1.85; 58.8–64.7) (QNPWS). **WEIGHT**: 191 (185–195; 5) (Walkinshaw 1973); 176 (170–185; 4) (QNPWS).

Clutch-size One to three, usually two. Average 1.8: C/1 x 6, C/2 x 20, C/3 x 1 (Walkinshaw 1973); 1.9: C/1 x 2, C/2 x 15 (Archibald & Swengel 1985).

Laying At 2-day intervals (Lowe 1971; Archibald & Swengel 1985). Will re-lay if eggs lost or infertile, up to twice in wild, three times in captivity; may incubate for more than 1 month before re-laying (Astley 1901; Arnol *et al.* 1984). For one pair in captivity: when clutches taken, re-layed in same nest after 8 days; third clutch in same nest after 14 days (Astley 1901).

Incubation By both sexes (Lowe 1971; Arnol *et al.* 1984), beginning with first egg as hatching asynchronous (Elliott 1938), continuously after laying of second egg (Lowe 1971). **INCUBATION PERIOD:** c. 31 days (Weber 1974), 31 days (n=1) (Ricklefs *et al.* 1986), 30 days (Archibald & Swengel 1985), 28–29 days (Lowe 1971).

Young Precocial, nidifugous. At hatching, covered in grey down, darker above, head tinged brown; bill, rich brown, almost orange, grey towards tip (Elliott 1938), pink, tipped greenish grey (Walkinshaw 1973); legs and feet, greyish, marked with dull red; iris, dark brown (Elliott 1938; Walkinshaw 1973). Weight at hatching, 99 g (Lavery & Blackman 1969). Leave nest 1–2 days after hatching. Body-feathers appear at 4–5 weeks; fully feathered at 80–90 days; able to fly at c. 14 weeks (Lavery & Blackman 1969; Arnol *et al.* 1984). **Parental care, Role of sexes** Both parents brood and guard young, for up to 11 months, or for another year if do not re-nest (Walkinshaw 1973). When danger approaches, chicks hide, and remain quiet and still (Elliott 1938); adults perform broken-wing display when nest approached (Aust. NRS).

Fledging to maturity One record of single juvenile staying with parents for two years (Anon. 1992a). Form pair-bonds at 3–4 years; seek territories at 4–5 years (Bransbury 1991).

Success From 26 eggs laid, 16 hatched. In captivity: from 12 eggs, 11 hatched, and four fledged (Archibald & Swengel 1985). In Aust. NRS: 27 eggs, 15 hatched; from 14 eggs, six hatched, four fledged. Nests deserted after flooding, trampling by cattle; eggs taken by raven *Corvus*, Brahminy Kites *Haliastur indus*; young taken by dingoes, foxes (Lavery & Blackman 1969; White 1983, 1992c; Bransbury 1991; Aust. NRS). Varies with site, two young reared successfully in some sites, one in others (White 1983).

PLUMAGES Prepared by D.I. Rogers.

Adult Sexes similar. Age attained unknown but after third year (Blackman 1971). **Head and neck** Top of head, and face and chin, mostly bare, with sparse black (89) bristles on forehead and face; skin, smooth, pale grey to whitish. Pennaceous feathers form grey (84–85) auricular spot, 22–32 mm long and 18–28 mm wide. Nape and uppermost throat covered by rough red skin with many flattened papillae; sides and centre of upper throat have denser covering of black (89) bristles that obscure skin somewhat, especially when flattened. Rest of neck has pennaceous feathering; pale grey (86) to light grey (85). **Upperparts** When fresh, grey (pale 84) with light-grey rump; scalloped or mottled by pale-grey (86) fringes to feathers. With wear, ground-colour grades to grey-brown (119B) on rump and upper tail-coverts, to dark brownish-grey (brownish 83) or dark brown-grey elsewhere; fringes of feathers broaden and discolour to light brownish-grey or more rarely, light brown (119C). Body-moult protracted, so upperparts usually look heavily mottled and upperparts look much paler and more worn than in Sarus Crane. **Underparts** Light grey (85), tinged by pale brownish-grey fringes to feathers. When worn, tips of feathers discolour to brownish grey (c79) and fringes broaden and discolour to light brown (c119D). Not so dark as in Sarus, which does not look heavily mottled when plumage worn. **Tail** Light grey (85) to grey (84); feathers become dark grey (83) or dark brownish-grey with wear. Shafts, white for most of length, grading to light grey (85) or grey (84) on distal third. In Sarus, shafts are mostly dark, grading to white at base. **Upperwing**

Median, lesser and marginal coverts, grey (84) when fresh, scalloped by pale-grey (86) fringes. Ground-colour develops brownish tinge with wear; fringes a pale brownish-grey (c44) tinge. Greater secondary coverts, light grey (c85–c86), usually slightly paler than rest of wing. Alula, primary coverts and primaries, grey-black (82); primary coverts grade to dark grey (83) at base, as do p1–p7; progressively less grey on outer primaries. Secondaries, grey (84) when fresh; ground-colour becomes slightly darker with wear and outer edges and tips discolour to dark brownish-grey (c83). Tertiaries, grey, grading to darker grey near shaft; when worn, fade to dark greyish-brown and pale-greyish fringes develop. **Underwing** Marginal coverts and lesser coverts, light grey (85) with narrow pale-grey (86) fringes. Median coverts, glossy pale-grey (pale 86). Greater coverts, light grey (c85) grading to pale-grey (c86) bases. Primaries, grey-black (82); proximal to emarginations, inner edges grey, broadening towards base. On p1–p4, entire inner edge, grey (85–86). Secondaries, grey (84) grading to dark grey (83) at tips; broad, pale-grey (86) inner edges narrow abruptly near tips, which form dark terminal bar, probably darker and more consistent than in Sarus.

Downy young Head and neck Mid-crown to nape, unfeathered, as is skin surrounding auricular spot. Chin and auricular spot, off-white. Forehead, light greyish-brown (119C). At distance, neck looks brownish grey; down, short and light grey (85) with projecting single dark-brown (119A) hair-like feathers. **Upperparts** Grey-brown with strip of darker grey-brown (121) on each side of rump. Sides of lower back, grey-white and usually concealed by wing-pads. **Wing-pads** Grey-white with broad greyish-brown trailing-edge. **Underparts** Greyish white.

Juvenile Head and neck Fully feathered; head, pale grey (c86) to light grey (c85); 'buff' tinge recorded (Lavery & Blackman 1969). **Upperparts, Underparts, Tail** Similar to adult. **Wings** Similar to adults. Tertiaries shorter, not drooping so much over tail; remiges narrower than adults with pointed tips to primaries.

Immatures Blackman (1971) recognized two immature age-classes. Yearlings (between second and third wet seasons of life) have more feathers than pale orange skin on head. Subadults (older than yearlings but not known when adult plumage attained) have orange papillose skin from nape to upper throat, interspersed with light-grey (85), somewhat downy, feathers.

BARE PARTS From photos (NPIAW 1985; Aust. RD; unpubl.: J.N. Davies) and labels (ANWC, MV) except where stated.

Adult Bill, olive-grey (c42) sometimes grading to dirty grey (c84) at base. Smooth skin on top of head, pale grey (c86) to grey-white or greenish white. Iris, yellow (55) to reddish orange (c94). Nape to upper throat, red (c13) to 'orange' (Lavery & Blackman 1969) with grey-black (c82) dewlap in centre of chin and upper throat; dense covering of flattened papillae cause rough texture. Legs and feet, grey-black (82). **Downy young** Bill, yellowish pink (c5) becoming orange-buff (c118) with age. Iris, black-brown (119). Feet and legs, dull pink (c5) with dark grey-brown (121) tinge on front of tarsus intensifying and spreading with age. **Juvenile** Bill, orange-buff (c118) or yellow-buff (c53) with olive-grey (c42) tinge spreading from tip with age; some attain adult colour before post-juvenile moult (MV). Iris, black-brown (119) becoming 'dark orange' before post-juvenile moult; orbital ring, pale yellow (c157). Tarsus and toes, grey-black (82). **Immature** In yearlings (between second and third wet seasons of life), irides assume adult colour, pale skin appears on top of head and 'light orange' papillose skin appears on nape to upper throat. Older immatures differ from adults in 'orange' papillose skin from nape to upper throat with some grey feathers still interspersed (Lavery & Blackman 1969; Blackman 1971).

MOULTS

Adult post-breeding Not well known. Standard sequence of moult of adults in sub-family Gruinae is for most, or all, body-feathers to be replaced every year; primaries and secondaries replaced every second year (or at even longer intervals) in a simultaneous moult that causes flightlessness; in Common *Grus grus* and Sandhill *Grus canadensis* Cranes, period of flightlessness occurs when chicks are small (Stresemann & Stresemann 1966; BWP, references therein). No records of Brolgas in simultaneous moult of flight-feathers have been made but there is some evidence to suggest that most follow typical gruine pattern: (1) most specimens examined had uniform wear on primaries, which would not be expected in such large birds if they replaced primaries sequentially or in staffelmauser; (2) some skins have primaries and outer seven or so secondaries much more worn than all body-feathers; however, of 31 examined (in this study and by Stresemann & Stresemann [1966]; not known if the Stresemanns included subadults), seven showed uneven wear in primaries; three of these were replacing a single primary (p6 in Jan, p7 in May and p9 in Apr.); a captive (no date) was replacing p9 and p10 and three had three or four worn primaries scattered between p6 and p10. Moult of secondaries is less consistent with standard pattern of Gruinae. An undated photo (NPIAW 1985: 296) of 17 adults or immatures over 3 years old includes 12 birds replacing some secondaries; moult-induced gaps were one to about three feathers wide and moulting birds had one to three gaps in secondaries of each wing. Three of these individuals also had one or two moulting primaries. No information on body-moult. **Post-juvenile** No information except that a yearling, probably at end of its second wet season, had retained all its juvenile remiges.

MEASUREMENTS (1) Aust., skins; BILL S = culmen from skull, BILL N = bill from rear edge of nares (ANWC, AM, MV). (2) NE. Aust., adults, live; methods unknown (Blackman 1971).

	MALES	FEMALES	
WING	(1) 587 (3.92; 583–592; 4) (2) 611 (19.6; 568–650; 43)	552 (16.5; 533–580; 7) 573 (13.4; 547–593; 25)	** **
8TH P	(1) 391, 408, 391	356, 371, 380	
TAIL	(1) 235.8 (13.4; 224–251; 4)	212.1 (5.98; 204–218; 7)	**
BILL S	(1) 162.0 (8.52; 155–173; 4) (2) 166 (7.22; 152–181; 94)	147.8 (11.2; 142–169; 6) 153 (6.12; 140–167; 62)	ns **
BILL N	(1) 113, 108, 119	103.3 (7.70; 96.5–116; 6)	
TARSUS	(1) 291.4 (12.9; 281–310; 4) (2) 299 (13.6; 265–360; 173)	280.1 (10.6; 272–299; 7) 273 (14.6; 235–308; 114)	** **
TOE C	(1) 105.8 (4.59; 99.0–109.1; 4) (2) 115 (4.63; 102–125; 112)	95.5 (6.61; 87.7–104.6; 5) 108 (4.71; 97–125; 73)	* **

WEIGHTS NE. Aust., adults: males, 6838 g (649.0; 4761–8729; 321); females, 5663 g (560.1; 3628–7255; 217) (Blackman 1971).

STRUCTURE Wing, long and broad. Eleven primaries; p7 longest, p10 31–52 mm shorter, p9 7–15, p8 2–16, p6 10–22, p5 98–119, p4 136–154, p3 160–183, p2 187–204, p1 200–220. Emarginations on outer webs of p5–p10 (inflexions of emarginations of p9 and p10 concealed by primary coverts) and inner webs of p7–p9. About 24 secondaries including about seven tertials. Tail, slightly rounded, 12 feathers; t1–t6, 24–41 mm. Adults have large (distensible?) dewlap, larger in males (Johnsgard 1983). Rest of structure, as *Grus antigone*.

SEXING Cloacal characters allow reliable sexing of adults and immatures after third wet season: males have two vascularized

erectile papillae, each c. 2.5 mm in height and terminal to the vas deferens ducts; the papillae were lateral to the vent and medial to the ureter openings (Blackman 1971).

GEOGRAPHICAL VARIATION None. Forms superspecies with *Grus antigone* (e.g. Johnsgard 1983). Captive hybridization with *Grus antigone* reported (Archibald 1981).

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Grus antigone Sarus Crane

COLOUR PLATE FACING PAGE 457

Ardea Antigone Linnaeus, 1758, *Syst. Nat.*, ed. 10, 1: 142 — Asia.

In Greek mythology, Antigone was the daughter of King Laomedon of Troy, who was transformed into a stork or crane by the goddess Hera. The better-known Antigone, daughter of Oedipus and the subject of Sophocles' famous tragedy, was another, entirely different character.

The English name may have derived from the Sar Us River, in Outer Mongolia, which is, however, north of its current range.

POLYTYPIC Nominate *antigone*, Pakistan and India; *sharpii* Blanford, 1895, e. Assam to Vietnam; *gilliae* Schodde 1988, n. Aust.

FIELD IDENTIFICATION Length: c. 145 cm; weight: 5–5.5 kg. Large stately light-grey crane, very similar in size, shape and jizz to slightly smaller Brolga *G. rubicunda*. Sexes similar in plumages; males slightly larger. Juvenile and immatures separable.

Description Adult Head and upper neck, mostly bare; forehead and crown, pale greyish-green; rest of head and upper third of neck, orange-red to dark crimson-red, with small feathered light-grey patch over ear and thick 'beard' of long black bristles on lower face, chin and throat; chin, pale grey. No dewlap. Rest of upperparts, light-grey, grading to darker grey breast, belly and flanks. Upperwing: light grey, with broad blackish tip formed

by outer primaries and primary coverts. Underwing, light grey with black tip, formed by primaries, which narrows to indistinct blackish trailing-edge on secondaries. Bill, light grey to buff, with varying blackish tip to culmen. Orbital ring, usually light grey and inconspicuous in field. Iris, reddish orange. Legs, dark pink, tinged dusky on tarsus. **Juvenile** Head and upperneck, feathered at first, cinnamon-brown; feathers lost first from face and nape. Lower neck and upperparts, like adult but down adhering to tips of feathers imparts light-brown tinge at first; upper wing-coverts, scalloped by pale fringes. Underparts, like adult but white down adhering to tips of feathers gives mottled appearance at first. Bill,

at first, buff-yellow, with varying blackish tip to culmen. Iris, black-brown. Legs and feet, browner than adult. **Immature** Gradually lose feathers from head and upperneck; skin, pale orange at first, then orange and gradually darkening to red.

Similar species Likely to be confused only with very similar Brolga (q.v.).

Found in similar swamp and grassland habitats to Brolga, though not recorded from deserts in n. Aust. Habits and calls very similar to Brolga (q.v.).

HABITAT Swamp woodlands, swamplands and grasslands in tropical Aust. Mostly coastal and subcoastal but large numbers on Atherton Tablelands in dry season and small numbers in inland districts between e. Gulf of Carpentaria and e. coast of n. Qld (Aust. Atlas). In dry season, generally occupy different habitats from Brolga and concentrated in different regions; in wet season, greater overlap with Brolga (Bravery 1970; Archibald & Swengel 1985; Garnett & Bredl 1985; Aust. Atlas).

Dispersive during dry season; occupy dry habitats so long as water available for roosting and drinking (Archibald & Swengel 1985). Recorded from tidal flats, salt pans, wide grassy plains, tall grasslands, grassy paddocks, bore drains, roadside ditches, edges of dams and billabongs, rocky pools along river beds, and open woodland (Bravery 1970; Gill 1970; Walkinshaw 1973; Storr 1984; Archibald & Swengel 1985; Garnett & Bredl 1985; Tanner & Jaensch 1988). On Atherton Tablelands, large numbers found on newly ploughed paddocks, foraging for native grasses, maize seed, rodents, unharvested peanuts and other food (Lavery & Blackman 1969; Gill 1971; Walkinshaw 1973; Archibald & Swengel 1985). Also found in shallow marshes dominated by sedges, grasses, and herbs (Lavery & Blackman 1969). Apparently feed in wetter, more remote parts of swamp, where swamp woodland dominant; Brolgas in drier, more grassy areas (Bravery 1969, 1970).

In wet season, most common in woodlands adjoining shallow flooded plains (Archibald & Swengel 1985), especially low open woodlands of paperbark *Melaleuca*, with grassy understorey (Bravery 1970; Walkinshaw 1973; Garnett & Bredl 1985).

In Gulf Country, nest in narrow wetlands, 30–100 m wide,

usually with scattered trees, and between slightly elevated, often forested, ridges (19 of 34 nests); shallow open wetlands with scattered trees, where wetlands abutted ridges (nine nests); open wetlands (four nests); next to small ponds in dry upland habitat (two nests) (cf. Brolga) (Archibald & Swengel 1985).

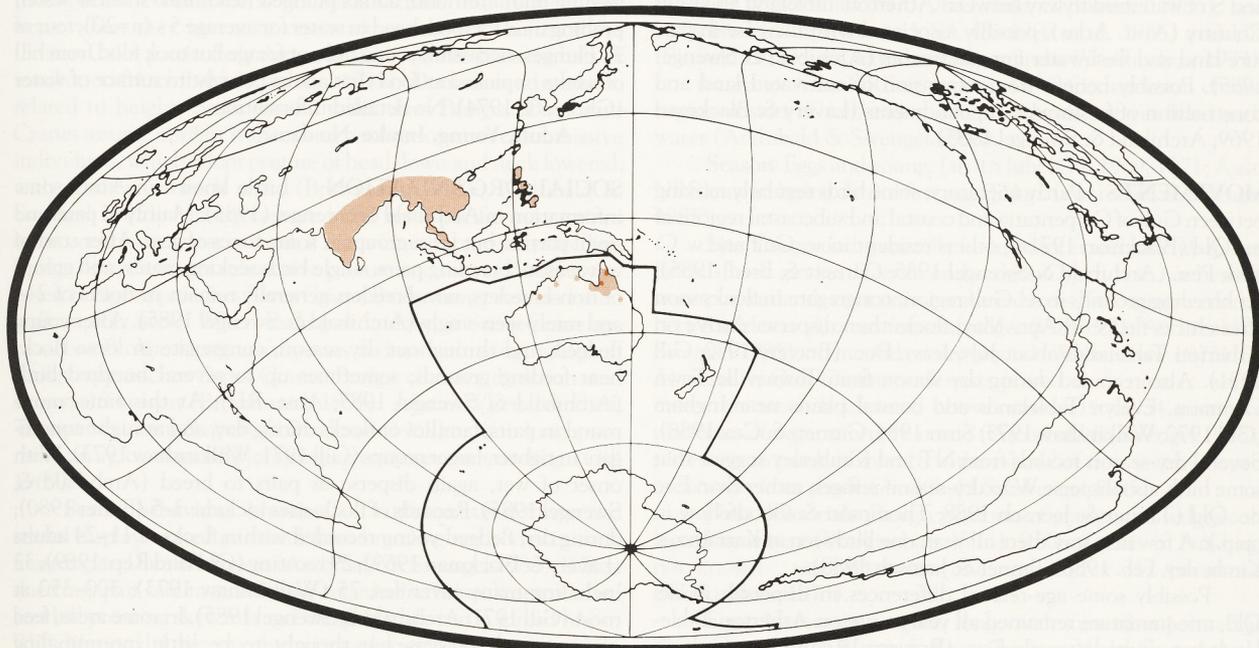
Require fresh water for drinking; have special roosting and bathing sites (Walkinshaw 1973; Archibald & Swengel 1985). On Atherton Tablelands, roost in marshes, or on long narrow peninsulas jutting into lake (Gill 1971; Archibald & Swengel 1985); recorded bathing and drinking at small ponds (Archibald & Swengel 1985).

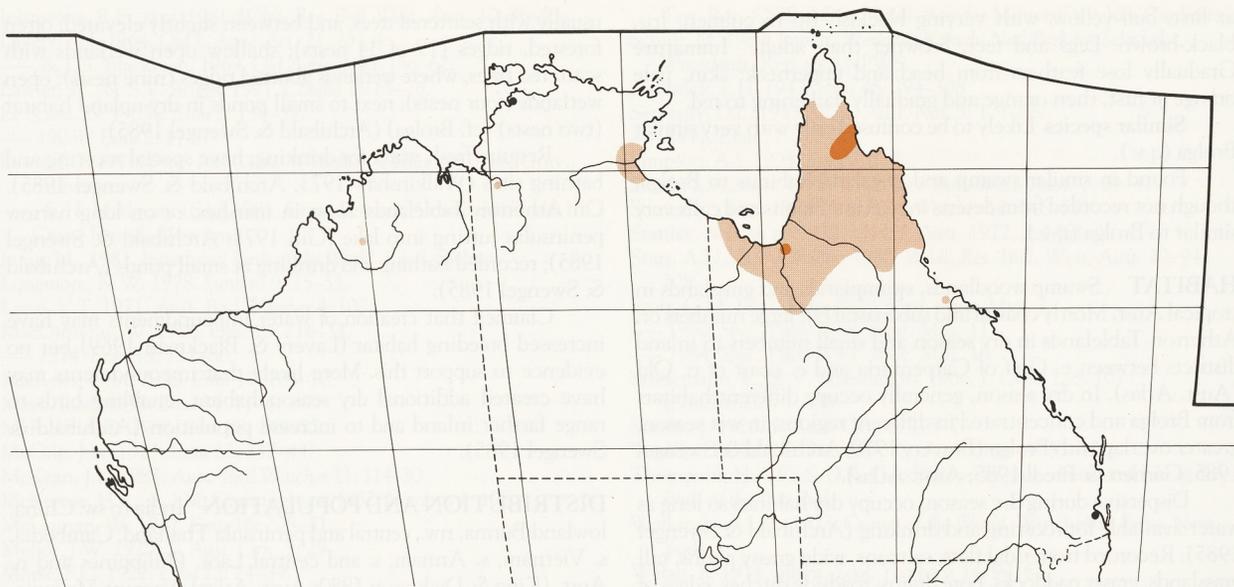
Claimed that creation of water impoundments may have increased breeding habitat (Lavery & Blackman 1969) but no evidence to support this. More likely that impoundments may have created additional dry season habitat, enabling birds to range farther inland and to increase population (Archibald & Swengel 1985).

DISTRIBUTION AND POPULATION India to sw. China; lowland Burma, nw., central and peninsula Thailand, Cambodia, s. Vietnam, s. Annam, s. and central Laos, Philippines and n. Aust. (King & Dickinson 1980; Aust. Atlas). Vagrant Malaysia. First Aust. record at Normanton, Oct. 1966 (Gill 1969), but may have been recorded in 1953 (Archibald & Swengel 1985 and note Hvass 1963: 173).

Aust. WA Kimberley Division. Single, Bigge I., 22 July 1977 (Aust. Atlas); pair, Windjana Gorge, 7 Aug. 1978 (Aust. Atlas); single, Maitland R., 28 km WSW of Karratha, 24 Feb. 1988 (Tanner & Jaensch 1988); unconfirmed reports, L. Argyle and Parry Floodplain (Jaensch 1989). NT Top End. Single, Spirit Hill Stn, 1981; Ngukurr, July 1980; Nathan R. HS, 16 Sept. 1978 (Aust. Atlas); three, Fogg Dam; five, Berry Springs (Fisher 1980); may occur regularly on and E of floodplains of Roper and McArthur Rs (Thompson & Goodfellow in prep.); two, Holmes Jungle, Dec. 1978 (Thompson & Goodfellow in prep.). Qld E from Corinda HS in Gulf Country, through C. York Pen., N to mouth of Jardine R. (Ford 1988; Beruldsen 1990) and S to Julia Ck and Townsville (Gill 1970; Blackman 1971a; Aust. Atlas).

Most s. record 20°44'S, though birds perhaps spreading S;





recent records from Townsville Common, Qld (19°15'S), and Karratha, Kimberley region (Garnett & Cox 1988; Tanner & Jaensch 1988).

Breeding First recorded Normanton, in same area as first sightings, in Apr. 1967 (Gill 1969). Few records. **Qld** Morr Morr Stn, 40 pairs, Jan. 1984 (Archibald & Swengel 1985); Magowra, one adult with two downy young, 10 Apr. 1985 (Aust. NRS); Strathgordon and Strathmay, adult with juvenile, 1 July 1981 (Aust. Atlas); Coen Airstrip, one pair, 23 Oct. 1981 (Aust. Atlas); Karumba, two adults and one immature, 11 Aug. 1978 (Aust. Atlas). Normanton area: two pairs, 28 Apr. 1967 (Gill 1969); one pair, 26 Jan. 1969 (Walkinshaw 1973); two pairs, 16 Jan. 1984 (Archibald & Swengel 1985).

Population and range expanding as habitat modified. Populations poorly known; in Atherton Shire, in 1970, estimated >120 in 620 km² (Gill 1971); Morr Morr Stn, 40 pairs in 31 km², Jan. 1984 (Archibald & Swengel 1985). Expansion recorded N and S of waterbird flyway between Atherton Tableland and Gulf Country (Aust. Atlas), possibly associated with increase in pasture land and freshwater impoundments (Archibald & Swengel 1985). Possibly benefit from expansion of cultivated land and construction of freshwater impoundments (Lavery & Blackman 1969; Archibald & Swengel 1985).

MOVEMENTS Partly migratory; some birds regularly moving between Gulf of Carpentaria and coastal and subcoastal regions of ne. Qld (Blackman 1971a); others resident in se. Gulf and w. C. York Pen. (Archibald & Swengel 1985; Garnett & Bredl 1985). At breeding grounds in se. Gulf region, congregate in flocks soon after chicks fledge in Apr.–May; flocks then disperse. Arrive on Atherton Tablelands about July, leave Dec. (Bravery 1970; Gill 1971). Also recorded during dry season from Townsville Town Common, Evelyn Tablelands and coastal plains near Ingham (Gill 1970; Walkinshaw 1973; Storr 1984; Garnett & Cox 1988). Several dry-season records from NT and Kimberley suggest that some birds also disperse W to dry-season refuges, rather than E to ne. Qld (Tanner & Jaensch 1988; Thompson & Goodfellow in prep.). A few may stay there all year; one bird seen at Karratha, s. Kimberley, Feb. 1988 (Tanner & Jaensch 1988).

Possibly some age-related differences in dispersal: in ne. Qld, one immature remained all year at site on Atherton Tablelands but adults left early Dec. (Bravery 1970); in se. Gulf, in

wet season, immatures formed separate groups or were solitary; adults were paired and defended territories (Archibald & Swengel 1985).

FOOD Maize seeds and native grasses (Lavery & Blackman 1969), grasshoppers (Walkinshaw 1973), rodents (Brown & Archibald 1977; Archibald & Swengel 1985). **Behaviour** Walk slowly and steadily, head down; grasp food items; do not dig for food (Archibald & Swengel 1985). Search intensely until mid-morning and widely during late afternoon (Lavery & Blackman 1969). Captive female recorded jabbing beak vigorously at grass then lifting head and neck to 75° holding House Mouse *Mus musculus*. Released and retrieved rodent, then tossed it 0.5 m above head onto ground. Repeated throw three times before seizing and swallowing prey. Later returned twice to same spot and dug vigorously in soil, 70 jabs/min (Brown & Archibald 1977). Extraliminally, three cranes, including one juvenile, observed feeding mid-afternoon; adults plunged heads into shallow water, probing mud for food; head in water for average 5 s (n=20); four of 20 plunges successful; young did not forage but took food from bill of adults or picked at food that adults brought to surface of water (Ghorpade 1974). No detailed information.

Adult, Young, Intake No data.

SOCIAL ORGANIZATION Little known in Aust.; some information in Archibald & Swengel (1985). Mainly in pairs and small parties, but large groups at some times of year. After start of wet season, breeding pairs, single birds seeking mates, and groups of non-breeders; non-breeders generally remain in flocks of 2–4 and rarely seen singly (Archibald & Swengel 1985). After young fledged, and throughout dry season, congregate in loose flocks near feeding grounds; sometimes up to several hundred birds (Archibald & Swengel 1985; Aust. RD). At this time, move round in pairs, families or flocks during day, and at night congregate in tighter, larger groups (Gill 1971; Walkinshaw 1973). With onset of wet, again disperse as pairs to breed (Archibald & Swengel 1985). Records of flock-sizes include: 3–5 (Fisher 1980); during dry, fledged young recorded within flocks of 11–24 adults (Lavery & Blackman 1969); 29 roosting (Qld Bird Rep. 1989); 32 including many juveniles; 75 (Walkinshaw 1973); 300–350 at roost (Gill 1971; Archibald & Swengel 1985). In some areas, feed or roost with Brolgas, but thought to be little intermingling

between species (Bravery 1969; Lavery & Blackman 1969; Archibald & Swengel 1985). Reports of associations between Sarus Cranes and Brolgas include: mixed flock of immatures (four Sarus Cranes and six Brolgas), which later divided into small parties of birds of the same species (Archibald & Swengel 1985); in one coastal area, Sarus Cranes made up to 5% of mixed flocks of Brolgas and Sarus Cranes in dry season (Garnett & Bredl 1985); report of adult Sarus Crane and adult Brolga behaving as pair (Archibald & Swengel 1985).

Bonds No studies in Aust.; elsewhere monogamous, pairing for life (Ali & Ripley 1980). Displays seen early in wet season (Lavery & Blackman 1969); in Jan., usually in isolated pairs, though some single birds still seeking mates (Archibald & Swengel 1985). **Parental care** Both sexes said to build nest, incubate, and feed young, which remain with them until next breeding season (Aust. RD).

Breeding dispersion Solitary. Pairs establish nesting territories of 50–80 ha; will defend it against intruding Brolgas (Archibald & Swengel 1985; Aust. RD).

Roosting Nocturnal. When not breeding, communal; congregations said to stand and roost in shallow water (Aust. RD); on end of grassy narrow peninsula on freshwater lake (Gill 1971; Archibald & Swengel 1985). Leave roost to feed shortly after daybreak. Near Normanton, Qld, in Jan., bathe and drink 08:30–09:30 (Walkinshaw 1973); in n. Qld, at midday, most gather at small ponds to drink, bathe, and loaf; then, in late afternoon, feed again before returning to roosts (Archibald & Swengel 1985).

SOCIAL BEHAVIOUR Little known in Aust. More wary and difficult to approach than Brolga; movements and displays also said to appear more elegant (Bravery 1969).

Agonistic behaviour In captivity, roosting Sarus Cranes and Brolgas may stand c. 2 m apart without avoidance or hostility (Brownsmith 1978). **Threat** When defending territory, male said to lead female against intruders; walks up to them and preens vigorously; if that fails, arches neck, points bill and jumps forward with wings outstretched (Aust. RD). Unison Call used in both territorial threat and sexual displays; pair answers neighbours if they call (Archibald & Swengel 1985); also see Sexual behaviour. Interspecific conflict between Sarus Cranes and Brolgas may occur when they nest near one another; answer one another's Unison Calls, particularly during last half, rather than first half, of incubation (Archibald & Swengel 1985). **Dominance** In cranes, related to height; Sarus usually taller than Brolgas. Dominant Cranes assume upright stances and tend to tower over submissive individuals, which adopt posture of head down and neck lowered, with feathers of neck erect (Brownsmith 1978; Archibald & Swengel 1985). Among captive birds, interspecific interactions often occur near water or food; if Sarus Crane approaches feeding Brolga, latter assumes submissive posture and moves slowly away; when Brolga approaches Sarus Crane, Brolga may pause and then walk rapidly away. When loafing at midday, if Sarus Crane approaches Brolga, latter usually runs 2–3 m with wings folded; if Brolga approaches Sarus Crane, Brolga changes direction and stops 8–10 m away (Brownsmith 1978). **Alarm** When disturbed, Trumpet in alarm (Lavery & Blackman 1969) or, if in long grass, move away, occasionally jumping up to survey surroundings (Gill 1969).

Sexual behaviour Unison Call both territorial threat and sexual display; mated pairs call from breeding territories in early morning and late afternoon (Archibald & Swengel 1985). When duetting, pair said to stand close together with neck upstretched and bill pointing skywards and wings of male partly spread (Aust. RD). Mating displays involve repeated stretching, bowing, wing-

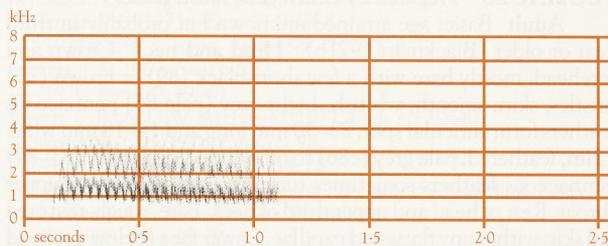
flapping, jumping and walking (Gill 1969; Lavery & Blackman 1969); one bird carried out clockwise pirouetting of the body while another watched (Gill 1969). Such Dancing-type displays said to be frequent in and out of breeding (Aust. RD).

Relations within family group No further information.

VOICE Not well known; no detailed studies. Vocal inventory of three congeners summarized by Johnsgard (1983); eight adult calls listed; sonographic analysis of Unison Call of Sarus Crane and of all but one congener used to derive taxonomic relationships (Archibald 1976). Calls are loud trumpeting, shrill notes and guttural sounds (Walkinshaw 1973). Individual differences not known. Unison Call of Aust. subspecies more highly pitched than that of nominate subspecies (Archibald 1976). Unison Call of Brolga of lower pitch (Archibald 1976).

Adult UNISON CALL: given simultaneously by members of pair, female initiating call. Calls different for each sex; calls of female are: introductory call, rapid series of very short calls, longer series of short calls; calls of male are: introductory call, rapid series of very short calls, longer series of calls; during longer series of calls, female makes two or three calls to each one of male. **FLIGHT CALL** (sonagram A): a guttural *graauw* (Walkinshaw 1973). **PARENTAL CALL:** guttural *purrr*, at times resembling snore (Walkinshaw 1973). **ALARM NOTE:** shrill single 'blast' (Walkinshaw 1973).

Young Shrill trilling *peep* (Walkinshaw 1973).



A R. Swaby; Malanda, Qld, June 1986; P36

BREEDING Very poorly known. Some information from birds in wild (Walkinshaw 1973; Archibald & Swengel 1985), and birds bred in captivity in USA (Ricklefs *et al.* 1986) and UK (Sinfield 1972); and, extraliminally, in India (Walkinshaw 1973); one record in Aust. NRS up to Dec. 1991. Construction of nest begins at start of wet season when wetlands not yet filled with water (Archibald & Swengel 1985).

Season Eggs and young, Jan. to July (Gill 1969, 1971; Aust. NRS); mean laying date of first egg, 22 Jan. (Archibald & Swengel 1985).

Site On ground, generally in vegetation such as club rushes *Scirpus*, rice grasses *Heersia* and sedges *Cyperus*; in, or beside, water; in wetlands containing scattered trees, favouring wetlands between elevated, often forested ridges (Gill 1971; Archibald & Swengel 1985); on mound on dry ground (Walkinshaw 1973). Of 34 nests in Gulf Country, all nests placed in or next to water, either on mounds elevated above water (16 of 34 nests) or platforms of vegetation (18 nests) (Archibald & Swengel 1985): nine next to trunk of tree; 18 within shade of tree; seven in open areas away from shade (Archibald & Swengel 1985).

Nest, Materials Rough platform of grasses and sedges collected near nest (Walkinshaw 1973). Role of sexes in building, not known. **MEASUREMENTS:** one nest, 212 x 212 cm across (Walkinshaw 1973).

Eggs Nominate *antigone*: long, oval, somewhat pointed at times at smaller end; pitted, glossy. In Aust., light blue, sparsely

spotted (Gill 1971); glossy white with tinge of blue (Walkinshaw 1973). **MEASUREMENTS:** 99.8 x 61.5, 101 x 62.7 (Walkinshaw 1973); eggs laid in captivity in USA (n=13): 98.1±3.5 x 62.4±1.9. **WEIGHT:** 182, 205 (Walkinshaw 1973); 214 (15.8; 13). **VOLUME:** 382.9±32.2 cm³.

Clutch-size Two, rarely three (Walkinshaw 1973); in captivity in USA: C/2 x 24, C/1 x 5 (Archibald & Swengel 1985).

Laying Eggs laid 2 days apart (Sinfield 1972; Walkinshaw 1973).

Incubation By both sexes. In India, one pair had stints of 112 min on average (36–203). **INCUBATION PERIOD:** in captivity: in USA, 31.8 days (0.4; 11); in UK, one egg hatched after 29 days.

Young Precocial, nidifugous. At hatching, covered in pale-buff down (Sinfield 1972). **Growth** In captivity: young c. 18–20 cm tall at hatching, c. 45 cm at 4–6 weeks; average weight (n=14 chicks): at 1 day, 125; 5 days, 132; 10 days, 217; 15 days, 357; 20 days, 541; 25 days, 780; 30 days, 1081. For details of rates of growth, see Ricklefs *et al.* (1986). **Parental care, Role of sexes** Both parents feed and guard young. Young start to feed themselves after 2 days.

Fledging to maturity Fledging, average 109 days (17.4; 4) (Ricklefs *et al.* 1986). In nominate *antigone*, remain with parents for at least 10 months; form flocks when parents breed again.

Success No information for Aust.

PLUMAGES Prepared by D.I. Rogers. Aust. *gilliae*.

Adult Basic; age attained unknown but probably in third year or older (Blackman 1971b). **Head and neck** Crown and forehead, mostly bare with a few short black (89) or brown (23) bristles; skin, smooth, whitish. Light-grey (pale 85) pennaceous feathers form auricular spot, 23–30 mm long and 15–18 mm wide. Chin, feathered, pale grey (c86) to off-white; line of grey (83–84) pennaceous feathers sometimes running onto midline of upper throat. Rest of head and upper third of neck, bare, rough-textured red skin with many flattened papillae. Lower face (below eye) and upper throat have fairly thick covering of long black (89) bristles that obscure skin somewhat, especially when flattened. Nape and collar below bristles of upper throat not feathered. Basal two-thirds of neck, feathered, light grey (85); in some, uppermost pennaceous feathers of neck, slightly paler grey (c86). Gill (1969) noted broad whitish collars in two pairs of adults with flightless chicks and suggested that this was a breeding plumage; this seems unlikely as there have been no other records of white-collared birds in Aust. and adults without collars but with chicks have been photographed. **Upperparts** When fresh, feathers, light grey (c85) with slightly paler fringes; when worn, darker brownish-grey (c84–c79) with broader pale-grey (c86) tips. Body-moult protracted in adults, so upperparts often look slightly mottled or scalloped by feathers of different ages. **Underparts** Breast, belly and flanks, grey (84), contrastingly darker than rest of body; feathers, grey (84) with inconspicuous light-grey (85) fringes; broader, pale-grey (85–86) fringes on thighs and under tail-coverts, which makes them look slightly paler. Axillaries, pale brownish-grey. **Tail** Grey (84); feathers develop faint brownish (c79) tinge with wear. **Upperwing** Tertiaries and median, lesser, carpal and marginal coverts, grey (84) when fresh, very narrowly fringed pale grey (86); with wear, feathers become light brownish-grey (light 79) and fringes fade to pale brown-grey (c44) before fraying away. Tertiaries, long and lanceolate, drooping down, well beyond tail. Greater secondary coverts, pale grey (c86) when fresh; take on pale brown-grey (c44) tinge with wear but usually remain paler than other coverts and remiges. Secondaries, light grey (85–86) when fresh; when worn, shaded areas of feathers become darker grey and exposed fringes fade to light grey-brown

(c79). Greater primary coverts and alula, dark grey (c83) to dark brownish-grey, becoming greyer towards bases. Primaries, grey-black (c82) to black-brown (119); p1–p3 have broad, grey (84) outer edges and other primaries have grey (84) outer edges proximal to emarginations. Primaries, primary coverts and alula have blackish (c82) shafts. **Underwing** Marginal and lesser coverts, grey (84). Median coverts, pale grey (pale 86), almost concealed by longest lesser coverts. Greater coverts, light grey (85–86). Secondaries, light grey (85) becoming pale grey (86) at bases; slightly darker grey (79–83) near shafts. Dark areas near shafts more exposed near tips of feathers and can form subtle dark trailing-edge. Primaries, grey-black (c82) or brownish black (c119), grading to pale grey (brownish 86) bases to inner edges; these are most extensive on inner primaries and p1 can have wholly light-grey (85) inner edge.

Downy young First down: **Head and neck** Pale brown (c39) grading to white on throat. **Upperparts** Mostly dark brown (121A) with indistinct and narrow yellow-brown (c123C) median line, most conspicuous on centre of mantle; sides of lower back, cream (c54), concealed when wing-pads folded. **Underparts** Mostly white, tinged buff at sides. Older chicks have lighter-brown (c123A) down on upperparts; assumed to be a second down, by analogy with other cranes (Fjeldså 1977). **Wing-pads** Reddish brown (c221B) with buff-white leading-edge outside carpal and buff-white underside.

Juvenile No specimens available; following based on two photos of fresh individuals (G.W. Archibald) and two of more worn juveniles (NPIAW 1985; Archibald 1989). **Head and neck** At first, head and upper third of neck covered by short cinnamon-brown (c123A) feathers, which are lost first from nape and face. Lower two-thirds of neck, similar to adult but initially tinged by pale-brown (c39) down adhering to tips of feathers. **Upperparts** Feathers smaller and narrower than in adult. Initially, down adheres to tips of feathers, making mantle, back and rump look light brown (c123A–c223C) and forming light-brown scalloping on scapulars. Scapulars apparently differ from adults in having dark-grey (c83) centres. **Underparts** Similar to adult but initially mottled by white down adhering to tips of feathers. **Tail** As adult. **Upperwing** Coverts scalloped by pale-grey (c86) to whitish fringes. Tertiaries, perhaps shorter than in adult, not projecting so far beyond tail. **Underwing** No information.

Immatures No photographs or specimens available. Blackman (1971b) reported two recognizable age-classes. Yearlings (between second and third wet seasons of life) with more feathers than pale orange skin on head and upper third of neck. Subadults (older than yearlings; not known how long this stage retained) with papillose skin on head and upper neck, orange, interspersed with feathers on nape.

BARE PARTS From photos of Aust. *gilliae* (Johnsgard 1983; NPIAW 1985; Archibald 1989; unpubl.: G.W. Archibald) and museum labels (ANWC).

Adult Bill, light grey (c85) to buff (c124) with varying amount of blackish brown (c19) on tip of culmen; extent of blackish brown may decrease with wear. Top of head and base of bill covered by greyish-white to greenish-white skin. Iris, reddish orange (15–116); 'bright orange' and 'golden' recorded on labels of two (of seven) adult females in ANWC, perhaps implying tendency for eyes of females to be less reddish. Orbital ring, cream (c92) to light brownish-grey (c44). Rest of head and upper third of neck, scarlet-red (c14); dense covering of flattened papillae causes rough texture. Tibia, tarsus and toes, dark pink (c108C) with black-brown (c119) centres to scales that cause dusky tinge, strongest on tarsus. Claws, 'black'. **Downy young** Bill, dirty buff

(c124), initially with extensive pinkish-orange (94) base; later bill becomes orange-buff (118) with cream (c54) base and tip. Iris, black-brown (119). Tibia, tarsus and toes, brownish orange, tinged dark brownish-grey (c79) on front of tarsus; legs become uniform cream later. **Juvenile** Bill, initially buff-yellow (c53) with varying amount of blackish brown (c19) on culmen; iris, black-brown (119); tibia, tarsus and toes, browner than adult. Not known when adult colours attained. **Immatures** Probably similar to adults. Amount of feathering on head and upper neck decreases with age; papillose area of skin, 'pale orange' in yearlings; 'orange' in subadults (Blackman 1971b).

MOULTS

Adult post-breeding Almost unknown; only information from seven individuals collected near Karumba, Qld, 17–18 Aug. All showed uniform wear of primaries and outer 8–14 secondaries. In four, primaries and outer secondaries were contrastingly older than most body-plumage. These observations consistent with usual gruine moult-strategy outlined in account for Brolga (q.v.). All had two or three ages of body-feather; all but one had some active body-moult. **Post-juvenile** No information.

MEASUREMENTS Aust. *gilliae*: (1) Adult, skins; BILL S = bill from tip to junction of culmen with skull; BILL N = bill from tip to rear-edge of nostrils (ANWC).

	MALES	FEMALES
WING	(1) 632, 624, 628	564, 566, 572
8TH P	(1) 428, 442, 431	391, 392, 401
TAIL	(1) 231, 228, 236	203, 237, 215
BILL S	(1) 162, 155, 156	138, 155, 150
BILL N	(1) 112, 104, 107	96.8, 105, 104
TARSUS	(1) 300, 287, 306	264, 283, 274
TOEC	(1) 113, 110, 118	110, –, 112

WEIGHTS (kg) In Karumba area, n. Qld, Aug.: adult males 6.50, 6.60, 6.90 (ANWC); adult females 5.25 (0.208; 5.00–5.50; 4) (ANWC). Atherton Tablelands, late Oct., two non-breeding adult males, 8.41, 7.84 (Walkinshaw 1973). Average weight of males 8.4 kg (Archibald *et al.* 1981).

STRUCTURE Wing, long and broad. Eleven primaries; p8 longest, p10 23–41 shorter, p9 3–9, p7 2–6, p6 5–14, p5 47–78, p4 108–133, p3 140–165, p2 158–193, p1 181–214; p11 minute, concealed by primary coverts. Strong emarginations on outer webs of p4–p10, points of inflexion concealed by primary coverts on p8–p10; inner webs of p10 to p7 emarginated, of p6 slightly so. Twenty-four secondaries, including seven tertials. Tertials, long and lanceolate, projecting well beyond folded wing and drooping over tail. Four short humerals. Tail, slightly rounded; 12 feathers; t1–t6 22–36 mm. Bill, stout and straight, about twice length of head; width at base c. 75% of depth, c. 20% of length. Gonys and mandibular rami almost perfectly straight; tomia and culmen gently decurved towards tip. Oblong nostrils situated about half way in long nasal groove. Tibia, slender and long with reticulate scaling. Tarsus, slender and long, slightly laterally compressed; scutellate in front, reticulate elsewhere with scales smallest on sides. Toes, short and slender; outer c. 78% of middle, inner c. 75%, hind 28%.

GEOGRAPHICAL VARIATION Three subspecies. Nominative *antigone* of India, larger (e.g. male: wing, 631 [590–675; 13]; tarsus, 329 [278–352; 13]; bill from nares, 121; Walkinshaw 1973); body-plumage, lighter grey; broad white collar of feathering directly below bare skin on neck; tertials paler than secondaries and upperparts. Endangered *sharpei* of se. Asia and Philippines, rather similar to Aust. birds and were combined till Schodde (1988) separated Aust. birds as subspecies *gilliae*; *sharpei* apparently differs from *gilliae* in larger size (Walkinshaw 1973); smaller and paler auricular patch of pennaceous feathers on chin; sometimes no patch (Schodde 1988); little information available on morphology of *sharpei* and more detailed study of subspecific differences needed. Form superspecies with Brolga *Grus rubicundus* (e.g. Johnsgard 1983); hybridize with Brolga in captivity (Archibald 1981).

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