

Order PSITTACIFORMES

Distinctive, familiar, and often strikingly coloured birds, with characteristic shape and structure. Often highly conspicuous. Small to large, ranging in size from tiny pygmy-parrots *Micrositta* of New Guinea, the Moluccas and the Solomon Is (c. 9 cm in length and weighing 10–18 g) to large macaws of South America (up to c. 1 m in total length including tail, and weighing up to 1.7 kg), large cockatoos (e.g. Red-tailed Black-Cockatoo *Calyptorhynchus banksii*; up to 60 cm in total length including tail, and weighing up to 870 g), and flightless Kakapo *Strigops habroptilus* of NZ (up to 64 cm in total length, including tail, and weighing up to 2 kg). Third largest non-passerine order. Roughly 329–356 species in 76–93 genera, distributed on all continents except Antarctica; most are tropical; distributed widely in s. hemisphere, including some subantarctic islands of HANZAB region; in n. hemisphere occur as far N as Safed Koh Mts in e. Afghanistan (Slaty-headed Parakeet *Psittacula himalayana*). Greatest morphological and ecological diversity in A'asia and probably originated in A'asian sector of Gondwana, radiating from subtropical rainforests (Homerberger 1991; see also Forshaw & Cooper 1989). In HANZAB region, 60 species in 27 genera. Appear to lack close living relatives, and nearest allies difficult to determine. Suggested that nearest allies are Columbiformes (pigeons) (Burton 1974; Forshaw & Cooper 1989), but this rejected by others (Sibley & Ahlquist 1990). Recent DNA–DNA hybridization studies suggest they should be placed between cuckoos and swifts (see Collar 1997; Rowley 1997). Other groups suggested as close allies include hawks, owls and piciforms (see Sibley & Ahlquist 1990). Recent works (e.g. Forshaw & Cooper 1989; Collar 1997; Rowley 1997) recognize three main groups: (1) cockatoos; (2) lorries and lorikeets; and (3) parrots. However, taxonomic level of each varies: some (e.g. Forshaw & Cooper 1989) classify each at same level, but others (e.g. Collar 1997) group parrots with lorries and lorikeets. On basis of biochemical (Christidis *et al.* 1991a) and chromosomal (Christidis *et al.* 1991b) studies, cockatoos were found to form a monophyletic lineage separate from all other Australo-Papuan parrots and lorries. As such, Christides & Boles (1994) recognized two distinct families within Aust.: Cacatuidae (cockatoos) and Psittacidae, including the Loriinae (thus, parrots and lorikeets); an arrangement also supported by morphological and behavioural studies (Brereton & Immelmann 1962; Smith 1975; Homerberger 1991). This arrangement followed here; both families represented in HANZAB region. Relationships between extralimital groups have not been examined closely and are in need of review. In recent works, extralimital subfamilies or tribes have been grouped with Aust. Psittacidae (Forshaw 1989; Collar 1997); that treatment has been followed here. The most widespread alternative taxonomy places all cockatoos and parrots in a single family, Psittacidae (e.g. Sibley *et al.* 1988; Forshaw & Cooper 1989; Sibley & Ahlquist 1990; Sibley & Monroe 1990; Peters). Many alternative taxonomies have been proposed; for reviews see Smith (1975), Sibley & Ahlquist (1990), and Schodde & Mason (1997); for discussion of Aust. taxa, also see alternative treatment of Wells & Wellington (1992).

Structure rather homogeneous. Bill distinctive: upper mandible downcurved, usually extending well beyond tip of lower mandible; lower mandible upcurved, and usually broad with rather square tip that fits neatly into inside of upper mandible. Usually have prominent cere. Rostrum movable, with hinge-like articulation at skull. Palate, desmognathous. Nares, holorhinal, impervious, always in cere. Basipterygoid process absent. Head usually large in proportion to body, and neck rather short; 13–15, usually 14, cervical vertebrae. Pelvic muscle formula, AXY. Sternum fenestrated or indented. Tongue, thick and muscular, tactile, grooved; moved by hyoid apparatus with large median foramen in entoglossum; tongue brush-tipped in some species (notably lorikeets in HANZAB region; see below). Feet, zygodactylous, with Type 1 flexor tendons (cf. Piciformes and Cuculiformes, which zygodactylous but with Type 6 flexor tendons). Crop present; no caeca. Oil-gland tufted or absent. Furcula weak or absent in some. Syrinx with three pairs of intrinsic muscles. Wings vary in shape from broad with rounded tip to narrow with pointed tip. Ten primaries; 10–14 secondaries; diastataxic. Tail short to very long; *Prioniturus* have ornate, projecting racket-shaped central rectrices. Usually 12 rectrices. Aftershafts, short and downy. Legs, short and strong; tarsus short, with small granulate scales or papillae; middle toe longer than tarsus. Orbital ring usually complete. Whole body covered in down. Powder downs present; especially in uropygial region. Young ptilopaedic.

Adult plumage often brightly coloured (especially in Psittacidae), though also white, grey and black (especially in Cacatuidae); coarse in texture; and arranged in diffuse tracts. Bare parts mostly dull colours, but some species have brightly coloured bills, irides, lores and facial skin. Sexes alike (e.g. Rainbow Lorikeet *Trichoglossus haematodus*) or highly dimorphic (e.g. Eclectus Parrot *Eclectus roratus*).

Adults undergo a post-breeding (pre-basic) moult each cycle; usually complete, but some species can arrest moult before it is finished. Adult pre-breeding moults not reported (Forshaw & Cooper 1989). Usually moult once a year, but some possibly take longer than a year to finish; in HANZAB region, timing varies (see Family introductions). Moult of primaries of adults usually centrifugal, from mid-primaries, but starting position varies. Moult of secondaries of adults often starts from s10 at about time moult of primaries starts, and replaced outward to finish with s1, but

sequence also often irregular (see Forshaw & Cooper 1989). Moults of tail usually starts after moults of primaries well advanced, but usually finishes before last primary shed; sequence irregular (see Forshaw & Cooper 1989). Young altricial; blind at hatching, covered by sparse pale down. Juvenile plumage often similar to, or slightly duller than, adult plumage, but remiges and rectrices usually more pointed than adults. Rate of maturation and attainment of adult plumage and bare parts varies greatly; slow in some species. Sequence of plumages to adult and timing of moults varies greatly. Post-juvenile (first pre-basic) moult typically partial, but some possibly compete (e.g. Nestorinae). Some species have one or more immature plumages.

Worldwide, occur in wide variety of habitats, from dense rainforest to open, treeless grassed plains, though predominantly, and with greatest diversity, in tropical rainforests (Forshaw & Cooper 1981). In HANZAB region, widespread throughout alpine, tropical, temperate, semi-arid and arid zones; occur in most habitats, from coasts to high altitudes, including above treeline in alpine zones.

No species of Cacatuidae can be regarded as completely migratory (Rowley 1997), though some populations of some species undertake regular movements and considered partly migratory. Other Cacatuidae are resident, sedentary, or dispersive. Worldwide, Psittacidae considered resident, dispersive, nomadic or irruptive (Collar 1997); only two species considered migratory; at least one other species is partly migratory (Collar 1997; see Psittacidae below). Few species of Psittacidae are considered sedentary, usually island forms, and some of these occur in HANZAB region.

Herbivorous. Most feed on seeds and fruits, supplemented by a wide range of other food, such as flowers, nectar, pollen and leaves. Many species include small quantities of invertebrates, mostly insects and insect larvae, in their diet; almost all eat some seed, which always husked before swallowing (Forshaw & Cooper 1981; Campbell & Lack 1985). Specialization evident in some groups (see Family accounts below). Feed arboreally and terrestrially; in HANZAB region, c. 35% of species feed mainly arboreally, c. 35% feed mainly on ground, and the rest feed both arboreally and terrestrially. Of those considered primarily arboreal or terrestrial, about a third of species within those categories occasionally feed on other substrates. When feeding in trees or shrubs, agile and acrobatic, and clamber actively through outer branches and foliage, stretching to reach food, and often hanging upside down; use both bill and feet; while climbing among foliage of trees, often use bill to grasp branches and then clamber up or across from previous position. On ground, equally active, picking up fallen seeds or fruits from ground, or taking them directly from flowering or seeding heads; when food beyond reach, will stretch up to reach, or stand on stalks of plants, felling them to ground; many also use bill to dig up underground roots, corms or bulbs, or scratch soil with feet (Forshaw & Cooper 1981; also see species accounts). Many use bill to tear away or crush hard seed capsules, such as those of *Eucalyptus* and casuarina, and extract seeds from them; bill also used by some to tear open trunks of trees and branches for wood-boring insect larvae. Many use feet to manipulate food and to bring food to bill (Smith 1971; Forshaw & Cooper 1981); some show preference for use of particular foot, usually left (Forshaw & Cooper 1981; Joseph 1989; Magrath 1994). In HANZAB region, Glossy Black-Cockatoos *Calyptorhynchus lathami* exclusively or predominantly left footed (Joseph 1989; Magrath 1994; Pepper 1996), Yellow-tailed *Calyptorhynchus funereus* and Red-tailed Black-Cockatoos, Gang-gang *Callocephalon fimbriatum* and Palm *Probosciger aterrimus* Cockatoos predominantly left footed; while Eastern *Platycercus eximius* and Pale-headed *P. adscitus* Rosellas predominantly right footed (Cannon 1977; Prendergast 1985; Joseph 1989). Drink water at least once during day; most come to drink early in morning, some in morning and late afternoon, and some throughout day depending on heat of day; most drink by scooping water in lower mandible, then tilting head back (Campbell & Lack 1985); also drink water by lapping, ladling or suck-pumping (Schodde & Mason 1997).

Usually very vocal. Calls described as squawks, screeches, squeals, shrieks, whistles, cackles, chatters, buzzes or twitters. Many calls harsh, guttural and described as strident, but other calls can be musical rolling screeches and melodic whistles or warbles, often piping in quality. Many calls loud and distinctive; sometimes raucous. In HANZAB region, exceptional calls are those produced by mechanical means by Palm Cockatoos, and remarkable Booming made by male Kakapo during displays (see those texts for details). In HANZAB region, voice not well studied, though several notable exceptions (see below and family introductions). Repertoire of calls of Budgerigar *Melopsittacus undulatus* well known from studies in captivity and in wild; otherwise, repertoires poorly known. Size of repertoire appears to vary greatly between species, though this may be more a reflection of lack of knowledge of many species. Some species have as many as 20 or more described calls. Brereton (1963a,b, 1971a,b) and Pidgeon (1981) compared repertoires of a number of Aust. species. Brereton (1971b) suggested that the information content of vocalizations low in species occurring mainly in habitats with abundant resources, and most complex when resources at intermediate levels, but again simpler with increasing scarcity of resources. Suggested that some calls of Budgerigar functionally equivalent to song of passerine birds (see account for Budgerigar); this may also be true of calls of some other parrots. Within species, variation in calls sometimes complex, with some described as grading from one to another across a wide range of intermediates; these variations generally not well understood. Individual variation often used for individual recognition within pairs, and used to recognize members within family or other groupings (e.g. *Calyptorhynchus*, Galah *Eolophus roseicapillus* and Budgerigar). Some calls sexually distinctive in many species of both families. In HANZAB region, little or no information on seasonal variation for most species. Regional

variations in repertoire and variations in call characteristics little studied in HANZAB region but rarely apparent. However, known from at least three species in HANZAB region (Australian Ringneck *Barnardius zonarius*, Red-crowned Parakeet *Cyanoramphus novaezelandiae* and Kaka *Nestor meridionalis*). Calls of young often show similarity in structure between related species. Courtney (1974, 1986, 1993, 1996, 1997a,b,c) studied development of calls in young of many species of Aust. parrots. Food-begging Calls of many young parrots change with age. Brereton & Pidgeon (1966) speculate on ontogeny of calls in Eastern Rosella and provide illustrative sonagrams. They suggest adult calls develop from simple squawk given by nestlings. In exceptional instance of Galah being reared in wild with brood of Major Mitchell's Cockatoo *Cacatua leadbeateri*, Galah adopted calls of foster parents (Rowley & Chapman 1986). Mimicry almost absent in wild (but see Palm Cockatoo), but common in many species in captivity, especially cockatoos and Budgerigar, but also Rainbow Lorikeet, *Polytelis*, Swift Parrot *Lathamus discolor*, Red-crowned Parakeet and Turquoise Parrot *Neophema pulchella*.

For discussion of Social Organization and Social Behaviour, see family accounts below.

Breeding well known for most species in HANZAB region, poorly known extraliminally. Breeding generally seasonal, though some species can breed at any time if conditions suitable. Nest mainly in hollows in trees; some species nest on ground, under rocks or vegetation, or in tunnels excavated in arboreal or terrestrial termitaria. Eggs white. Clutch-size varies; in HANZAB region, largest clutches laid by Psittacinae and most species of Platycercinae in temperate areas and tropical semi-arid areas. Incubation by female only in Psittacidae and some Cacatuidae, by both sexes in *Cacatua*, *Callocephalon*, *Eolophus* and *Nymphicus*. Young altricial, nidicolous. Naked at hatching; generally develop down within first week. Young usually fed by female at first, then by both sexes. Fledgelings usually remain with parents for some time (Forshaw & Cooper 1981).

Worldwide, at least 90 species of parrots (c. 25% of all species) considered threatened (King 1981; Collar & Andrew 1988; Collar *et al.* 1994). In the HANZAB region, the only extinct taxa are: the Paradise Parrot *Psephotus pulcherrimus* (the only species extinct on mainland Aust.), probably through combined effects of overgrazing and drought; the Norfolk Island Kaka *Nestor productus*, which was killed for food and whose habitat was largely cleared; Lord Howe I. subspecies of Red-crowned Parakeet *Cyanoramphus novaezelandiae subflavescens*, possibly killed off by hunting and trapping; and the Macquarie I. subspecies of the Red-crowned Parakeet *C.n. erythrotis*, which was extirpated by cats (Garnett 1993). However, many more species are threatened: Garnett (1993) lists another 22 taxa in Aust. that are nationally threatened; of these, seven species are endangered, five vulnerable, five rare, and five insufficiently known. In addition, of the eight species of parrots native to NZ, the Kakapo is endangered; Orange-fronted Parakeet *Cyanoramphus malherbi* is rare; Kaka, Forbes' Parakeet *C. forbesi* and Antipodes Island Parakeet vulnerable; and Yellow-crowned Parakeet *C. auriceps* and Kea *Nestor notabilis* near threatened (Taylor 1985; Collar *et al.* 1994). In temperate woodlands and grassy woodlands of s. Aust., one species of woodland-dependent parrot, the Paradise Parrot, is extinct, and six others threatened; another three species of woodland-associated parrots are also threatened (Robinson & Traill 1996).

Overall, major threatening process is extensive clearance and fragmentation of habitat, particularly in S. America (King 1981; Collar & Andrew 1988; Collar *et al.* 1994). In HANZAB region, degradation, clearance and subsequent fragmentation of natural habitats for agriculture and forestry, including collection of firewood, have adversely affected many species (e.g. Glossy Black-Cockatoo, e. population of Regent Parrot *Polytelis anthopeplus*); small and isolated remnants are often too small to support viable populations of birds. Overgrazing and altered fire-regimes also change structure of vegetation, and have reduced populations and range of several species (e.g. Golden-shouldered Parrot *Psephotus chrysopterygius*, Scarlet-chested Parrot *Neophema splendida*, Ground Parrot *Pezoporus wallicus*). In Tas., preferred feeding habitat of Swift Parrot threatened by clearfelling and woodchipping of forests of Tasmanian Blue Gum *Eucalyptus globulus*. Orange-bellied Parrots *Neophema chrysogaster* threatened by destruction of coastal saltmarsh, the main feeding habitat on mainland Aust. In some areas, removal of hollow-bearing trees causes local shortages of nesting hollows, which, in turn, then reduces opportunities to breed. In s. Aust., harvesting of forests for firewood usually removes old dead trees, which often contain hollows; as a result, the reduction in the number of hollows available for nesting has caused declines of populations of many parrots throughout range (Robinson & Traill 1996). There is little replacement of suitable hollow-bearing trees, e.g. in sw. WA, the lowest average age of nest-trees used by parrots was estimated at 275 years and 446 years for cockatoos (Mawson & Long 1994, 1997; *contra* Stoneman *et al.* 1997). Further, introduced hollow-nesting species, such as Common Starlings *Sturnus vulgaris* and Common Mynas *Acridotheres tristis*, and some introduced parrots (such as Sulphur-crested Cockatoos *Cacatua galerita* in WA and Crimson Rosellas *Platycercus elegans* in NZ and on Norfolk I.), as well as Common Brushtailed Possums *Trichosurus vulpecula* and feral honeybees *Apis mellifera*, appear to compete with some species for use of hollows; this problem exacerbated in areas where hollows in short supply as a result of changes to habitats (Smithers & Disney 1969; Dawe 1979; Saunders *et al.* 1985; Garnett 1993).

Conversely, populations of some species (e.g. Elegant Parrot *Neophema elegans*) have increased, and ranges expanded after native vegetation cleared and converted to farmland, which has created habitat of similar structure to preferred natural habitats. Other species (e.g. Rainbow Lorikeet) have experienced increases in populations and

expansion of range since the 1970s, probably resulting from greater availability of food after the establishment and maturation of native trees in parks and gardens in urban areas (Veerman 1991). In some areas, changes to habitats through establishment of agricultural production, particularly grain production, and provision of water for stock, has allowed some species, notably Galahs, Sulphur-crested Cockatoos and Little *Cacatua sanguinea* and Long-billed *C. tenuirostris* Corellas, to undergo dramatic increases in population and expansion of range, to the extent that they are considered pests in some rural areas (Saunders *et al.* 1985; Rowley 1990; Serventy & Whittell). Worldwide, some species are threatened by persecution in agricultural areas, where seen as pests to crops (e.g. Blue-winged Macaw *Ara maracana*, Hispaniolan Parakeet *Aratinga chloroptera*); the Carolina Parakeet *Conuropsis carolina* of N. America was hunted to extinction in late 19th and early 20th centuries because it was considered a pest of agriculture (Halliday 1978; Collar *et al.* 1994). In agricultural areas of sw. Vic., one of the most common causes of death of Long-billed Corellas is shooting by farmers (Emison *et al.* 1994); in WA, an open season declared on feral Sulphur-crested Cockatoos (Saunders *et al.* 1985), and several other species of parrots are also legally shot (Robinson & Brouwer 1989). In NZ, large numbers of Red-crowned Parakeets were formerly shot as pests around crops (Turbott 1967; Taylor 1985; Oliver).

Popular cage-birds. Throughout world, illegal taking of eggs or young from nests, or adults from wild populations for avicultural trade a major threat to continued survival of some species, e.g. Red-and-Blue Lory *Eos histrio*, Spix's Macaw *Cyanopsitta spixii*, Hyacinth Macaw *Anodorhynchus hyacinthinus*, Thick-billed Parrot *Rhynchopsitta pachyrhyncha*, Green-cheeked Amazon *Amazona viridigenalis* (King 1981; Collar & Andrew 1988; Ridgely 1989; Snyder *et al.* 1989; Juniper 1991; Collar *et al.* 1994). However, the effect of illegal collecting is exacerbated by threats posed by loss of habitat as described above (Collar *et al.* 1994; Forshaw). In HANZAB region, several species of cockatoos and parrots with small populations are threatened by illegal collecting for aviculture, for both local and overseas markets, e.g. Eclectus Parrot and subspecies *narethae* of Blue Bonnet *Northiella haematogaster* (Garnett 1993). In Aust., many hollows destroyed by collectors hacking holes in trees to get access to nest-hollows and eggs or young. Hollows that are not destroyed often repeatedly robbed, either in subsequent seasons or after birds re-lay in same season after theft of clutch (Forshaw). In NT, trial programme introduced to legally exploit wild populations of Red-tailed Black-Cockatoos, involving collection of eggs, nestlings and adults (Anon. 1995). Similar schemes have been proposed in other areas of Aust., involving other abundant or pest species, but have not been accepted. Extralimitally, extinction or declines in populations have also been blamed on human persecution, especially if thought to be pest of agricultural production, and including hunting (e.g. Snyder *et al.* 1989).

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Family CACATUIDAE cockatoos

Usually large (30–60 cm in length, 250–900 g) stocky parrots, with large strongly decurved bills, large ceres, and erectile crests; Cockatiel *Nymphicus hollandicus* atypical in size and shape, being medium-small and slender (c. 30 cm in length, 80–100 g). About 19–21 species in six genera (Schodde & Mason 1997); 14 species, from all six genera, occur HANZAB region. Most strongly represented in Aust. but also found across much of s. Asia including the Philippines, Solomon Is and other islands in the sw. Pacific Ocean, Sulawesi, Lesser Sunda Is, and a few small Indonesian islands, and New Guinea; also introduced to Hong Kong, Singapore and NZ.

Four subfamilies recognized (Schodde & Mason 1997, on which following based):

SUBFAMILY MICROGLOSSINAE: Monotypic Palm Cockatoo *Probosciger aterrimus*. Large slate-black cockatoo of C. York Pen. and New Guinea, with massive bill, feathered cere, bare and coloured lores and periophthalmic ring, large erectile crest and uncoloured tail. Sexes alike in plumage and bare parts but differ in size. Scratch head from under wing. Young have grey down, uniquely among Cacatuidae.

SUBFAMILY CALYPTORHYNCHINAE: Black-cockatoos; five species in single genus *Calyptorhynchus*, all endemic to Aust. Large, mainly black cockatoos with long tails, which are banded or barred with red, white or yellow, uncoloured erectile crests, and bare ceres. Moderate sexual dimorphism in plumage and bare parts; some differ slightly in size. Scratch head from under wing.

SUBFAMILY CACATUINAE: White cockatoos. Medium-sized, white, grey or pink cockatoos, usually with up-curved erectile crests, feathered nares, and plain tails. Thirteen to 15 species in three genera: monotypic *Eolophus* and *Callocephalon*, and *Cacatua*. Seven species, from all three genera, in HANZAB region. Slight sexual dimorphism except in *Callocephalon*. Scratch head over wing. Position of *Callocephalon* problematical (see Homberger 1991; Schodde & Mason 1997).

SUBFAMILY NYMPHICINAE: Monotypic Cockatiel. Small, slender, grey cockatoo endemic to Aust., with coloured up-curved crest, and bare cere. Sexually dimorphic in plumage and slightly in size. Scratch head over wing.

Naso-frontal hinge ossified or not. Carotid arteries paired in hypophyseal canal, and sometimes coalesced. Syrinx bronchial, the first rings straight, cartilaginous and separated by membrane. Gall bladder present. Powder downs particularly well developed (Smith 1975). Feathers have no Dyke-texture (cf. Psittacidae) (Smith 1975).

Adult plumage rather plain: mainly white, black or grey. Many are sexually dimorphic in plumage. All species have well-developed erectile crests. Bare parts mostly black, grey, brown or cream; irides mostly brown or reddish brown; bare orbital skin around eyes (periophthalmic ring) often enlarged and coloured. Post-breeding (pre-basic) moult of adults usually complete; some possibly take more than 1 year to finish moult. Moult of primaries centrifugal; can begin from any primary, but usually between p5 and p8. Some appear to have slow continuous moult of remiges and rectrices, which possibly takes longer than 1 year to finish. Nestlings have a single down; usually wispy and sparse. Juveniles usually similar in appearance to adult females. Can take up to 5 years to attain full adult plumage. Age of first breeding not known in many, but up to 4 years.

Occur in most habitats; from arid and semi-arid zones to tropical rainforest. Some species strictly arboreal (e.g. Palm Cockatoo), and others partly terrestrial and partly arboreal (e.g. Sulphur-crested Cockatoo *Cacatua galerita*, Long-billed Corella *C. tenuirostris*). All require hollows, and therefore old trees, in which to nest, and are adversely affected by the removal of hollow-bearing trees (Robinson & Traill 1996). Further, clearance and fragmentation of natural habitats has also adversely affected some species (see introduction to Psittaciformes). However, populations of some species, such as Galahs *Eolophus roseicapillus*, have increased dramatically, and ranges expanded after clearing of native vegetation and conversion to farmland, which has created habitat of similar structure to preferred natural habitats, as well as providing vastly increased availability of food. As a result, some species now agricultural pests in some regions, especially those areas where wheat and other grain grown (Saunders et al. 1985; Saunders & Ingram 1995; Vic. Atlas). In WA, feral Sulphur-crested Cockatoos, populations of which have increased, may compete with endemic species for nest-hollows and food, as well as potentially pose a threat to agriculture. Populations are, therefore, controlled by local authorities (Saunders et al. 1985; Saunders & Ingram 1995). There have been few extralimital introductions of cockatoos (see Long 1981).

Patterns of movements appear to vary widely, but movements of most species in HANZAB region not well known and some very poorly known. Few detailed studies in HANZAB region, and almost none for extralimital forms. Well-established migration only shown in some populations of Short-billed Black-Cockatoo *Calyptorhynchus latirostris*

(Saunders 1980), and this appears to be over short distances. Other species in Calyptorhynchinae considered resident or sedentary (Rowley 1997). Cacatuiinae generally sedentary, often with formation of locally moving flocks in non-breeding period or when birds young (Rowley 1983; Smith & Moore 1992). Most movements, from sedentary to migratory, have been attributed within and between species in this family. Many species described as nomadic or dispersive, which appears merely to reflect lack of knowledge of true patterns. Some species appear to move differently in different parts of range or in different habitats.

In some species, leg bands not appropriate method of marking because birds damage or destroy them, and colour-bands on short tarsi difficult to see or impossible to fit; wing-tags (coloured and labelled plastic or metal tags; Rowley & Saunders 1980) have been used to study movements (e.g. Saunders 1980; Rowley 1983; Smith & Moore 1992).

Mostly herbivorous; specializing on seeds and nuts (Campbell & Lack 1985). In HANZAB region, feed mainly on seeds of grasses, herbs and trees; also take a wide range of other plant food, including flowers, fruits, nuts, roots, corms, shoots and leaves; most species eat insects and their larvae, and one species feeds mainly on insect larvae (see below). Ground-feeding forms (e.g. *Cacatua*, *Eolophus*) mainly eat seed of grasses and herbs; some specialize in extracting bulbous roots and corms from soil (e.g. Long-billed Corella). Most arboreal forms (e.g. *Calyptorhynchus*) feed mostly on seeds of *Eucalyptus* and some other native trees; some specialize on seeds of Proteacea (e.g. Short-billed Black-Cockatoo); Glossy Black-Cockatoos *Cacatua lathami* feed exclusively on seeds of *Allocasuarina*; Palm Cockatoo eat more fruits than seeds and nuts; and Yellow-tailed Black-Cockatoos *Calyptorhynchus funereus* almost insectivorous, feeding mainly on wood-boring insects, supplemented by plant food. Usually feed in small groups, less often in pairs or singly; some feed in large flocks (e.g. Little Corella *Cacatua sanguinea*). Bills large and robust and specialized in some species, e.g. in Yellow-tailed Black-Cockatoo, for example, bill narrow with elongated and pointed tip to upper mandible that enables bird to dig into timber for wood-boring insects; Red-tailed Black-Cockatoos *Calyptorhynchus banksii* have broad blunt bill, for crushing seeds and hard woody nuts; Glossy Black-Cockatoos have protruding bulbous bill, with exceptionally broad lower mandible, an adaptation for tearing hard seed-cones of *Allocasuarina*; Cockatiels have narrow bills suited for feeding on small seeds, such as those of grasses; and Palm Cockatoos have massive bill that can crack nuts of *Pandanus* (Saunders 1974, 1979; Forshaw). Ground-feeding forms mainly feed in flocks; they have short tarsi which bring eyes and bill close to ground and enable birds to search and harvest an area quickly and efficiently. Dispersion of seeds determines pattern of flock foraging: where seeds densely accumulated in small area, feeding flocks dense; where food more dispersed, flocks feed in lines, moving in constant direction, usually into wind; when food in short supply, feeding flocks progress in rolling fashion, with birds at rear continually flying to the front (Rowley 1990, 1997).

Social organization and social behaviour not well known for species that occur outside HANZAB region (e.g. see Coates 1985; Coates *et al.* 1997); most of below based on Aust. data. Highly gregarious, especially *Cacatua*, *Eolophus* and Cockatiel; most species usually forage and roost in flocks of up to 100 with congregations of 1000s common, especially in non-breeding season; flocks sometimes immense; in HANZAB region, Palm Cockatoo is main exception, remaining in pairs or small groups except for occasional congregations of up to 30 at sources of food. Within flocks, pairs and family groups remain together and individuals, pairs and small groups often come and go independently. During breeding, flocks smaller, as breeding pairs disperse to nest, though many continue to form smaller groups with other breeders or non-breeders in area. After breeding, pairs with their offspring rejoin flocks. All species monogamous, pairing for life except for occasional divorces. Re-pair after death of mate or divorce, usually by next breeding season. Mates rarely apart, moving, feeding and roosting together. First breed when several years old, except for Cockatiel, which can breed in first year. Sexes generally share all aspects of parental care except only females incubate in black-cockatoos *Calyptorhynchus* and, probably, Palm Cockatoo. Young can remain with parents till next breeding season, or even for several years in larger species, but in *Cacatua* and Cockatiel, normally leave soon after independence. Crèches of young sometimes formed by Galahs and Gang-gang Cockatoos *Callocephalon fimbriatum*. Nesting generally solitary but nests often close together, even in same tree, with only a small area around nest defended. However, Palm Cockatoo and Major Mitchell's Cockatoo *Cacatua leadbeateri* nest farther apart, appearing to maintain territories of many hectares. Nests are often used year after year, and *Cacatua* tend to have a year-round association with nest. Roosting usually communal, except for nesting pairs who roost in nest-tree, in all except Palm Cockatoo, which roosts year-round in pairs or family groups within territory. Roosts often used regularly for years, though nomadic birds often use sites for only days or weeks before moving on.

Most species noisy and conspicuous. Wary and difficult to approach when on ground but more confiding if in trees. Very wary near active nests. Flocks, when disturbed, fly off together calling loudly; often mob predators. Belief that many species have sentries to warn foraging flocks of danger probably spurious (Noske 1980). Daily activity consists of leaving roost around sunrise then feeding before resting in trees over middle of day, feeding again in the afternoon, and returning to the roost around sunset. Crest important in virtually all social interactions, generally raised whenever aroused in aggressive, sexual or alarm contexts. Aggression mostly infrequent, generally only involving mild threat or displacement, rarely escalating to fighting and then usually only over nest-sites. Commonest threat behaviour consists of gaping bill widely; most fighting with bill. Submissive behaviour generally consists of turning away or

retreating. Some species have apparent territorial displays, e.g. Heraldic Display of the Galah (Rowley 1990), but none so complex as that of Drumming Display of Palm Cockatoo, for which bird prepares sticks to drum on trees (Wood 1988; see that text). In all species, display in which wings swept forward and over head given by both sexes when excited (Courtney 1974). No evidence of stable hierarchies in wild. Sexual displays of males can involve bobbing or shaking of head, spreading of wing and tail and calls; female *Cacatua* can respond to males similarly. Courtship feeding by regurgitation; most developed in species in which only female incubates, with male feeding female often as part of courtship and continuing to provision female during nesting; in other species, courtship feeding is much reduced and absent in other species. Allopreening between mates occurs in many species, particularly in breeding season; also occurs in many species between parents and young, between siblings and between unrelated birds. Before roosting, flocks commonly perform noisy display flights. *Cacatua* strip vegetation from trees, especially during midday rest periods. Bathe in rain or wet foliage, rarely in pools, often with much excitement.

Calls usually loud, harsh and often piercing; most calls described as squawks or shrieks, but some melodic and whistle-like (e.g. Forshaw & Cooper 1981; Coates *et al.* 1997; Forshaw). Most remarkable sound is that produced by Palm Cockatoo during Drumming Display, when a tool or foot is used to produce a loud drumming sound from resonant surface on a tree (Wood 1984, 1988; see that text). Calls usually distinctive, including quavering cry of Major Mitchell's Cockatoo and soft, strange, creaky calls of Gang-gang Cockatoo.

Breeding well known in HANZAB region, poorly known extraliminally; breeding for some extralimital species of *Cacatua* known only from captivity (Forshaw & Cooper 1981). Breeding generally seasonal; in HANZAB region, laying usually from July or Aug. in s. Aust., Apr. or May in n. Aust., but most species will lay at other times of year if conditions suitable. Nest predominantly in large hollows of trees; in HANZAB region mostly in eucalypts; Sulphur-crested Cockatoos and Long-billed Corellas also known to nest in holes in cliffs. Most species maintain and enlarge tree-hollows by chewing bits of wood from sides of hollow to form lining at bottom; Galahs line nest with sprays of *Eucalyptus* leaves. Eggs white but may become stained in nest. Mean size of eggs varies from 24.5×19 for Cockatiel to 52.7×36.4 for Red-tailed Black-Cockatoo (nominate *banksii*). Usual clutch-size varies: 1–2 for *Calyptorhynchus* and *Probosciger*; 2–4 for *Cacatua* and *Callocephalon*; 2–5 for *Eolophus*; and 3–6 for *Nymphicus*. Incubation by both sexes in *Cacatua*, *Callocephalon*, *Eolophus* and *Nymphicus*, and by female only in black-cockatoos *Calyptorhynchus* and *Probosciger*. Incubation period 20–30 days in *Cacatua*, *Callocephalon*, *Eolophus* and *Nymphicus*; 28–35 days for *Calyptorhynchus* and *Probosciger*. Young altricial, nidicolous. Young develop down within a few days of hatching; yellow in *Calyptorhynchus*, buff-white to pale yellow in *Cacatua*, reddish in *Callocephalon*, pinkish in *Eolophus* and grey in *Probosciger*. For *Calyptorhynchus* and *Probosciger*, young fed by female only or by female for first few weeks then assisted by male; in other genera, both sexes feed young. Fledging period ranges from 28 days for *Nymphicus*; 6–10 weeks for *Cacatua*, *Eolophus* and *Callocephalon*; 8–9 weeks for *Probosciger*; and 80–90 days for *Calyptorhynchus*. Fledgelings usually remain with parents for some time after leaving nest.

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Cacatua roseicapilla Vieillot, 1817, *Nouv. Dict. Hist. Nat.* 17: 12 — 'dans les Indes' = region of Shark Bay, Western Australia.

The generic name refers to the pale rose-pink crest, giving the appearance of the rising dawn (Greek ἠώς, dawn, and λόφος, crest). The specific name refers to the pink-suffused crown feathers (Latin *roseus*, rosy, and *-capillus*, capped).

OTHER ENGLISH NAMES Rose, Roseate, Rose-breasted or Willock Cockatoo; Willock.

POLYTYPIC Nominate *roseicapillus*, WA to Eighty Mile Beach and s. fringes of Great Sandy Desert, and E to central ranges of NT and n. SA; *albiceps*, Schodde, 1989, se. Aust. W to Eyre Pen. and L. Eyre Basin, and N to 20°S; *kuhli* (Mathews, 1912), Dampier Pen. and Kimberley Div., through Top End of NT, to s. coast of Gulf of Carpentaria and C. York Pen.

FIELD IDENTIFICATION Length 35 cm; wingspan 75 cm; weight c. 330 g. Small cockatoo. Widespread, abundant, familiar and unmistakable: mostly grey above and deep pink on head, neck and underbody, with pinkish-white cap and short crest. Sexes differ slightly in bare parts. No seasonal variation. Juvenile separable. Slight geographical variation. **Adult male** Head and neck, including narrow band across lower forehead, deep pink to rose-red, with varying pinkish-white cap and short erectile crest; pink tinge to cap faint in nominate *roseicapillus* or strong in subspecies *albiceps*. Also have narrow arc of paler feathering beneath periophthalmic ring that varies in prominence. Rest of upperparts, grey, grading to darker grey on tips of primaries, and with: contrastingly paler grey-white back, rump and uppertail-coverts; prominent pale panel across secondaries; and diffuse dusky-grey terminal tail-band. Underbody to lower belly and thighs, deep pink to rose-red; vent and undertail-coverts, grey; undertail, dark grey. Most underwing-coverts, pink as underbody; rest of underwing, dark grey. Bill, off-white. Iris, dark brown. Periophthalmic ring large, with pronounced carunculations; varies in colour: dull crimson in *albiceps* or white or grey-white in *roseicapillus*. Legs and feet, dusky grey. **Adult female** As male except: iris, pink-red; periophthalmic ring smaller, with less well-developed carunculations. **Juvenile** Similar to adult, differing by: plumage generally duller, with sides of crown, nape, hindneck, sides of neck, foreneck and breast strongly washed grey; upperparts delicately scaled paler above; iris, brown; and periophthalmic ring, pale grey with faint pink tinge.

Similar species Normally unmistakable. Flying birds seen against light could be confused with **Gang-gang Cockatoo** (which has broadly similar flight-silhouette): Galah distin-

guished by slimmer build and, especially, by proportionately narrower wings and longer, narrower tail; flight also faster and more buoyant, and calls very different.

Gregarious. Seen singly, in pairs or large flocks, sometimes numbering in thousands. Found in almost any open habitat with suitable trees. Typically gather in large flocks at abundant food, or at water. Active, noisy and conspicuous. Large flocks gather to drink at watering holes in early morning and late afternoon. Form large communal roosts where birds indulge in playful noisy antics; often call and fly about wildly after sunset. Forage mainly on ground but also in foliage. Walk with slow waddling gait. Normal flight direct and rather buoyant; wingbeats shallow and continuous, with emphasis on downstroke and slight pause on upstroke; glide only when coming in to land. Particularly toward dusk, large flocks often perform wild wheeling flights accompanied by loud calling before settling to roost. Typical flight call unmistakable loud high-pitched *chill chill*; also utter softer, less urgent buzzing *chet chet* or *czzk czzk* in flight or at rest, and harsher screeches in alarm.

HABITAT Occur in wide variety of open habitats. Often in grassland and agricultural areas, including crops, pasture and stockyards, especially on riverine plains with nearby open clumps of riparian trees, particularly River Red Gums *Eucalyptus camaldulensis* (Sedgwick 1949; Hobbs 1961; Serventy 1977; Emison & Porter 1978; Gibson 1986; Jones 1986; Saunders & Ingram 1995; Henle 1989; Forshaw); also in other open, lightly timbered areas, such as open forests, woodlands or savanna, of *Eucalyptus*, *Acacia*, *Casuarina*, or *Callitris* associations; occasionally also in low shrublands, bluebush and saltbush (Jones 1952; Storr 1953; Ford & Sedgwick 1967; McEvey & Middleton

1968; Halse *et al.* 1985; Black & Badman 1986; Jones 1986; Gibson & Cole 1988; Leach 1988; Badman 1989; Reid 1994). Often in urban areas: gardens and lawns, playing fields, golf courses, parklands and townsites (Howard 1980; Morris 1986, 1989; Dunn 1989; Forshaw; NSW Bird Reps). May occasionally occur in treeless habitats, such as samphire flats, spinifex sandplains and dunes, sedge-plains and claypans (Ford & Sedgwick 1967; Crawford 1972; Moriarty 1972; Wilson 1974; Matheson 1976; Hatch 1977; Johnstone *et al.* 1979; Gibson & Cole 1988; Badman 1989). Down by the seaside, occasionally on grassy foreshores, on beaches or among mangroves (Butler 1970; Matheson 1976; Garnett & Bredl 1985; Morris 1986, 1989); also on offshore islands (Shaughnessy 1968; Stirling *et al.* 1970; Parker & Cox 1978; Storr 26) and rarely at sea (Brandis *et al.* 1991; NSW Bird Rep. 1981). Either absent or rare in sandy deserts or in heavily timbered areas such as rainforest or wet sclerophyll forest (Morris *et al.* 1981; Forshaw).

Breed in holes and hollows, usually in smooth-barked *Eucalyptus* trees (Rowley 1990); often in River Red Gums along watercourses (Wood 1959; McEvey 1965; Nielsen 1969; Moriarty 1972; Rix 1976; Forshaw), or remnant along roadsides or in farmland (Conole 1981; Leach & Hines 1987; J.M. Peter). Also in open *Eucalyptus* forests and woodlands (Cooper 1972; Masters & Milhinch 1974; Gepp & Fife 1975; Leishman 1994; Mawson & Long 1994), or in trees on dry plains (Elliott 1938; Moriarty 1972). Occasionally in other trees, including Mulga *Acacia aneura* and *Callitris*; once in palm tree in urban parkland (Carpenter & Matthew 1986; Rowley 1990; Serventy & Whittell). In some treeless areas, recorded nesting in caves, crevices and holes in cliffs and rock-faces (Shaughnessy 1968; Beruldsen 1972; Baxter 1989; Rowley 1990); in ne. SA, seen breeding in crab-holes in ground (Teague 1987); once in concrete pipe incorporated into fence (Rowley 1990).

Mainly forage on ground in open; rarely among tall or dense cover (Rowley 1990). Often feed on open plains (Hobbs 1961; MacDonald & Colston 1966) and farmland, especially in paddocks with crops (germinating, ripe or in stubble) or pasture (Rowley 1990); in sheep pens, cattle yards and horse paddocks with spilt food and undigested grain in dung (Elliott 1938; Boehm 1962; Carruthers 1968; Boekel 1980; Saunders *et al.* 1985; Rowley 1990) and in grassy habitats in urban areas, including lawns and golf courses (e.g. Morris 1986, 1989). Also feed in other areas with spilt grain, including wheat storages and besides roads (Eckert 1972; Favaloro 1984; Rowley 1990). Once seen feeding on freshly graded roadside, on exposed corms (Boehm 1990); recorded foraging at muddy edges of rapidly drying wetland (O'Donaghue 1915). Will dig to excavate newly germinating grain or corms of weeds and grass (Quinn 1961; Cleland 1969; Rowley 1990). Recorded foraging in low *Atriplex* and *Sclerolaena* shrubland (Badman 1989); once observed foraging on beach, on beachcast moths (Morris 1989). Occasionally feed above ground, on plants, including some seeding wattles, Desert Poplars *Codonocarpus cotinifolius* and on Sunflowers *Helianthus annuus* (Jones 1984; Biddiscombe 1985; Rowley 1990) and possibly on flowering *Arctotheca populiflora* in sand-dunes (Storr 28). Also among mistletoe (Forshaw).

Usually roost in clumps of large trees, especially River Red Gums, growing near watercourses or other wetlands, and within c. 2 km of current feeding site (Sedgwick 1949; Hobbs 1961; Boekel 1980; Rowley 1990; Forshaw). Mostly among foliage at top of canopy, but occasionally also on dead branches (Warham 1957; Rowley 1990). Once recorded roosting in dead pine tree (Bradley & Bradley 1971). Often loaf in shade among foliage of trees and shrubs near water; trees may be dead or alive; also in

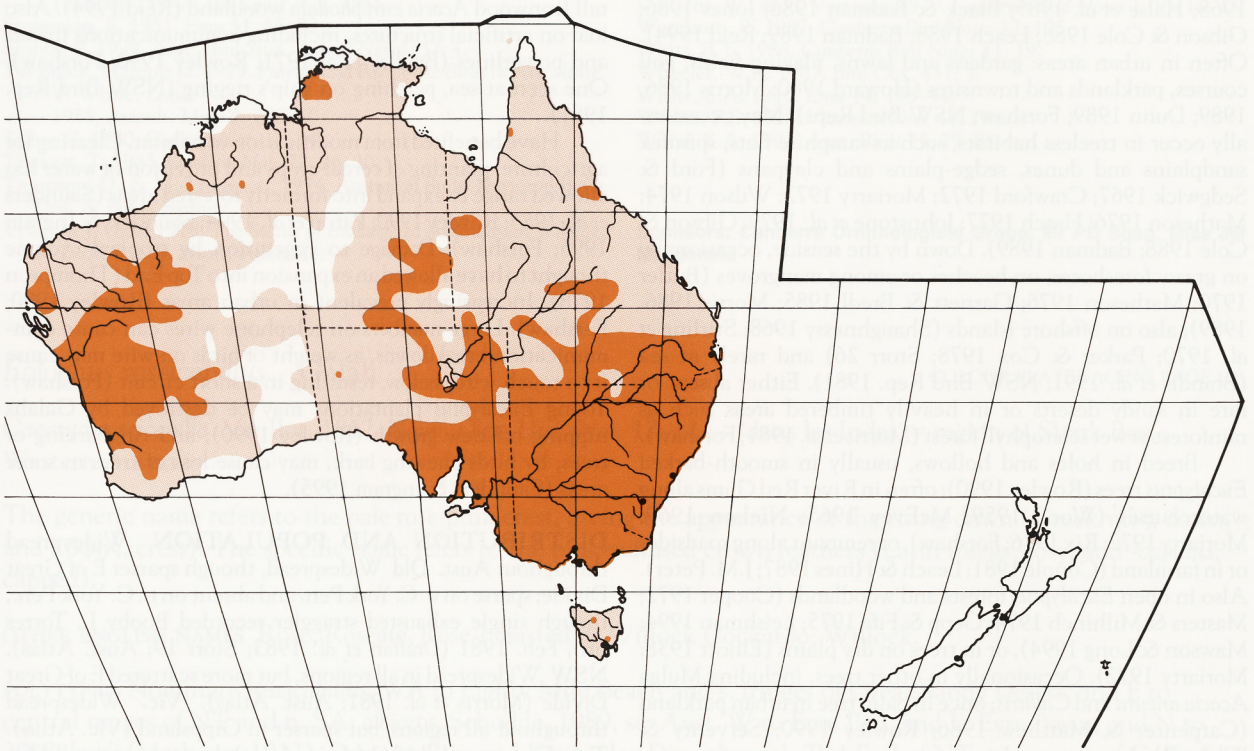
tall Ironwood *Acacia estrophiolata* woodland (Reid 1994). Also loaf on artificial structures, including communications towers and powerlines (Bradley *et al.* 1971; Rowley 1990; Forshaw). One seen at sea, perching on ship's rigging (NSW Bird Rep. 1981).

Have benefited from modification of habitat. Clearing for agriculture, planting of cereal crops and provision of water has allowed range to expand into formerly forested areas (Saunders *et al.* 1985; Rowley 1990; Paton *et al.* 1994; Saunders & Ingram 1995; Forshaw). Damage to vegetation by tropical cyclone thought to have allowed an expansion into Top End (Thompson 1978). Increasingly prevalent in urban areas (Rowley 1990; Forshaw). Large numbers on telephone wires can cause communication breakdowns, as weight of birds on wire may cause it to touch wires below, resulting in a short circuit (Forshaw). Young *Eucalyptus* plantations may be destroyed by Galahs nipping off new growth (Rowley 1990); and ringbarking of trees, by birds chewing bark, may cause loss of trees in some areas (Saunders & Ingram 1995).

DISTRIBUTION AND POPULATION Widespread throughout Aust. **Qld** Widespread, though sparser E of Great Divide; sparse on w. C. York Pen. and absent on n. C. York Pen., though single exhausted straggler recorded Booby I., Torres Str., Feb. 1981 (Draffan *et al.* 1983; Storr 19; Aust. Atlas). **NSW** Widespread in all regions, but more scattered E of Great Divide (Morris *et al.* 1981; Aust. Atlas). **Vic.** Widespread throughout all regions, but sparser in Gippsland (Vic. Atlas). **Tas.** First recorded 1842 (Aust. Atlas), but not again till May 1908 when three (including two shot) at Jerusalem Plains, near Bridport (Littler 1910). In 1922, several escaped from ship in Huon R., but thought not to have survived (Sharland 1952). Occasional records on islands of Bass Str., including Deal (Gray *et al.* 1987), Flinders (Newman *et al.* 1984) and King Is (Green & McGarvie 1971), together with many records in n. Tas., from Rushy Lagoon and Bridport, W to Wynyard, and S to Launceston, may indicate natural immigration from mainland (Brown & Holdsworth 1992; Forshaw). Elsewhere, feral populations recorded S to round Hobart. Range expanding to E, with recent records at St Helens and Oxford (Brown & Holdsworth 1992; Aust. Atlas; Tas. Bird Reps). **SA** Occur in all districts, but less often in w. half of state (Aust. Atlas). **WA** Sparsely scattered records in Nullarbor and round s. coast, extending into extreme SW; widespread in Wheatbelt, extending N through Gascoyne Region to n. Pilbara Region, and E to c. 122°E; also widespread throughout most of Kimberley Div. Either absent or sparsely scattered in Great Sandy, Gibson and Great Victoria Deserts (Saunders & Ingram 1995; Aust. Atlas). **NT** Occur throughout most districts, though uncommon or absent in sandy desert areas in w. regions; also not recorded round Gove Pen. (Boekel 1976; Gibson 1986; Storr 7; Aust. Atlas; H.A.F. Thompson & D.K. Goodfellow).

NZ Presumed feral population, consisting of up to 34 birds, recorded W of Firth of Thames, in area from Ponui I., S to Mangatawhiri, and W to Bombay and Clevedon (CSN 36, 37, 41). Single escapes also recorded at Woodhill and Rotowaro (CSN 22, 37), and may potentially occur anywhere near settlements.

Breeding Widespread in SE, S of 26°S and E of 135°E; in WA, widespread from Wheatbelt, N to c. 22°S in Pilbara Region, and E to areas E of Kalgoorlie and near L. Disappointment. Sparsely scattered records in Kimberley Div. and Top End; widespread in s. NT. Few, scattered records N of 21°S in Qld, but widespread in central Qld. Occasional records else-



where in range, including Tas. (Aust. Atlas; NRS).

Change in range Formerly a bird of the inland, has expanded range, after clearing for agriculture and establishment of new and permanent water sources, to include most of continent. Colonization of some settled areas augmented by escapees or released birds. **Qld** Before 1880s, only occurred W of Great Divide, and, in S, thought not to have extended farther E than Warrego R. By 1920s, e. boundary extended from Alpha to Goondiwindi; established on Darling Downs by late 1940s and penetrated areas E of Great Divide by 1950s, and first recorded round Nanango in 1955 (Templeton 1992; Storr 5). Formerly only extended E of Great Divide during inland droughts (Lord 1956). **E. range expansion** in n. and central regions less pronounced (Storr 5). **NSW** Formerly occurred mainly in w. regions, but expanded E; first recorded round Orange in 1940s (Heron 1973), and appeared in areas E of Great Divide about the same time (e.g. Bell 1983); unknown in County of Camden before 1960, but numbers round Sydney rapidly increased since c. 1970 (Gibson 1977; Morris 1986). Formerly only visited coastal regions during severe inland droughts (Hoskin 1991). **Vic.** Formerly inhabited arid and semi-arid areas in N; slowly expanded S and SE into peripheral areas of range. First recorded Portland in 1950s (Officer 1958), and considered resident Geelong by mid-1950s (Wood 1959). Rarely recorded Melbourne before 1970, but now common (Vic. Atlas). Expanded E into Gippsland since mid-1960s (Bedgood 1980). **Tas.** Range expanding to E (Brown & Holdsworth 1992). **SA** Populations in Gawler Ras may have rapidly declined by late 1890s (Paton 1975). Previously occurred mostly in NE, but range expanded southward round 1920s; first recorded Mt Mary Plains in c. 1918 (Boehm 1959), round Naracoorte in 1925 (Attiwill 1972), and Kangaroo I. in c. 1930 (Wheeler 1960). Breeding first recorded at Wilmington, s. Flinders Ras, in c. 1924 and Mt Mary Plains in 1926 (Boehm 1959; Ragless 1988).

Colonization of s. SA 'has long been complete' (Paton *et al.* 1994). By 1930s expanding into NW (McGill 1935), where previously rarely reported; now numerous and widespread (Close & Jaensch 1984). **WA** Expansion into Wheatbelt and SW well described (e.g. Saunders *et al.* 1985; Saunders & Ingram 1995; Serventy & Whittell). Range spread S and SW from inland areas N of Mulga-Eucalypt line and Murchison R.; transients reached Moora before 1913, and first recorded round Wongan Hills and Kellerberrin in early 1920s; colonized Dalwallinu in 1928. Expanded into ne. parts of Northam District in 1946, and by early 1950s had reached Mogumber, Gingin and Lower Chittering. By 1970s had colonized areas W of Darling Ra., including Perth, and had reached s. coast. Thought that range will continue to expand till all suitable habitat occupied. **NT** Formerly not recorded S of Reynolds Ra.; s. regions colonized during 1920s and 1930s, apparently via Sandover and Finke Rs (Storr 7).

Introductions Unknown number collected Morefield, PNG, thought to have been released captives (Beehler *et al.* 1986). Imported to Hawaii and possibly introduced; later escapees failed to become established (Long 1981).

Populations In sw. Vic., in early 1980s, minimum density of Galahs was 1 bird/485 ha (Emison *et al.* 1981). Recorded at 0.18 birds/ha in *Eucalyptus* forest near Armidale, NSW (Ford *et al.* 1985). In Yinberrie Hills, NW of Katherine, NT, recorded at mean density of 0.1 birds/ha (Woinarski & Tidemann 1991). On road-trip round inland e. Aust., recorded at rates of up to 0.68 birds/km in 177 km section between Longreach and Winton (Brereton 1977). In Wheatbelt, WA, c. 350 breeding pairs occur in 450 km² of mosaic woodland among wheat paddocks (Saunders *et al.* 1985). Total Tas. population probably 100–200 birds (Brown & Holdsworth 1992). In three Canberra suburbs, measured at abundance of five 'territories' in 74.5 ha, four 'territories' in 35.7 ha and three 'territories' in 197.2 ha

(Lenz 1990). In e. suburban Melbourne, two nesting pairs recorded along 1.5 km of creek (J.M. Peter).

Considered a pest in grain-growing regions, because damage newly planted or sprouting crops (Boehm 1959; Jarman & McKenzie 1983; Rowley 1990) and, in past, also fed on wheat stored in sacks awaiting transportation, or in open-air grain-storages, which became contaminated with faeces (Rowley 1990). Because pest, often shot and occasionally poisoned (Boehm 1959; Rowley 1990). Have been used for trap-shooting by local clubs (Dickison 1951; Pescott 1983). Chew through electrical wires on aerials, or caulking round windows (Shaughnessy 1968; Rowley 1990). Often feed on roadsides, where they are often struck by vehicles, sometimes in large numbers (Eckert 1972; Vestjens 1973; Disney & Fullagar 1978; Favaloro 1984; Rowley 1990; Lepschi 1992). Sometimes attacked by cats or dogs (Dowling *et al.* 1994). Have benefited from introduction of stock and horses: feed on spilt sorghum and seeds spilt from hay, and upon undigested seeds in dung (Boehm 1962; Boekel 1980; Saunders *et al.* 1985; Rowley 1990). Of 242 wing-tagged Galahs recovered dead and where cause of death known: 182 were shot, 18 killed by cats, 18 killed by raptors (probably picked out because of conspicuousness of wing-tag), 11 struck by vehicles, six drowned in stock tanks, five died through 'technical accidents', such as wing-tags becoming tangled among branches, one was electrocuted, and one was trodden on by a cow; once seen to collide with a cannon-net projectile in flight (Rowley 1990). Popular cagebird.

MOVEMENTS Account based mostly on contribution by I.C.R. Rowley. Non-migratory (I.C.R. Rowley). Often said to be resident (e.g. Rowley 1975; Thomas & Wheeler 1983; Hardy & Farrell 1990; Durrant & MacRae 1994; ACT Atlas). In Wheatbelt of WA, most of population nomadic, but breeding birds sedentary. Also claimed that movements vary considerably according to habitat (Sindel & Lynn Undated). Often travel at speed, up to 70 km/h, which enables birds to travel long distances to forage and obtain water. Travelling flight appears to have two speeds: an initial flight after take-off, with fast deep wing-beats, and, once speed and altitude attained, overdrive flight, with slower shallower wing-beats. Can cross stretches of water: in WA, vagrant to some islands, such as Rottnest (Saunders & de Rebeira 1993), Barrow (Storr 16), Dirk Hartog Is (Storr 21) and Houtman Abrolhos (Storr 24).

In Wheatbelt of WA, population can be split into three categories: (1) core community of breeding pairs, which might consist of sedentary pairs that tend to return to same nesting hollow every night but which forage up to 10 km from hollow; (2) juvenile flocks that wander over varying distances, some over considerable distances, apparently seeking food; juveniles join such flocks after independence from parents; and (3) locally nomadic flocks in which birds from juvenile flocks settle in a locality and form part of a locally nomadic flock, which may forage over >1000 km², and tend to roost at sites close to current sources of food; after 1–2 years, birds pair, obtain a breeding hollow and then become part of community of breeding pairs (Rowley 1975; Sindel & Lynn Undated; I.C.R. Rowley).

Movements elsewhere in range not studied in detail and not known if fit above pattern. Always present in some districts (e.g. Warringal Cons. Soc. 1981), though numbers vary seasonally in many areas (e.g. Norris *et al.* 1995). No large-scale seasonal pattern of movement (Aust. Atlas) and suggested that mobile flocks responsible for reported seasonal movements (Forshaw). However, some records suggest seasonal movement, e.g. in NT, largely leave far n. subhumid zone in wet season,

Nov.–Apr., and partly vacate n. semi-arid zone at height of rains, Jan.–Feb. (Storr 7); absent Darwin area, NT, Mar. and Apr., and common mid-Sept. (Deignan 1964); combined, suggests movement to n. coast in dry season and away from it in wet season. In Vic., high reporting rates in winter and spring, but reason not known (Vic. Atlas). Some movements apparently influenced by rainfall: in ne. Qld visit coast and Atherton Tableland in times of drought (Wieneke 1992); in 1941 large influx into Sydney area attributed to drought (Hoskin 1991). Able to tolerate harsh winters at intermediate altitudes (ACT Atlas).

Dispersal of young In Wheatbelt of WA: in Jan., when c. 100 days old, juveniles deserted by parents and join juvenile flock, which disperses widely. Initial movement after desertion by parents appears to be largely directed by prevailing early morning wind; a second phase of movement takes place in mid-winter in response to changes in availability of food. Study of marked birds showed that ultimate direction of dispersal from natal hollow was random, with early tendency to drift with prevailing summer easterly wind in WA (Rowley 1983, 1990). Data from resighting of tagged and banded nestlings (Buckland *et al.* 1983; Rowley 1983) suggest 12% moved >20 km from natal hollow (Saunders *et al.* 1985); some apparently remain in, or return to, natal area, with one banded as nestling recovered nearby 9 years and 10 months later (ABBBS 1981). By second year, young have usually settled into a locally nomadic flock (I.C.R. Rowley). One banded as juvenile in WA, recovered almost 3 years later 210 km away (I.C.R. Rowley). In e. Aust., marked juveniles (n=263 banded, eight recovered) travelled an average distance of 109 km, suggesting birds nomadic or widely dispersing (Pidgeon 1970) as in WA. One banded as nestling recovered 473 km from banding site (ABBBS 1965).

Banding Of 8267 banded in Aust., 1953–96, 996 recoveries (12.0%): 859 (86.2%) <10 km from banding site; >107 (10.7%), 10–49 km; 19 (1.9%), 50–99 km; 11 (1.1%) ≥100 km. Long-distance recoveries: Parkerton 3 km NE of Kalgoorlie, WA, to E of Mandurah Township, WA (580 km, 248°, 78 months, Mar.; +1, M); 14.5 km N of Lower Light Post Office, SA, to Pira, Vic. (477 km, 104°, 23 months^D, Sept.; P); Manmanning, WA, to 212 Mile Peg near Moorine Rock, WA (200 km, 105°, 36 months^D, Apr.; J, F); Lucindale, SA, to Portland, Vic. (169 km, 136°, 18 months, Oct.; P); 16 km E of Langhorn, SA, to Dukes Highway, c. 8 km from Keith, SA (129 km, 129°, 55 months^D, Oct.; J); Kanni, SA, to Kenton Valley, SA (129 km, 236°, 16 months^D, Feb.; P); 19 km NW of Finley, NSW, to 11 km from Carrathool on Murrumbidgee R. Rd toward Darlington Pt, NSW (125 km, 6°, 5 months^D, Dec.; I); Erinvale Aviaries, WA, to Konnongorring, WA (119 km, 36°, 14 months^D, Nov.; J, F); Manmanning, WA, to N of Trayning, WA (111 km, 37°, 27 months^D, Mar.; J, M); Glenvar, WA, to Kellerberrin, WA (110 km, 135°, ≤26 months^D, Feb.; J). Longest lived, 20 years (244 months).

Analysis of recoveries of 880 banded 1953–67 showed average distance travelled from banding site, 3.7 km (Pidgeon 1970).

Between 1970 and 1976, 2460 juveniles were marked, 699 with leg-bands only and the rest (1761) with individual wing-tags and bands. Of these, 265 bands (10%) returned after birds had been found dead. Bands from wing-tagged birds were returned more often (13.2%) than those from birds carrying only metal bands (4.6%). Besides these known-age birds, 532 birds of unknown age but not juveniles were caught and wing-tagged; 47 of these were reported dead and their bands returned. Of 48 band returns from birds where sex was known, 30 males

had travelled on average 18–19 km and 18 females travelled 26.6 km (I.C.R. Rowley). Of 304 birds wing-tagged in summer 1975 and autumn 1976 and subsequently identified as non-breeding adults: 48.7% not sighted in core study area after 1 year; once mortality estimate included, suggested 35% dispersed beyond study area (Rowley 1990).

FOOD Seeds of grasses and herbaceous plants, including cereal grains; also fruits, berries, nuts, roots, rhizomes, stolons, green shoots, leaf buds, flowers, and insects and their larvae.

Behaviour Based on studies in Wheatbelt of WA by Rowley (1990) unless stated. Usually forage on ground, searching for and ingesting seeds, which are located by sight. Seeds either taken from surface or from just below surface after soil or litter raked sideways with bill. Rarely dig, though will unearth grain that has been sown too shallowly, and sometimes eat rhizomes of grasses. Feed on wheat throughout year from one of four sources: standing crops, spillages, grain fed to livestock, or from animal dung; standing crops not available to Galahs for c. six months of year, while wheat still in vegetative growing stage; when crop flowers and seeds set in Oct., start feeding on new milky grains around edges of crops, by felling flowering stalks before extracting unripe seeds; rarely feed in tall and dense cover of main crop. Feed on *Erodium* seeds, especially during Sept. and Mar. when little wheat available; harvest seeds before schizocarp splits, then discard style and ingest fine seeds. Toward end of winter, search for and eat sprouting green clover *Trifolium*. At Swan Vale and Wallangra, NSW, feed on seeds from native grasslands available mostly from mid-spring to late autumn, and on seeds from cultivated crops available throughout year as standing crops or stubble areas; in autumn and winter feed on Sunflower *Helianthus annuus* and Sorghum *Sorghum*, and in spring and summer on Wheat *Triticum aestivum*, Barley *Hordeum vulgare* and Oats *Avena sativa* (Noske 1980). Small seeds husked individually, using tongue and bill; large grain cracked and soft part of grain eaten (e.g. Maize *Zea mays*), or husked and broken into smaller pieces before ingestion (e.g. Sunflower) (Pidgeon 1970). Have learnt to probe fresh cattle and horse dung for undigested grain (Boehm 1962; Rowley 1990). Occasionally feed in trees and shrubs, e.g. Desert Poplar *Codonocarpus cotinifolius*, or on unripe, still green pods of *Acacia acuminata* while still on tree. Also feed above ground on crops with strong stems, such as Sunflower, Sorghum and Maize (Pidgeon 1970; Noske 1980). In se. SA (direct observation of 10,750 Galahs; data extracted from Fig. 5 and recalculated; Emison & Beardsell 1985): 45% of birds observed foraging fed on pasture, probably on onion grass *Romulea*; 6.8 on germinating cereals (oats, wheat and barley); 0.7 on cereal stubble; 2.8 on mature sunflower; 29.0 on sunflower stubble; 7.5 on ploughed paddocks; 7.2 on feed trails. Unlike other parrots, rarely hold food in foot while eating (Rowley 1990); but observed to use foot when feeding on fleshy inner parts of onion grass *Romulea rosea* corms after digging them from soil with bill (Cleland 1969), and when extracting and eating seeds from some small seed-heads, such as Wheat and some thistles (e.g. *Cirsium vulgare*) (Noske 1980). **SIZE OF FORAGING GROUPS:** Size and composition of feeding flocks vary with time of year, between years and between localities; at Wheatbelt flocks of 500–1000 birds not uncommon (see also Social Organization). In Swan Vale and Wallangra, NSW, feeding flocks of 10 to over 500 birds when feeding on crops in standing crop or stubble, and in flocks of 1–100 birds when feeding in native grasslands (Noske 1980). In se. Aust., size of feeding flocks varied seasonally; mean size greatest in autumn (c. 31 birds), lowest in spring (c. 5); also

mean sizes of flocks largest when birds feeding (c. 35), compared with flying (c. 6) or roosting (c. 15) (Emison & Nicholls 1992). In Wheatbelt of WA, forage with Red-tailed Black-Cockatoos *Calyptrorhynchus banksii*, Major Mitchell's Cockatoos *Cacatua leadbeateri* and corellas *Cacatua*; when feeding with other species, Galahs maintain separate flocks and feeding schedules but respond to common alarm calls. In se. Aust., feed with Long-billed Corellas *Cacatua tenuirostris* and Sulphur-crested Cockatoos *Cacatua galerita*; similarly respond to alarm calls of any species (Emison & Nicholls 1992). **SPACING WITHIN FLOCKS:** Individuals in foraging flocks usually space themselves out so that no bird closer than 0.2 m to another. When feeding on stubble or pasture, flocks tend to be spread over broad front and some 5–10 birds deep; move forward mainly by walking but occasionally birds at back fly over others and land at front. Most foraging peaceable and quiet, except for Contact Calls when new arrivals join feeding flock. In places where food supply is concentrated in small area, birds feed closer together and quarrelling common and noisy. **TIMES OF FEEDING:** In ne. NSW, spend several hours of each day feeding, usually in two main sessions of 1–4 h duration, one in early morning, beginning within 1 h of dawn, and one in mid- to late afternoon, up to 5 h before dusk (Pidgeon 1970; Noske 1980). Also feed in shorter periods of 15–30 min throughout day (= Brief Feeding Loop of Pidgeon [1970] or minor feeding of Noske [1980]). In se. Aust., numbers of feeding birds vary with time of day (morning, midday or afternoon) and season: during summer, birds fed substantially less during midday (11:00–16:00); for rest of year, birds fed slightly more in this period of day; number of feeding birds also changed with changing temperatures: numbers seen feeding were highest when temperatures below 20 °C and lowest when temperatures ≥ 30 °C (Emison & Nicholls 1992). In Wheatbelt of WA, feed all day when food scarce or when breeding birds have young to feed (Rowley 1990). In Canberra area, pattern of foraging also varied with season, changes of food resources and physiological demand of winter (Westcott & Cockburn 1988). For detailed description of daily activities, see Social Behaviour: Daily Activity. **PEST STATUS:** Considered economic pest in many areas where cereal and oilseed crops are cultivated, namely Wheat, Sorghum, Barley, Oats, Maize, Sunflower, Canola *Brassica napus* and Safflower *Carthamus tinctorius*; damage caused mainly by feeding on seeds, or digging up newly sown and germinating crops (e.g. Bennett 1978; Jarman & McKenzie 1983; Noske 1980; Jones 1983; Rowley 1990; ENRC 1995), though less so than formerly, with development of modern machinery and better transport and storage techniques (see Habitat, Distribution). In WA, damage young eucalypt plantations by cutting off new growth; also dig up grass rhizomes in planted loams, or on sports ovals and racetracks (Rowley 1990). In Vic., also implicated, with several other parrots, in damaging fruit and nut crops, including citrus fruits, Apples *Malus sylvestris*, grapes, Walnuts *Juglans nigra*, Chestnuts *Castanea sativa*, Hazelnuts *Corylus avellana*, Pistachios *Pistacia vera* and Almonds *Prunus amygdalus*; eat nuts or seeds of fruit, or damage trees and vines by pruning growth or ringbarking trees (ENRC 1995). However, ENRC (1995) does not clearly identify damage caused by individual species of parrot. **DRINKING:** Usually drink once a day, but more in hot weather. Drink by sipping: dip bill into water, fill it and then raise head and swallow water, aided by movements of tongue. **DEFECATION:** Takes place wherever bird may be, either perched or on ground; body briefly levelled, slightly lowered and excreta voided.

Detailed studies At CUNNAMULLA, QLD (34 crops; Allen

1950): **Plants** Poaceae: *Astrebla lappacea* 35% freq., 4.3% no. of sds; *Dactyloctenium radulans* 97; 68.7; *Iseilema* 53, 13.5; Asteraceae: *Calotis hispidula* 12, 13.2; other Poaceae (including Wheat *Triticum aestivum*) 44, 0.2.

On NSW ROADS (46 crops, from road-kills; Vestjens 1973): Wheat *Triticum aestivum* only.

At AUST. AIRPORTS (56 crops; van Tets et al. 1977): **Plants** (Seeds unless stated.) MONOCOTYLEDONS: Cyperaceae: unident. 1.7% freq.; Poaceae: *Avena sativa* 16.0; *Bromus* 1.7; *Dactyloctenium* 7.1; *Danthonia* 1.7; *Eleusine* 5.3; *E. indica* 1.7; *E. tristachya* 3.5; *Critesion murinum* 1.7; *Panicum* 7.1; *P. effusum* 1.7; *Paspalum* 17.8; *Triticum aestivum* 1.7. DICOTYLEDONS: Amaranthaceae: *Amaranthus* 1.7; Asteraceae: *Arctotheca calendula* 1.7; Caryophyllaceae: *Cerastium* 1.7; Chenopodiaceae: *Maireana* 3.5; *Rhagodia* 1.7; Epacridaceae: 1.7; Euphorbiaceae: *Euphorbia* 1.7; Fabaceae: *Medicago sativa* 1.7; *Trifolium* 3.5; *T. repens* 1.7; Geraniaceae: *Erodium* 21.4; *E. cicutarium* 10.7; *Geranium* 5.3; Malvaceae 1.7; Myrtaceae: *Eucalyptus* 1.7; Nyctaginaceae: *Boerhavia diffusa* 1.7; Oxalidaceae: *Oxalis corniculata* 1.7; Polygonaceae: *Polygonum* 21.4; *P. aviculare* 10.7; *Rumex acetosella* 1.7; Solanaceae: *Solanum* 1.7.

In MULGA ZONE OF PASTORAL AREA OF WA (149 crops; Rowley 1990): **Plants** Poaceae 39.6% freq.; Cyperaceae 9.4; Amaranthaceae: *Amaranthus* 2.0; *Ptilotus* 11.4; Apiaceae: *Schoenolaena* 4.8; Asteraceae: *Arctotheca calendula* 8.0; Asteraceae 3.4; Boraginaceae: *Echium plantagineum* 17.4; Brassicaceae: *Sinapis alba* 2.7; Chenopodiaceae: *Atriplex* 17.4; *Chenopodium* 2.0; *Enchylaena tomentosa* 11.4; *Maireana* 1.3; Geraniaceae: *Erodium* 10.7; Goodeniaceae: *Velleia cynopotamica* 22.1; Gyrostemonaceae: *Codonocarpus cotinifolius* 5.3; Mimosaceae: *Acacia* 10.1; *A. aneura* 28.8; Molluginaceae: *Mollugo* 9.4; Nyctaginaceae: *Boerhavia* 8.0; Polygonaceae: *Emex australis* 20.8; *Polygonum* 3.3; Portulacaceae: *Calandrinia* 3.4; *Portulaca oleracea* 3.4.

At MANMANNING, WA (247 crops; Rowley 1990): **Plants** Poaceae: *Avena sativa* 42.1% freq.; *Danthonia* 2.5; *Critesion murinum* 8.5; *Hordeum vulgare* 23.5; *Lolium* 0.5; *Triticum aestivum* 80.56; unident. 3.7; Amaranthaceae: *Ptilotis* 4.0; Asteraceae: *Arctotheca calendula* 39.2; Brassicaceae: *Brassica tournefortii* 5.6; *Raphanus raphanistrum* 5.6; Chenopodiaceae: *Maireana* 8.0; Fabaceae: *Trifolium* 6.4; Geraniaceae: *Erodium* 31.5; green leaves 0.8. **Animals** INSECTS: larv. 0.7.

At SWAN VALE and WALLANGRA, NSW (91 crops; Noske 1980): **Plants** Crop seeds (mainly wheat, oats and sunflower) 87% freq.; seeds from native plants 79; green matter, bark and seed husks 48.

Other records **Plants** (Seeds unless stated.) Unident. seeds, leaves, young shoots, flowers, nuts, fruits, berries, bulbous roots, corms and tubers^{1,2,3,7,13,19,30,36,37,44,47,48}. GYMNASPERMS: Araucariaceae: *Araucaria heterophylla* lvs⁵³; Cupressaceae: *Callitris*¹³; *C. endlicheri*^{30,54}. MONOCOTYLEDONS: Cyperaceae: unident²¹; Iridaceae: *Gyndandriris setifolia* bulbs³⁹; *Romulea rosea* corms^{18,30,35,41}; Liliaceae: *Hypoxis*⁵²; Poaceae: *Avena*⁴²; *A. sativa*^{30,31,33}; *Bothriocloa*³⁰; *Dactyloctenium aegyptium*¹⁷; *D. radulans*⁵²; *Danthonia*; *Echinocloa*³⁰; *Hordeum vulgare*^{30,33}; *Oryza sativa*²¹; *Panicum laevinode*¹³; *Pennisetum clandestinum* rhizomes, stolons⁴²; *Phalaris*³⁰; *Setaria*³⁰; *Sorghum*^{20,30,33}; *Spinifex sericeus*⁴⁶; *Triticum aestivum*^{11,15,19,20,22,24,25,27,30,32,33,36,37,41,47,50,51,52}; *Zea mays*^{20,30,33,41}; unident.⁵². DICOTYLEDONS: Amaranthaceae: *Alternanthera nana*³⁰; *Amaranthus retroflexus*³⁰; Asteraceae: *Arctotheca calendula* fl.⁴²; *A. populifolia* fl.^{46,51}; *Carthamus lantanus*¹⁵; *Centaurea calcitrapa*¹⁰; *C. melitensis*⁴⁹; *Cirsium vulgare*^{27,30}; *Cryptostemma niveum*⁵⁰; *Cynara cardunculus*¹⁶; *Helianthus annuus*^{28,30,33,41}; *Helipterum floribundum* fl.²²; *Hypochaeris*³⁰; *H.*

radicata fl.⁴²; *Microseris lanceolata* roots¹⁸; *Onopordum acaulon*¹⁵; *Silybum marianum*^{30,42}; *Taraxacum*⁴²; *T. officinale*³⁰; Betulaceae: *Betula pendula*; Brassicaceae: *Cakile edentula* fru.⁴⁶; *C. maritimus* fl., fru.⁵⁵; *Capsella bursapastoris*⁴²; Caryophyllaceae: *Cerastium glomeratum* sds, fl., lvs⁴²; Chenopodiaceae: *Atriplex spongiosa*¹; *A. vesicaria*²²; *Bassia*^{5,50}; *Maireana*⁴⁹; *Salsola kali*⁶; unident.⁵²; Cucurbitaceae: *Citrullus*²⁷; *C. lanatus*^{22,50}; *Cucumis myriocarpus*⁵⁰, fru.²⁹; Fabaceae: *Cysticus*⁴⁵; *Medicago*³⁰; *M. denticulata*⁴⁹; *M. polymorpha*⁵²; *Trifolium*^{19,50}; *T. dubium*⁵²; Fagaceae: *Quercus palustris*²⁶; Geraniaceae: *Erodium*^{27,36,37}; *E. cicutarium*⁵⁰; *E. crinitum*⁴²; Hamamelidaceae: *Liquidamber styraciflua*²³; Lamiaceae: *Salvia verbenaca*⁴³; Lorantheae: *Amyema*⁵⁰; Mimosaceae: *Acacia*^{36,52}; *A. mollifolia*³⁴; *A. murrayana*¹³; *A. victoriae*¹³; Moraceae: *Ficus platypoda* fru.⁴³; Myrtaceae: *Angophora costata*³⁰; *A. floribunda*³⁰; *Eucalyptus bark*²⁷; *E. albens*³⁰; *E. crebra* lvs⁴⁶; *E. melliodora*³⁰; *E. salomonophloia*⁴³; Nyctaginaceae: *Boerhavia*⁴⁹; Plantaginaceae: *Plantago*³⁰; *P. varia*¹³; *P. lanceolata*⁴²; Platanaceae: *Platanus orientalis*⁴⁰; Polygonaceae: *Emex australis*^{4,8}; *Muehlenbeckia*²⁷; *Polygonum*^{30,52}; Portulacaceae: *Portulaca*⁵²; Proteaceae: Unident.³⁶; *Banksia integrifolia* lvs⁴⁶; Rosaceae: *Cotoneaster* fru.⁴⁶; *Crataegus monogyna*⁴²; *P. armeniaca* fl.⁴²; *P. dulcis*^{9,11,34}; Rutaceae: *Geijera parviflora*²⁷; Sterculiaceae: *Brachychiton populneus*³⁰; Verbenaceae: *Dicrastylis*⁴⁹. **Animals** INSECTS: Unident. larv.^{13,36}. Lepidoptera: larv.⁷; Noctuidae: *Agrotis infusa*³⁸. **Other matter** Grit^{7,27,47,48}; salt^{12,14}.

REFERENCES: ¹Berney 1906; ²Barnard 1914; ³White 1917; ⁴Serventy 1927; ⁵Macarthur Onslow 1929; ⁶Stead 1929; ⁷McKeown 1934; ⁸Brooks 1945; ⁹Crompton 1945; ¹⁰Rix 1945; ¹¹Lashmar 1946; ¹²Shanks 1949; ¹³Allen 1950; ¹⁴Hindwood & McGill 1951; ¹⁵Boehm 1959; ¹⁶Ashton 1985; ¹⁷Carruthers 1968; ¹⁸Cleland 1969; ¹⁹Frith 1969; ²⁰Pidgeon 1970; ²¹Crawford 1972; ²²Simpson 1973; ²³Davies 1974; Rowley ²⁴1975, ²⁵1983; ²⁶Wilson 1975; ²⁷Vestjens 1977; ²⁸Bennett 1978; ²⁹Klapste 1979; ³⁰Noske 1980; ³¹Lyndon 1981; ³²Jarman & McKenzie 1983; ³³Jones 1983; ³⁴Delroy 1985; ³⁵Pollock 1985; ³⁶Saunders et al. 1985; ³⁷Smith & Saunders 1986; ³⁸Morris 1989; ³⁹Boehm 1990; ⁴⁰Browne 1990; ⁴¹Emison & Nicholls 1992; Lepschi ⁴²1993, ⁴³1997; ⁴⁴Saunders & Ingram 1995; ⁴⁵Wood 1995; ⁴⁶Rose 1997; ⁴⁷Cleland; ⁴⁸Lea & Gray; ⁴⁹Hall; ⁵⁰Forshaw; ⁵¹Storr 28; ⁵²FAB; ⁵³J.M. Peter; ⁵⁴T. Saunders; ⁵⁵C.J. Schipper.

Young For details of feeding of nestlings and fledgelings, see Social Behaviour and Breeding. Based on studies in Wheatbelt of WA by Rowley (1990) unless stated. At first, nestlings appear to be fed clear liquid; first fed regurgitated solid food on second day. On Day 2, each nestling fed once during a feeding visit by parent; as nestlings become older, feeding visits by parents consist of one or more feeding bouts; during a bout each nestling in turn receives several (2–9) brief feeds. When 14 days old, nestlings receive only one feed per bout and tends to be only one bout per visit. From 8 days old, feeding rate averaged one feed every 53 min, which was the same regardless of number of nestlings being fed. More feeds were delivered in morning (0.94/h; n=248) than in afternoon (0.82/h; n=165). Fledgelings dependent on parents for food for 6–7 weeks. At MANMANNING, WA (nestlings [unspecified no.] collected Sept.–Oct.; Rowley 1990): **Plants** Geraniaceae: *Erodium* sds 58.6% vol.; Poaceae: *Triticum aestivum* sds 25; Asteraceae sds 15.2; other plant sds 1.2. Juveniles also recorded feeding on *Erodium* seeds (Smith & Saunders 1986).

Intake At CUNAMULLA, QLD (Allen 1950) average number of seeds/crop 16,087 (8719; 419–27,542; 29 crops) with average dry weight of 7.98 g (3.4; 2.31–13.62). At SWAN VALE and WALLANGRA, NSW (Noske 1980) crops contained mean 6.16 g

dry weight of seeds in afternoon ($n=26$ crops) and 2.72 g in morning ($n=29$ crops). Pidgeon (1970) estimated daily consumption of 12 g of food/day, based on morning weights of crops of 9.2 g (1.1; 15), and evening weights of 15.2 g (2.8; 23). For more details of rates of intake, daily energy requirements and estimate of damage to crops, see Noske (1980).

SOCIAL ORGANIZATION Account based on contribution prepared by I.C.R. Rowley. Very well known from studies in Wheatbelt of WA, mainly at Manmanning (Rowley 1983, 1990) and in ne. NSW, mainly at Inverell and Armidale (Pidgeon 1970), and Swan Vale and Wallangra (Noske 1980). Apparent differences between areas may be artefact of differences in details of studies. Highly gregarious and social throughout year. Commonly seen in large flocks, up to thousands, small groups, and pairs; rarely solitary (Pidgeon 1970; Lendon 1973; Noske 1980; Rowley 1990). In Wheatbelt, three levels of social organization: (1) **COMMUNITIES OF BREEDING PAIRS (CBP)**: In CBPs, pair is basic social unit. Daily movements centre on nest-hollow, to which pair return each evening throughout year. Several pairs can nest close together in same patch of woodland; these pairs tend to fly to and from feeding areas, and forage, together. Such associations usually stable and membership of community the same so long as individual pairs persist. At Manmanning, WA, c. 130 pairs formed 12 CBPs in area of 9000 ha. (2) **JUVENILE FLOCKS (JF)**: During first year, juveniles form flocks and disperse widely from natal area in two pulses (see Movements). (3) **LOCALLY NOMADIC FLOCKS (LNF)**: In second year, most subadults tend to stop wandering widely and settle down and join loose association of immatures, unmated adults, and males and females who have lost or divorced mates; LNF forages over large home-range of >1000 km². Birds stay in LNF till able to find a mate and place to nest. Most (90%) young disperse outside natal range (Rowley 1990); of 12 that returned and settled in natal range, only one was a female (I.C.R. Rowley). **Foraging flocks** In Wheatbelt, can include birds from all three levels but most are non-breeders whose lack of territorial ties allows them to range farther than territorial pairs. Any large flock composed of c. 50% unmated subadults or adults, 25% mated pairs and 25% juveniles, though varies considerably depending on time of year and locality. Flocks of 500–1000 birds not uncommon. In spring, food can be abundant and foraging flocks small and dispersed; when food concentrated, flocks can contain >1000 birds (Rowley 1990). Pattern in ne. NSW similar: some adults sedentary (equivalent to CBP) while juveniles, and possibly other adults, form nomadic flocks (equivalent to JF or LNF or both). Local populations of sedentary adults have home-ranges that varied in size from c. 1500 ha to c. 4500 ha and likely that sedentary birds move freely in overlapping home-ranges; diurnal pattern of congregation and dispersal centred on communal roosting sites (cf. Wheatbelt where roost at nesting hollow). Nomadic birds appear to move freely over home-ranges of sedentary birds without conflict and feed, roost and travel with residents; presence of small and large foraging flocks in non-breeding season perhaps because sedentary and nomadic populations segregated at times. Nomadic birds arrive and leave, which causes fluctuations in population and sizes of flock in an area, probably determined by local conditions. Nomadic birds leave home-ranges of sedentary birds at start of breeding season but continue to form large flocks elsewhere (equivalent to LNF), which appear to persist throughout breeding season. Sedentary adults tend to move in pairs in breeding season and feeding congregations are smaller; any larger flocks, of 20–40 birds, possibly non-breeding mem-

bers of sedentary population. After being deserted by parents, juveniles form nomadic flocks which can join up with immatures and non-breeding adults. Dispersion of birds at roosting and nesting sites varies between areas and seasons, and because birds congregating at roosts tend to congregate to feed, influences dispersion while foraging; e.g. during breeding season at Inverell, all nesting and roosting occurred at one site and thus congregations larger than at Armidale, where nests and roosts more widely scattered (see also Roosting, Breeding dispersion and Flock behaviour) (Pidgeon 1970; Noske 1980). In se. Aust., mean size of flocks in all activities c. 10 in spring and summer, and c. 30 in autumn and winter; flocks largest when feeding (mean across all seasons): c. 35 when feeding, c. 16 when roosting during day, and c. 6 when flying; lower sizes of flocks in spring–summer coincide with breeding and use of more widely dispersed food resources; in autumn–winter, congregate at concentrated sources of food (Emison & Nicholls 1992).

Bonds Monogamous; pairs usually remain together till one member dies (Pidgeon 1970; Rowley 1990). Divorce occurs occasionally but appears unrelated to previous breeding success. Pairs remain together constantly except when one on nest (Rowley 1990). Homosexual bonds recorded between captive young of both sexes, even if opposite sex available; not known if such pairs would persist after reaching sexual maturity if potential heterosexual partners still available; homosexual pairs behave as heterosexual pairs, engaging in allopreening, synchronous displays (see below) and, at least in the case of one female–female pair, attempted copulation (Rogers & McCulloch 1981; Rowley 1990). Males can breed at end of third year if can find mate and suitable hollow, but many do not do so until 1 year later; some males at end of third year pair and occupy nest-hollows but do not breed. Age of first breeding known for only two females, both doing so at end of third year; captive study indicated females do not pair until 3 years old (Rowley 1990). In captivity, both sexes can first breed when 3–4 years old (Shephard 1989; Sindel & Lynn Undated). If female of mated pair dies during breeding season, male usually pairs again within days, finding replacement from LNF. During breeding season, males returning from foraging flock to relieve mate on nest often fly in with another female, which quickly leaves male when he takes over at nest; associations with some such females regular ('aunts') and suggests breeding males aware of unmated females in LNF. Females losing mate in breeding season only occasionally pair again that season, and usually rejoin LNF and often miss a season before pairing again; one female lost both mate and hollow and spent next five seasons as an 'aunt' associating with two neighbouring pairs, of which the males of both paired again during this time with other females (Rowley 1990). In one study of captive birds, pair-bonds formed in first 18 months of life, at least 3 years before reproductive maturity (Rogers & McCulloch 1981); other captive birds behaved asexually toward each other until 2 years old (Rowley 1990). In captivity, trios can form, consisting of single bird of either sex with two of opposite sex; in each trio, allopreening virtually restricted to heterosexual dyads, occurrence between same-sex members of trio only as frequent as rare allopreenings with extra-trio individuals (Rogers & McCulloch 1981). **Parental care** At Manmanning, both parents incubate and brood; in most pairs, both spend night in nest but uncertain which covers eggs. Overall, incubation and brooding shared equally between sexes, but either sex can be main provider in some pairs (Rowley 1990). In ne. NSW, incubation and brooding usually entirely by female, and only sometimes shared, with male then incubating

during day and either or both at night (Pidgeon 1970); Forshaw (1963) also stated female does most incubating. In captivity, male usually incubates during day and female at night (Sindel & Lynn Undated). Both parents feed nestlings and fledgelings (Pidgeon 1970; Rowley 1990; Sindel & Lynn Undated). At Manmanning, fledging appears to be stimulated by arrival of parent that refuses to feed young and instead flies away despite intense begging; if nestling does not follow, parent sometimes gives in and feeds it but continues intermittently to urge young to leave hollow for hours or days. Usually, both parents present for first flight of fledgeling and they fly one on each side of it for as far as 2 km to a crèche; subsequent fledgelings taken to same crèche (Rowley 1980, 1990). **Crèches** Conspicuous at Manmanning and C. York Pen. (Rowley 1990; Sindel & Lynn Undated) but not apparent in ne. NSW (Pidgeon 1970; Noske 1980). At Manmanning, some patches of woodland appear to be used traditionally as areas where recently fledged young, from several broods, are left, with parents coming there to feed offspring. Juveniles in crèche often take flight and fly around noisily in a flock, independent of parents, apparently practising flying. Within crèche, siblings spend little time together apart from when they gather to be fed (see below), and often perch more than 100 m apart. Crèches can persist for several weeks, but individuals remain only 6–10 days till all siblings fledge and join crèche; parents then move brood to trees closer to feeding area, where congregate with other broods to form flock of dependent juveniles. Young then spend most of time for 2–3 weeks perched in cover of canopy where fed by parents; thereafter, start to accompany foraging parents and are fed on ground. By 1 month after fledging, young begin feeding themselves. Parents return to roost near nest-hollow each night; juveniles roost with flock of dependent juveniles near feeding area. Juvenile flock moves off with prevailing wind each morning, with older birds starting to feed themselves; parents join juveniles after foraging themselves and feed dependent offspring. Most juveniles thus disperse farther from natal nest-hollow each day, forcing provisioning parents to travel farther to feed them; parents eventually desert young and stop coming to feed them 6–8 weeks after fledging, by which time juveniles have moved mean of 4.78 km (0–18; 35) from nest-hollow (Rowley 1980, 1990). In ne. NSW, situation apparently differs from WA: earlier fledgelings move away from nest-tree but not known to where; once entire brood fledged, family rarely returns to nest-tree; when foraging, parents leave fledgelings, which remain close together, often touching, in a tree; young feed themselves 3–4 weeks after fledging, are then apparently deserted by parents and form nomadic flocks with other juveniles (see above) (Pidgeon 1970). In captivity, independent 4–6 weeks after fledging (Shephard 1989).

Breeding dispersion Will nest solitarily or close to others (Pidgeon 1970; Noske 1980); more than one pair will nest in same tree (Barrett 1916; Brereton 1963). At Manmanning, if sufficient suitable hollows available, can nest in loose colony with other pairs of CBP; 85% of nests 10–80 m from another; mean distance between nests in nesting congregations 49.1 m (23.5; 434), but seldom <20 m apart and only three times <10 m apart, in each case in different branches of same tree (Rowley 1990). At Nereeno Hill, WA, 48 nests in area of 15 ha (Saunders *et al.* 1982). Often use same hollow in successive years, especially if hollows in short supply. If mate dies, surviving partner of either sex will sometimes re-use site with new mate (Rowley 1990; I.C.R. Rowley). At Inverell, ne. NSW, all residents, both breeding and non-breeding, moved to one roost-site where all nesting and roosting took place; elsewhere,

including Armidale, nests more scattered (Pidgeon 1970). **Home-ranges** At Manmanning, pairs seldom forage >15 km from nest-hollow, and usually within 10 km (area of 300 km²), returning to it each evening (Rowley 1990). Almost daily visits to nest by pair also recorded at Cowra (Bourke 1949). At Wallangra and Swan Vale evidence also suggests year-round association with nest (Noske 1980). **Territories** Breeding pairs defend nest-hollow only; allow other pairs and flocks to perch in nest-tree without any aggression, but conspecifics, and most other species, approaching within 3 m of hollow are driven off. Residents first give warning call (Chet-it; Rowley 1990); if intruder stays, resident may fly and Bill-Gape at, or walk along branch toward intruder; if intruder still stays, fights begin; usually resident sidles up to intruder and bites it on foot, and, if still does not leave, full-scale fight can ensue with loud Screeching and Bill-Fencing. Territorial aggression mostly occurs early in breeding season; in WA, increases again in Oct. when non-breeding birds search for hollows. Early in breeding season, two pairs can dispute ownership for several days; interaction usually intense and physical, with both males and females fighting either sex; interactions stop once incubation begins (Pidgeon 1970; Rowley 1990). Young pairs look for nesting sites late in breeding season when breeding pairs nesting (I.C.R. Rowley). In captivity, much aggression occurred between males of two pairs with adjacent nest-boxes (Pidgeon 1970).

Roosting Roost within foliage of canopy of large trees; usually communally, except for breeding pairs in breeding season; in flocks up to hundreds or thousands of birds (Nicholls 1924; Pidgeon 1970; Rowley 1990). At Manmanning, pairs of CBP return each evening to their nest-hollow to roost in canopy nearby, while members of LNF tend to roost in nearest suitable site to current feeding and drinking sites, though often have preferred area. During rest periods during day, members of foraging flock will perch together in trees close to feeding area (Rowley 1990; I.C.R. Rowley). At Inverell, at least six roosting sites within range of study population; most birds in range roost in only one site on any evening; during breeding season, both breeding and non-breeding residents roosted in sole nesting site, non-breeders roosting near breeding birds. At Armidale, six roosting sites present but birds normally roosted at different sites; occasionally larger congregations did form, especially in early part of non-breeding season, and these roosted together at one site on any evening, as at Inverell, but such congregations only lasted several days before they broke up (Pidgeon 1970). At Swan Vale and Wallangra, dispersed to more than one roost each night, though most usually roosted together (Noske 1980). At both Inverell and Armidale, home-range much smaller than at Manmanning, and both residents and nomads return to night-roosts for rest periods during day; elsewhere in ne. NSW where night-roost farther from feeding area, birds rest close to feeding area (Pidgeon 1970; Noske 1980). When female incubating during day, male commonly rests in nest-tree or nearby (Pidgeon 1970). Waking and roosting occur at same time relative to sunrise year-round (Pidgeon 1970). Leave roost soon after sunrise; move to final roost just before dark; before this, after returning from afternoon feeding, perch on more exposed branches below canopy (Rowley 1990). Move off to night-roost, after drinking, c. 30 min before sunset (I.C.R. Rowley). When resting, perch on one or both feet, with body at angle of c. 45° to horizontal, face forward, and withdraw head into shoulders and, depending on conditions, fluff or sleek plumage. When sleeping, which occurs during rest periods as well as at night, adopt slightly more horizontal position, lower body to

touch perch, close eyes and usually relax feathers; in prolonged sleep, can also turn head over shoulder and tuck it into feathers of back and scapulars, covering eyes (Warham 1957; Pidgeon 1970; Rowley 1990).

SOCIAL BEHAVIOUR Account based on contribution prepared by I.C.R. Rowley. Well known from studies in Wheatbelt of sw. WA, mainly at Manmanning (Rowley 1983, 1990) and in ne. NSW, mainly at Inverell and Armidale (Pidgeon 1970), and Swan Vale and Wallangra (Noske 1980). Can often be approached to within 50–100 m; size, and habits of feeding in open and usually resting in exposed spots during day make them easy to observe (Pidgeon 1970; Noske 1980; I.C.R. Rowley). Much of behaviour similar to that of other *Cacatua* (I.C.R. Rowley). Below, nomenclature of calls follows Rowley (1990); for corresponding names of Pidgeon (1970), see Voice. **Feather postures** Feathers of body can be held in four positions: (1) sleeked, which is usual position before and while walking and when showing subordination; (2) relaxed, which is normal position when feeding or when perched; (3) partly raised, when cold or when interacting with others in order to increase apparent size; and (4) fluffed up, in which feathers raised fully and much bare skin exposed; adopted to rain-bathe or to bask in sun. Partial and full spreading of wings and tail conspicuous part of some displays. Erectile crest smaller than in most Cacatuidae; can be held relaxed (Fig. 1a); raised only at rear in CAP DISPLAY, which indicates alertness and is usually performed when interacting with others (Fig. 1b); or fully raised in ERECT CREST, an important component of more complex displays (Fig. 1c) (Rowley 1990). When crest raised, feathers of face also fanned forward but not so striking as in *Calyptrorhynchus* (Rowley 1990). **Flock behaviour** Recognize each other individually by Chet Call. Lik-lik Call often followed by Wing-Leg Stretch before bird flies off; Call indicates intention to fly; functions to co-ordinate activity of flocks as, often, others join in calling and several fly off together (see C-Flight) (Rowley 1990). If small flying flock sights another flock either feeding or perched, it usually joins it (Barclay 1976; Rowley 1990). When flying long distances, flocks tend to break up into pairs, and each member of pair gives Titew Call back and forth (Pidgeon 1970).

Daily activity Pattern similar at all sites studied, though timing of activities before leaving roost in morning, degree of co-ordination in moving between sites of different activities, and numbers of birds and time spent congregating vary (Pidgeon 1970; Noske 1980; Rowley 1990); see also Emison & Nicholls (1992) and Westcott & Cockburn (1988) for diurnal and seasonal variation in foraging routine related to temperature and availability of food. Following based on study at Inverell, NSW (Pidgeon 1970) except where stated and, where necessary, his nomenclature of calls also provided in brackets. Wake c. 20 min before sunrise and start preening and sometimes give Titew Calls to one another; after c. 10 min, some start to give Chet (C or Cv) or Lik-lik Calls and, as light improves, move round canopy and to exposed perches, especially those in sun, where they may bask briefly. Amount of calling increases and birds then begin BRIEF FEEDING LOOP (BFL), where they fly to ground and feed for 15–30 min (though suggested that birds may be gathering gravel rather than feeding [Rowley 1992]) then return to trees where they may preen and call; may then fly to another tree, usually calling in flight, or return to ground. There is little co-ordination of birds at this time, with different individuals engaging in different activities at same time. Then, often about sunrise, some move off in C-FLIGHT: birds suddenly

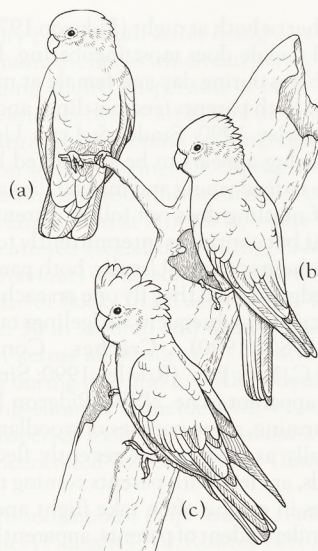


Figure 1 Crest displays (a) Sleeked crest (b) Cap Display (c) Erect Crest

take flight, giving loud Chet, and some Lik-lik Calls, and often spiral upward over roosting site; C-Flight also performed in other contexts, especially alarm, but in all circumstances usually results in others following and calling loudly, so that congregation often forms, particularly at roosting site; flights usually of 10–50 birds but sometimes larger. Rowley (1990) noted the initial move to C-Flight started by one bird uttering Lik-lik Call and flying off; if others do not follow, it will return and wait till others ready. Birds usually move to, and perch in, a tree, often dead, some distance from roost (= assembly area of Rowley 1990) but sometimes move directly to feeding area. After leaving roost, flying flocks often break up into pairs (different and same-sex) or small groups, that often move independently of each other. After several C-Flights over 15 min, most birds have left roosting area; flights can move in different directions or follow others. At assembly area, can again start BFL; appears more co-ordinated than earlier BFL but gradually breaks down as birds move to join others feeding elsewhere and enter FULL FEEDING LOOP (FFL) for much of morning, in which feeding bouts generally much longer than in BFL. Groups in FFL regularly take flight in C-Flight, sometimes in response to alarm, and others from nearby groups may join them; after C-Flights, either move to nearby tree or settle at another feeding site, groups splitting up and moving independently of each other. Those that move to trees soon resume feeding, though some birds preen first; leave trees in pairs, small groups and, occasionally, as flock. Toward end of morning feeding session, pairs and small groups leave foraging flocks and fly to night-roost or nearby trees (see Roosting for details of sites used); eventually, rest of foraging flock takes flight in C-Flight and follow others that have left, arriving as flock if site nearby, otherwise disintegrating into smaller groups and pairs *en route*, which congregate again at roost. At roosting site, tend to congregate in trees, particularly dead ones, at edge of site, and BFL occurs before birds gradually move to roosting area, where they preen and rest; during this BFL occasional C-Flights occur, during which birds can disperse through roosting area. At Inverell, while resting (and apparently when roosting at night; see below) tendency for only a few adults but large numbers of juveniles to perch in any one tree, though there is much mixing

of age-classes; in WA, breeding pairs, immatures and juveniles tend to settle in different trees (Rowley 1990). In study of six captive birds, two groups of three formed, which perched and allopreened only with other group members; such formation of small social groups within larger flock may also explain occurrence of small groups perching and travelling together in wild. After resting during middle of day, pattern of morning is repeated. Toward end of afternoon feeding period, pairs and small groups leave foraging flocks and move to water, usually to closest source, where birds congregate on perches and fly down singly to drink; in w. NSW, large numbers congregate at water each evening, apparently using same site each day; elsewhere, usually drink in evening but this varies (e.g. Jackson 1912; Cameron 1938; Davies 1972; Fisher *et al.* 1972). After drinking, move in pairs and small groups to roost, most going to same site. At roost-site, repeat morning pattern of BFL and dispersal. A few birds usually first move to roosts other than where main flock is, but move to join main flock at dusk. On Western Plains of NSW, as BFL activity declines before roosting, 5–10 min before dark, perform C-Flight in which all birds fly in tight flocks and circle roosting area before diving and weaving through trees and flying up again (see also Warham 1957; Hobbs 1961); after several minutes, begin dispersing and settling in trees and becoming quiet. Time spent in morning and afternoon feeding stays constant through year, and time spent resting and in BFL at midday increases with length of day. During breeding season, daily pattern similar to non-breeding season, but congregations during day much smaller and birds more often move between activities in pairs; second BFL often forgone completely, birds going directly to FFL, and tend not to congregate at water (Pidgeon 1970). In se. Aust., feed less when temperature high, especially when $>30^{\circ}\text{C}$, and this reflected in low numbers feeding during midday hours in summer; through rest of year, numbers feeding highest at midday (Emison & Nicholls 1992). Reproductive behaviour occurs while perched during BFLs and midday rest periods. When female incubating during day, male rests in nest-tree or perches nearby, with small number of other birds, possibly mates of other incubating birds (Pidgeon 1970). At Manmanning, within CBPs, pairs interact with each other, can co-operate in defence against predators, and often commute to and from foraging and drinking areas together (Rowley 1990; I.C.R. Rowley).

Maintenance behaviour **Preening** Nibble feathers of head and body and draw remiges and rectrices through bill. Usually begin bout by preening neck and upper breast, then lower back, before preening other areas, such as wings and tail. Plumage generally fluffed while preening and area being preened usually ruffled, though feathers of neck and cheeks can remain ruffled while preening other areas, especially when using oil-gland. Often ruffle entire plumage then settle it by rapid shaking of body; typically occurs at end of preening but can also occur during it. Often, but not always, use oil-gland; first nibble gland then rub side of head over it and transfer oil to plumage during preening; preening usually lasts longer when using oil-gland. Clean feet with bill, bringing foot up under wing to bill; usually occurs after preening. Bill cleaned by shaking head or wiping bill on perch, or by using feet if other methods ineffective. Often chew wood and will rub bill against galvanized iron, especially when iron wet. Before going to sleep, grind tip of lower mandible against inside of tip of upper mandible for up to 10 min; this always last activity before sleeping and apparently not performed at other times (Pidgeon 1970; Rowley 1990). Often strip leaves and bark from branches while perched, which may help to maintain bill (Rowley 1990; Forshaw). **Stretching**

Component movements can be performed separately or in sequence. In full sequence, usually first lean forward and extend neck, sometimes gaping widely to stretch jaw, while partly extending both wings above back so that wings almost touch. Then perform WING-LEG STRETCH: slowly extend wing and leg on same side back and down away from body, then spread tail and turn it to same side before resuming normal posture and repeating stretch on other side. Full sequence most often performed after waking or prolonged rest; often precedes flight; separate movements often occur in isolation, particularly in preening bouts, though movements of Wing-Leg Stretch always occur together (Pidgeon 1970; Rowley 1990). **Bathing** Bathing in standing water rare in wild; occasionally seen to fly briefly onto surface of water and off again (Rowley 1990; I.C.R. Rowley). **RAIN DANCE** (Fig. 2): In light rain, particularly if weather warm, will lean forward, or sometimes hang upside down, with plumage ruffled, wings arched or outspread, and tail splayed; for up to 10 min, but seldom >5 min; followed by shaking and long preening bout with frequent use of oil-gland. Inactive in heavy rain, and shelter within foliage. Several birds will usually Rain-Dance at same time; dead trees seem most suitable for rain-bathing and birds will fly from foliated trees to dead ones to do so (Pidgeon 1970; Hawkey 1985; Rowley 1990).

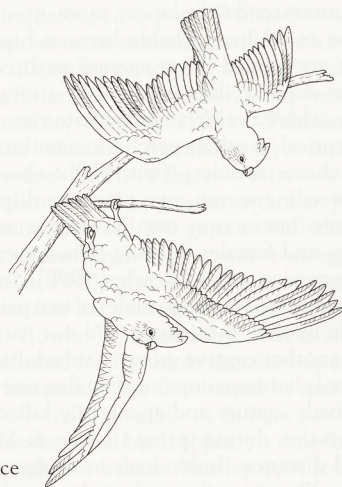


Figure 2 Rain Dance

Thermoregulation Plumage fluffed when cold and sleeked when hot; when very hot also raise wings away from body and pant (Pidgeon 1970; Rowley 1990). On cold mornings and evenings, upon leaving or just before entering roost, sometimes fly rapidly with sudden changes in direction and height (Barclay 1976). **Play** Both adults and juveniles hang upside down from perches, usually holding on with feet but sometimes with bills, swinging with wings spread and screeching mildly; actions similar to those of Rain Dance but do not ruffle feathers; usually occurs between feeding periods during fine, calm weather, and several birds join in once one starts (Fig.3) (Barclay 1976; Rowley 1990; I.C.R. Rowley). Fly deliberately and repeatedly into willy-willies, calling and flying aerobically; behaviour possibly confined to certain areas (McNaught & Garrard 1991; Reid 1994). Also slide down guy-wires (Rowley 1990); hold onto spinning blades of windmill (Reid 1994); roll down inclines and lie on backs manipulating objects with feet and bills while calling excitedly (e.g. Lyndon 1981). Some members of one flock observed on several occasions, and for no apparent reason, harassing incubating terns and plovers by approaching them in posture similar to Heraldic Display (Schipper & Weston 1998). One said to have engaged in apparent play with

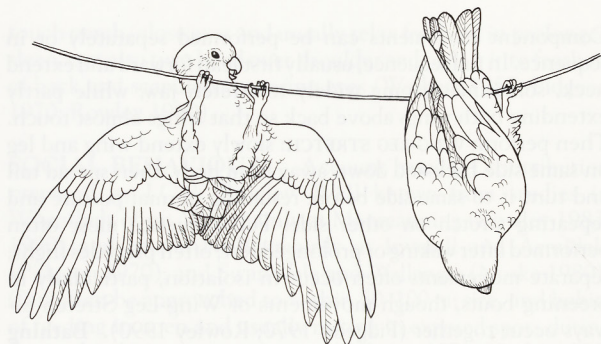


Figure 3 Play

Brown Goshawk *Accipiter fasciatus*; each took turns to chase the other and perched beside one another while rest of flock of Galahs continued feeding (Keays 1986). When holding food, 89% ($n=68$ individuals) use left foot (Rogers 1980).

Agonistic behaviour Overt aggression among adults not common, even in captivity; in wild, virtually none during normal feeding and very little when perched, even during breeding season (Pidgeon 1970; Rowley 1990). Aggression between juveniles far more common, especially when perched, and encounters tend to be longer, more intense and more vocal than those of adults, probably because hierarchy and social bonds not yet formed. Most aggression directed at displacing another to achieve desirable spatial arrangement. Breeding pairs drive others away from immediate vicinity of nest-hollow (see Territories); if others perch too near breeding pair, one of pair often chases intruder off with Flight-chase (Pidgeon 1970). Early in breeding season, two pairs can dispute territories for several days; interaction usually intense and physical, with both males and females fighting either sex; once incubation begins, aggression stops (Rowley 1990). In captivity, much aggression occurred between males of two pairs when two nests placed side by side, but females did not participate (Pidgeon 1970). In another captive group of subadults, overt aggression occurred only between unpaired females; one pair then became reproductively mature and apparently killed all other males, but not females, during spring (Rogers & McCulloch 1981).

Individual distance Individuals in foraging flock usually no closer than 20 cm, just beyond reach of each other, and more usually 1–2 m apart; if food concentrated, feed much closer together and aggression frequent. Perch c. 20 cm apart unless birds paired, or parents with offspring. Closer approach to another usually accompanied by contact call or invitation to allopreen; if move aggressive, usually accompanied by Bill-gape or Bill-thrust or attempt to bite foot. When another joins perched or feeding group, often much movement and calling before desired spacing achieved (Rowley 1990). Often crowd together when drinking and bodies can touch (Nicholls 1924; Pidgeon 1970). Captive experiments show tendency to perch close together, especially at roosting time, but maintain individual distance of c. 17 cm; come closer when feeding or allopreening; in breeding season, individual distance between members of pair decreases but distance between unpaired birds increases (Pidgeon 1970). In another captive study, pairs always remained >30 cm apart when perching, roosting or feeding; inter-pair distance usually $1+m$ (Rogers & McCulloch 1981). **Threat** **MOVEMENT TOWARD:** Aggressor moves toward opponent in normal posture, either on perch or ground; often results in opponent showing avoidance behaviour if aggressor is dominant in hierarchy of group. Little overt aggression occurs during feeding on ground, and most aggressive encounters

consist of such avoidance. Two birds will feed side by side so long as not directly facing one another; if do come face to face, one usually avoids other (Pidgeon 1970). **BILL-GAPE** (Fig. 4): Aggressor faces opponent, with either head or whole body, and opens bill slightly or fully; plumage generally sleeked; performed in normal perched posture, or while leaning toward or away from opponent; generally not accompanied by calls except when under stress, such as being bitten, in which case ES Call given. Most aggressive form of Bill-gape is to lean toward opponent with bill fully open; least aggressive is to lean away with bill half-open. Opponent usually moves away, though rarely flies off, or responds with Bill-gape while leaning away; latter often results in Bill-thrusts (Pidgeon 1970). **Attack** Can be preceded by aggressor folding crest (I.C.R. Rowley). **BILL-THRUST:** Aggressor rapidly thrusts bill, either half or fully open, toward opponent; sometimes accompanied by Screech Call (Scr), more so in interactions between juveniles. Sometimes performed from normal perched posture but usually from one of Bill-gape postures when that act has not succeeded in displacing opponent. When performed from normal perched posture,

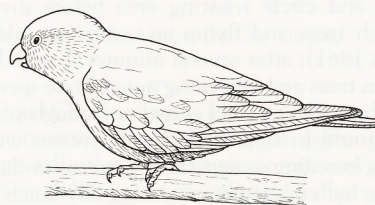


Figure 4 Bill-gape

opponent often appears to be taken by surprise and flies away in response; if opponent does not retreat it generally gives Bill-gape while leaning back (Pidgeon 1970). **Fighting BILL-FENCING:** Usually results when one does not retreat after Bill-thrust by another; opponents then thrust simultaneously and rapidly at each other, usually at bill, but if another part of opponent closer then will often bite it; severe injury can result, especially to head, carpal joints and feet. Birds sometimes entangle feet while Bill-fencing and fall from branch, usually separating before hitting ground (Rowley 1990). **FLIGHT-CHASE:** Aggressor flies at opponent perched some distance away, generally trying to land on top of it; opponent usually flies from perch as soon as attacker hovers above; if it does not, attacker usually lands beside it and Bill-thrusting and Bill-fencing ensue; once opponent moves, aggressor perches where opponent was for several seconds then renews pursuit; victim appears reluctant to leave tree in which perched and 5–6 chases may occur before it does so. Flight-chase occurs year-round but is intense only in breeding season; in non-breeding season, appears intended to chase opponent from another individual rather than from tree; in all observed cases with marked birds, attacker was male and directed at another bird perched near a female; in two cases the female was known to be mate of attacker, but gender of opponent not known in any case. In less intense encounters, only 1–3 chases occur and victim perches some distance from aggressor, but remains in same tree. In captivity, Flight-chase very intense when breeding, apparently as victim cannot escape, and flight of aggressor can develop into Hover Flight and female then often joins male in chase, following him round but never initiating chase herself. Normally no calls given during Flight-chase (Pidgeon 1970). **Territorial displays** Cheat Call often given by one or both members of pair returning to hollow; appears to advertise territorial ownership and sometimes leads to Heraldic Display

(Rowley 1990). **HERALDIC DISPLAY** (=Wing-spread Display of Pidgeon 1970): Bird stands upright, sleeks plumage of body, raises crest and spreads wings and fans tail while giving Screech Call (Fig. 5a); in extreme version, rocks forward in bowing action with wings fully spread (Fig. 5b). Performed year-round by either sex; directed at variety of objects, including predators,

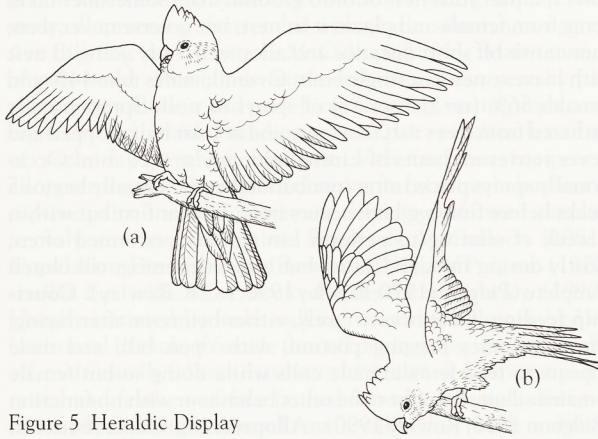


Figure 5 Heraldic Display

holes in trees, twigs and often, apparently, nothing (Pidgeon 1970); considered to be usually performed in defence of nest-hollow from other Galahs and predators (Rowley 1990). Does not appear to evoke response in other birds, though mate of performer sometimes displays. Sometimes appears intended to threaten predator and, when directed at holes, may function to scare other animals in hollow; at other times, possibly displacement activity, even when performed while inspecting hollow as performer seems to be in conflict about entering hollow and display usually preceded by intention movements toward and away from entrance. Once, male seen to direct Display to a female that had replaced his dead mate but that had not yet been allowed into nest-hollow. Subadults seen to give less intense version while prospecting for hollows late in breeding season (Pidgeon 1970; Rowley 1990). **SCARRING** (=Bark-stripping of Pidgeon 1970): On most nest-trees birds remove patches of bark to expose cambium, which dries to form a scar (Rowley 1990); or both bark and cambium removed to expose xylem (Pidgeon 1970). Scars made on main trunk of tree below nest and round entrance to nest and vary in shape and size; at entrance to nest, usually only extend up to 10 cm from hole; at Manmanning, those on trunk usually c. 30 cm in diameter, but larger scars common throughout WA Wheatbelt, and in ne. NSW regularly much larger, up to nearly 5 m long. Pair usually enlarge scar each year by chewing at its edges, but sometimes make a new one. Amount of time spent Scarring by pairs varies greatly; some make no scar at all, though most at least do so round or near entrance to nest, others only make small scar on trunk or only slightly enlarge existing scar, while others spend up to at least 1 h/day Scarring. Pair can work on scar together or separately; males active at scar five times more often than females (Jackson 1912; Trewin 1926; Bryant 1934; Elliott 1938; Pidgeon 1970; Rowley 1990). Sometimes intersperse bouts of working on scar with **BILL-STROPPING**, rubbing alternate sides of bill on bare area of scar; sometimes Bill-strop so vigorously that bird rests carpal joints against tree to maintain balance. Also perform **EYE-WIPING**, particularly males, by wiping sides of face on scar; leaves behind dusting of fine powder from skin of periorbital ring (Fig. 6); also rub preen gland with bill during Eye-wiping. Remove bark and Bill-strop else-

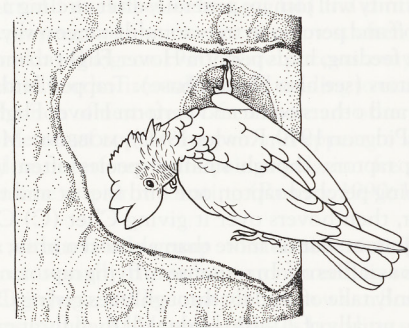


Figure 6 Eye-wiping

where on tree besides scar but Eye-wipe only on scar (Rowley 1990). In ne. NSW, work on scar begins at start of breeding season and continues till incubation begins; most work done during midday break from feeding, but brief periods can be spent in early morning and late afternoon (Pidgeon 1970). Scarring and associated behaviours perhaps function as territorial advertisement; in ne. NSW, incidence of Scarring much higher at greater nesting densities (Pidgeon 1970; Rowley 1990). Bill-stropping perhaps also part of bill maintenance and, as it is noisy, perhaps serves as communication with incubating bird. Bowing and sitting for periods in entrance to nest (see Nest-inspection in Relations within family group) possibly also function as territoriality (Rowley 1990). **Submission** No ritualized submissive behaviour. Avoidance of, or turning away from, aggressor prevented further aggression in case of Movement Toward; walking or flying from attacker prevented further aggression if receiving Bill-gape or Bill-thrust; with Flight-chase, victim must fly long distance from aggressor to stop attack (Pidgeon 1970). Occasionally a victim (usually only females) crouches in mating position in response to aggression (I.C.R. Rowley). **Hierarchy** Hierarchies often develop at concentrated food as birds aggressively attempt to gain access; such hierarchies are dominated by most recently arrived large male, which, possibly as hunger sated, can be replaced by another; at water, birds appear to wait for space to drink rather than fight for access (Rowley 1990). In captive group of six birds, hierarchy formed with males more dominant than females (Pidgeon 1970). **Alarm** When perched in trees can be approached to within 50–100 m before flushing but cannot be approached so close when birds on ground (Pidgeon 1970; Noske 1980). In response to slight threat, raise then lower crest without interrupting activity, or sometimes pause momentarily and raise head, with crest raised, before resuming activity; do not call, and behaviour does not seem to cause others to respond. In response to greater threat, often stop activity, raise head, with crest raised, and sleek plumage; can cause others to respond similarly; if threat continues, Chet (C) Calls can be given, causing all to fly off in C-Flight. Obvious danger results in immediate Chet (C) Calls and flight, in which crest not necessarily raised first. Will respond to alarm calls of other *Cacatuidae* (Pidgeon 1970; Rowley 1990). **HOVER FLIGHT:** When individual or group perched in tree approached by terrestrial predator, begin uttering Titew or Chet Calls (W, H, C or Cv Calls) with others gradually joining in; if predator continues to come closer, give Chet Call more often (only C Call) then fly off, first flying away from predator then performing Hover Flight round it, flying with short abrupt wing-beats (shorter than when hovering over perch to land), crest raised and uttering Chet (C) and Screech Calls while circling. Others

in vicinity will join in; generally after circling 3–4 times, group flies off and perches in trees some distance away. Only perched, never feeding, birds perform Hover Flight to mob approaching predators (see also Flight-chase). Trapped birds utter Screech Call, and others come and perform Hover Flight over trapped bird (Pidgeon 1970; Rowley 1990). **MOBBING:** Mob perched and flying raptors, though smaller species often ignored. When mobbing perched raptor, one bird flies at and then away from raptor, then hovers over it giving Chet (C) Call; others can then join in, but no more than about ten or so, and will pursue raptor as it flies off. In response to flying raptor, nearly all in area suddenly take off and fly through trees giving Chet (C) Call; a group, usually of 20–100 birds, will then fly at raptor and chase it for up to 10 min or so while others settle down again. Flight during mobbing is normal and unlike Hover Flight (Pidgeon 1970). Observed to form large tight flocks that fly high giving Chet Calls, which appears to confuse raptors (Rowley 1990). One small flock stayed perched in foliage with Australian Hobby *Falco longipennis* perched nearby, perhaps to prevent it attacking effectively (Hewish 1991). Another flock continued feeding despite presence of Brown Goshawk said to be playing with one of flock (see above) (Keays 1986). In captivity, one responded to presence of Dugite *Pseudonaja affinis* by landing within 1 m of snake and batting partly opened wings and giving loud Screech Call; several others then joined in; no contact made but snake left rapidly (Rowley 1990).

Sexual behaviour Sexes can be ready to breed at different times; if male ready first, female does not respond to courtship behaviour, such as allopreening, till ready herself (Rowley 1980). In captivity, courtship displays, mounting and copulatory movements began in one pair of immatures in their second spring, despite not reaching reproductive maturity for several more years (Rogers & McCulloch 1981). **Courtship** No elaborate displays associated with pair-formation. Pairs begin to perform reproductive activities at start of breeding season with no sign of pair-formation behaviour. Allopreening and Lining are common and clearly important in courtship; calls appear unimportant in sexual behaviour (Pidgeon 1970; Rowley 1990). Displays attributed to courtship (Forshaw 1963; Sindel & Lynn Undated; Forshaw) appear to be similar to, and perhaps are, Imponieren Display, which is part of copulation (see below), but additionally record that male weaves head slightly from side to side and utters soft chatter while approaching female. Forshaw claimed that aerobatics always forms part of courtship display: after male approaches female, she flies off, flying erratically through trees, and calling excitedly, followed by male; female then lands and male repeats performance similar to Imponieren Display and preens female before they take flight again; no such aerobatics observed by Pidgeon (1970), and Rowley (1990) does not mention aerobatics in context of Imponieren Display but sometimes observed two birds flying in similar manner, but silently, and suspected behaviour of being involved with courtship. **LINING** (= Leaf-Carrying of Pidgeon 1970): As breeding approaches, pair visits and inspects nest more often. At first, male dominates female and will sometimes not let her enter hollow; as laying approaches, female gradually spends more time in hollow than male; Lining is important part of this change in behaviour. Bout of Lining typically begins with pair perched together near nest; male then cuts a spray of several leaves of new eucalypt foliage and immediately shakes it with vertical tucking motion of head; male then moves to nest, sometimes stopping briefly to shake leaves again; female usually then approaches male, who continues shaking spray, and tries to grab part or all of spray from male, which she eventually

succeeds in doing and then shakes it in same way as male. If not yet at nest, and female has taken all of male's leaves, he quickly gets another spray then rejoins mate and both move to nest. Once at nest, both shake leaves, hitting them on inside edge of hole; then start moving heads in and out of nest, still holding leaves, often leaning far inside, before eventually dropping leaves, either into nest or onto ground; male sometimes takes spray from female and places it in nest, but reverse never seen; then move off short distance and allopreen, only going to nest with leaves once in a single bout. Overall, males take 44% and females 56% ($n=313$ sprays) of sprays to nest. Sprays usually gathered from trees <100 m away and at least half dropped and never retrieved; bouts of Lining seldom last ≥ 20 min. Occasionally sprays placed after incubation begun. Usually begins 5 weeks before first egg laid; occurs irregularly at first but within 1 week of starting to perform Lining it is performed often, mostly during midday loafing but also in evening, till clutch complete (Pidgeon 1970; Rowley 1990; I.C.R. Rowley). **Courtship feeding** Occurs very rarely, either before or after laying; female assumes begging posture, with open bill, and male appears to feed female; male calls while doing so but female remains silent; thought to be relict behaviour with no function (Pidgeon 1970; Rowley 1990). **Allopreening** Occurs between birds of same and opposite sex, usually, but not always, between members of pair or between parent and offspring; frequency of allopreening between members of pair increases during breeding season (Pidgeon 1970; Rowley 1990; cf. Noske 1980). Soliciting bird turns region to be preened toward other bird, usually ruffles the area, and tends to lower head below bill of other (Fig. 7a); recipient usually closes eyes while being preened. Allopreening mostly confined to head and throat, and particular attention paid to area round eye; occasionally preen remiges and rectrices (Fig. 7b). Allopreening often reciprocal, and soliciting posture often used if reciprocal bout lasts for some time, as it tends to in mated pairs; preening seldom lasts more than 1 min before roles reversed. Bouts of allopreening not always preceded by soliciting posture and soliciting posture not always successful in eliciting allopreening. Bouts of allopreening in non-breeding season usually only last up to c. 1 min; during breeding season, pair invariably allopreens during midday rest

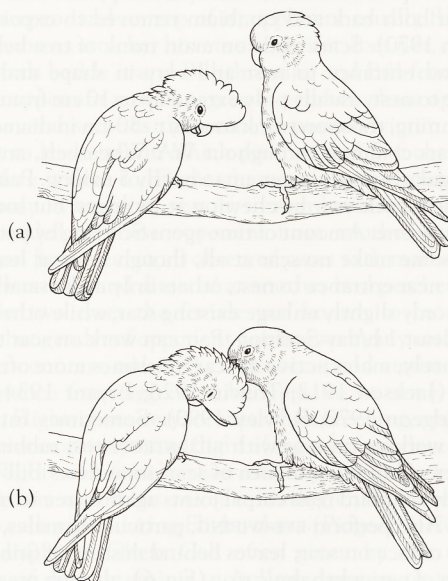


Figure 7 Allopreening

period and bouts are long, up to 15 min, but interspersed with autopreening (Pidgeon 1970; Rowley 1990). Captive group of six birds formed two groups of three and allopreening only occurred within those groups (Pidgeon 1970). In another captive study, allopreening between members of trios was almost exclusively with opposite sex, occurring between same-sex members only as often as with birds outside group; in same study, allopreening often ended with gentle, silent, non-aggressive Bill-fencing (Rogers & McCulloch 1981). **Maintenance of pair-bond** Pair-bonds reinforced throughout year by pair visiting nest-hollow and travelling, foraging, resting and roosting together; outside breeding season, pair spends at least half of each day perched together, with frequent reciprocal allopreening (see above). For observation of other behaviour of captive pairs, including apparent displays performed simultaneously and in parallel, see Rogers & McCulloch (1981). **Copulation** Descriptions of Rowley (1990) and Pidgeon (1970) similar but with some marked differences. Rowley (1990): Usually initiated by male walking toward female perched on horizontal branch; if female flies off, male stops; if female walks off, male usually follows in IMPONIEREN DISPLAY with crest partly raised and feathers of face fanned forward. If female does not move off, male sidles toward female till bodies touch and then begins to bob head; if female is receptive, she begins bobbing head also, then each bends head forward to briefly touch own breast with bill then to touch breast of partner; after several repetitions of touching, male extends neck and places head over neck of female several times, then places foot on her back; if ready, female squats, with wings held slightly from body, and male mounts, placing both feet between shoulders of female, and begins thrusting with tail every 1–1.5 s, with 3–5 thrusts to right then 3–5 to left; if male well balanced, sometimes reaches forward while thrusting and preens neck or touches bill of female; after 1 min or so, thrusting intensifies and male dips tail sideways under that of female and achieves cloacal contact; he then half opens wings and steps off. Pidgeon (1970): Typically follows preening or resting. Male holds body nearly horizontal, with plumage slightly fluffed, and facing same direction as female but with head turned away from female; then sidles slowly toward her till they are touching. If female not receptive, she may move away from male during his approach, sometimes flying away if he continues to follow; or she may respond aggressively to him, often causing him to dismount during copulation by biting at his feet. If allowed to approach, male rubs carpal joint against wing of female who then, if receptive, lowers body to horizontal position while keeping head up; both then push against each other several times, male often placing leg nearest to female onto her back and withdrawing it several times; male then steps onto back of female and grips with feet. Male tends to keep body horizontal during mounting and does not raise head, which he places over one shoulder of female so that their heads are side by side. When male mounts, female raises wings slightly from flank and holds them there. Male then crouches with tail to one side of female's and wriggles back and forth and from side to side to bring cloacas together; continues to move slightly for a few seconds to 2 min. After copulation pair moves apart and autopreens (Pidgeon 1970; Rowley 1990). Mean duration of copulations is 92 s ($n=68$); probably incomplete if <45 s. Most copulations occur in early morning before 08:00, with smaller peak in evening, but can occur at any time of day; occurs from 5 weeks before laying and number of copulations by pair gradually increases to peak on day before first egg laid, declining only slightly in following week, during which laying is finished (Rowley 1990). In captive pair, copu-

lation first occurred 3 weeks before first egg laid and continued for 4 weeks after laying; copulations occurred most often up to and including midday (Pidgeon 1970). Rarely occurs away from nest-area and usually on horizontal branch, tending to occur on one particular branch of nest-tree. Often there are other birds within several metres of copulating pair and appear to watch closely but seldom interfere. Extra-pair copulation frequent, especially when one of pair incubating (Rowley 1990; I.C.R. Rowley).

Relations within family group NEST-INSPECTION: In ne. NSW, occurs occasionally throughout non-breeding season, increases slightly in June, and becomes common when Scarring and Lining starts in July. At Manmanning, as breeding season approaches, pair show more interest in nest-hollow and inspect it during day as well as during usual evening visits. Nest-inspection performed by both sexes, either concurrently or alternately. In captivity, male initiated inspection by examining hole alone, then moving to female and sometimes preening her; female then went to nest and male remained behind. Such alternation of inspections typical, but much variation occurs; female often comes to nest while male still there and they inspect it together. In wild, same pattern observed. When first inspecting hole, perch on or near entrance and examine outside, sometimes looking into hole, but not actually inserting head, and often look away from it; often then leave but will also look farther into hole and lean into it, occasionally thrusting body inside, accompanied by arching wings over back and Screech Call; generally only one goes into hole at once and other bird perches nearby (Pidgeon 1970); Rowley (1990) calls this behaviour BOWING and found that between Bows, often look around, turning head slowly to each side; considers whole process a ritualized territorial advertisement. Occasional inspections during non-breeding season always superficial and birds rarely lean into hole. Pairs with well-established nests will superficially examine other holes in different trees (Pidgeon 1970). Early in breeding season, either member of pair often perches in entrance to nest for 5 min or more; especially common during middle of day; possibly functions as display of occupancy (Rowley 1990). In ne. NSW, during incubation, female leaves nest to feed at usual times; in morning, leaves nest before sunrise and perches beside male and preens for 10–30 min; pair then go to feeding site before returning for midday rest period and preen and rest for up to 90 min before one enters nest; occasionally, female returns to nest-tree at midday, before male, and then sits in tree, preening occasionally, till male returns. In afternoon, female again leaves with male to feed. When returning from afternoon feeding, pair typically spend a long time preening, calling and flying from tree to tree till sunset, when settle in nest-tree; female enters nest just before dark. When female incubating during day, male commonly perches and rests in nest-tree (Pidgeon 1970). Upon coming to nest to relieve sitting partner, relieving bird, and sometimes both, utters short Cheat Call (Rowley 1980); male of captive pair often gave Titew Call when approaching nest where female incubating, whereupon she emerged and perched with male or he relieved her (Pidgeon 1970). **Feeding of young** Parents usually come to nest together to feed young (Rowley 1990). When still blind, nestlings only able to raise head off floor, wave it feebly and call weakly. When parents enter nest, older nestlings immediately start to call (see Voice); fluff plumage of body, ruffle feathers of head, raise crest, hold wings away from body, open bill and sometimes sway from side to side. To transfer food, parent turns head sideways, grasps bill of young with its own and immediately bobs head vigorously as

food transferred; vocalizations continue during feeding, from both adult and young (see Voice); parent does not bob head before transfer, unlike in other *Cacatua*. Each feeding bout usually lasts ≤ 5 s and begging resumes immediately after each bout; transfer of food repeated several times per chick (Pidgeon 1970; Rowley 1990). When parents land at nest after foraging, often utter Cheat Call; young recognize call of parents and begin begging, and adult then enters nest to feed them; adults will not enter nest till nestlings beg; in nest-hollow, parent sometimes calls softly to nestlings before feeding them. When very young, nestlings beg in response to any auditory stimulus near nest; as they grow, visual stimuli appear to become more important in eliciting begging, till eventually juvenile must see parent nearby before it starts or continues to beg (Pidgeon 1970). Up to 3 weeks old, nestlings respond to any visitor with begging; thereafter, begin to recognize and respond only to calls of parents; by 40 days old, come to entrance of nest and call to and answer parents, at which time parents begin recognizing offspring. By fledging, both parents and offspring recognize each other fully, presumably visually as well as by voice (Rowley 1980, 1990; I.C.R. Rowley); Pidgeon (1970), however, found that fledgelings beg to any adult landing near them. Fledgelings beg in same way as nestlings, as soon as parents return to feed them; parents first perch nearby for several minutes, often facing away from young, before approaching them; as parent approaches, Food-begging Call becomes louder, swaying more pronounced and plumage more ruffled; if both parents approach, fledgelings can direct begging from one to other; parent sometimes pauses and looks away from young first, then turns to it, leans over, grabs its bill and immediately starts to feed it. After being fed, young may follow parents from tree to tree; begging stops once adult moves away again (Pidgeon 1970; Rowley 1990). Young sometimes beg on ground; Rowley (1990) found that parents would feed them there, but Pidgeon (1970) found that, if responding, parents flew to nearby tree followed by young and feeding occurred there. Adults sometimes respond to juveniles perched in trees and giving Lik-lik Calls by replying with same Call then flying to and feeding them (Pidgeon 1970). Within crèche, siblings usually widely scattered but assemble in same tree whenever they hear calls of parents returning to feed them (Rowley 1980, 1990). Parents can be aggressive to offspring that continue to beg when parent finished feeding them or if beg after being weaned; in captivity, one pair killed independent offspring (Pidgeon 1970). When left alone in nest, still naked nestlings tend to huddle in pyramid, with heads draped over each other's necks (Rowley 1990). Young preened by parents till independence (Elliott 1938; I.C.R. Rowley). **Anti-predator responses of young** When older, nestlings sometimes respond to strange auditory stimulus near nest by begging for food but more often with threat, backing into corner, arching wings slightly and Bill-gaping while giving Screech Call (Fig. 8) (Pidgeon 1970). At 4–5 weeks old, nestlings begin to respond to Alarm Calls of adults uttered outside nest by becoming still and silent (Rowley 1980). Bite and screech at human handlers (I.C.R. Rowley). In ne. NSW, where crèches not observed (see above), fledgelings remain perched close together, often touching, when parents leave them to forage; if observer approaches, they freeze, staying quiet and still and can be quite difficult to flush (Pidgeon 1970); Rowley (1990) says they remain motionless for many minutes. **Parental anti-predator strategies** Parents approach nest cautiously, though often noisily; never fly directly to nest, usually taking many minutes to gradually move to entrance and then sit there quietly for some time before entering (Elliott

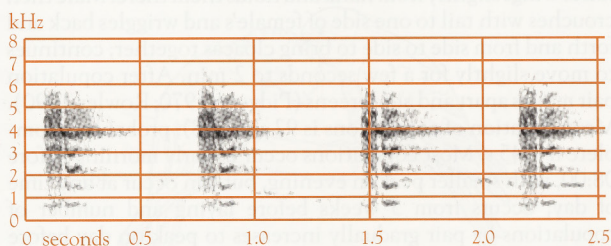


Figure 8 Anti-predator response of young

1938; Sindel & Lynn Undated). If alarmed, raise crest and utter Chet Calls, more rapidly as alarm increases, as in usual alarm (see above); will also perform Heraldic Display in defence of nest (I.C.R. Rowley).

VOICE Well known. Detailed studies of repertoire and function, in e. Aust. (Pidgeon 1981) and in Wheatbelt of sw. WA (Rowley 1990) and of calls of young (Courtney 1993; 1996), all with sonagrams. Noisy and conspicuous, especially at roosts in evening and morning; recently fledged young beg noisily and, in WA, noisy at crèches. Common call of adults, often given in flight, an unmistakable thin, high-pitched splintered *chill chill* (Pizzey 1980); also give loud screeches (Forshaw); whingeing Food-begging Call of recently fledged young distinctive. Pidgeon (1981) recognized nine structurally different calls; Rowley (1990) lists eight loud calls (though some belonged to graded series) and a variety of close-contact calls (his murmurations). Rowley considered most calls served as a means of contact between individuals and to evoke a call in response, which may lead to closer association or to synchronization of activity; loud distant-contact calls used between pair, between members of flocks, or between strangers; quiet close-contact calls often given between paired birds in close proximity or between parents and their young. Will respond to alarm calls of other Cacatuidae with which foraging (see Alarm). No calls have been identified as sex-specific. Individual recognition by call does occur but mechanism not known (Rowley 1990), though Pidgeon says fledged young cannot recognize adults (see Relations within family group). Regional variation not studied. Mimicry not reported in wild; in captivity may become proficient talkers (Eastman & Hunt 1966; Lendon 1979; Forshaw).

Adult Based mostly on Rowley (1990) and information supplied by I.C.R. Rowley, with nomenclature and descriptions of Pidgeon (1981) added. **CHET CALL** (= C and Cv Calls of Pidgeon): *Chet*; a brief (<0.5 s) two-part sound, the first at c. 4 kHz followed by a strongly structured harmonic complex of descending frequencies (sonagram A) (Rowley 1990); also described as thin, high-pitched splintered *chill chill* (Pizzey 1980); and as high-pitched metallic, disyllabic screech

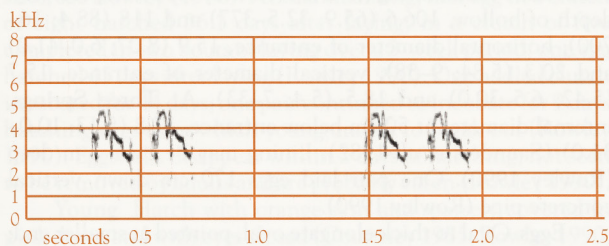


A R. Buckingham; Port Augusta, SA, July 1987; P39

(Forshaw). Chet Call is basic utterance functioning as a contact, identity and alarm call; individuals somehow recognize each other from this call (Rowley 1990). Generally given quietly at intervals of about 10 s or more, in flight or when perched. Given in mornings at roosts, especially as part of C-Flights (see Social Behaviour: Daily activity). Also used in response to threat, in alert and alarm; intervals between repetition of *chets* progressively reduced with increasing alert to alarm; at most intense, intervals reduced further till noise reaches a peak and calls staccato and almost continuous; most staccato *chets* only given in flight and may become antiphonal between members of a pair or develop into a confused cacophony when several pairs call, e.g. when mobbing a predator. C Call of Pidgeon described as a long call, most commonly of 2–3 syllables repeated in long sequences as *choot-choot*, *choot-choot* ... When given while perched, crest raised, plumage sleeked, body held erect and slightly forward and head bobbed sharply with each syllable. C Call often preceded by Titew (W) Call or H Call. When given in flight, behaviour and calling vary: at high intensity, uttered with crest raised and short abrupt wing-beats (Hover Flight q.v.); at low intensity, wing-beats normal and crest only partly raised. H CALL: Described only by Pidgeon and possibly part of Chet Call of Rowley. A soft one-syllable honking sound, like a clearer and quieter version of Chet Call (specifically C Call of Pidgeon); suggested a generalized low-intensity alarm or alert signal. ACX CALL: Described by Pidgeon (1981) and possibly part of Chet Call of Rowley. Similar in sound to Chet Call (specifically C Call of Pidgeon) but more complex; composed of 4–12 syllables like *a-choo-choo-choo-choo* ..., each syllable lasting longer than in Chet Call, and of slightly lower frequency (c. 3 kHz). Given only by adults when perched and without raising crest. Most commonly given before roosting, when most birds already settled or about to do so, and in breeding season (May–Oct.). At roosts in evening, prolonged bouts often last longer than 10 min; one bird of pair in tree calls and call repeated by birds from other pairs in other trees as if echoed; these bursts of calls rise and fall over 30 min or more till dark. Occasionally given at other times of day and outside breeding season, but then without response from other birds. ACx Call probably not simply a call to signal intention to roost, since occurs mainly in breeding season, and may be used to indicate nest territory; often used when more than one pair perched together in tree, so call apparently not intended to exclude all individuals, other than the mate, from near the caller. CHEAT CALL: Like Chet Call but syllable longer and usually repeated 2–4 times (sonagram B). Often given by member of pair returning to nest-hollow, sometimes by both members. Appears to advertise ownership of hollow and sometimes leads to Heraldic Display. TITW CALL (= W Call of Pidgeon): Single-syllable *wheoo* (Pidgeon 1981), though also said to have two parts (Rowley 1990). Often alternates with Cheat Call or replaces it, especially when in transit on long

flights (Rowley 1990). Given: in long flights, to maintain contact between members of a pair; when birds woke or stopped resting and particularly in association with Wing-Stretching and flight-intention movements (Pidgeon 1981); when soliciting for and during alloprenning; and when approached by a predator (see Hover Flight). CHET-IT CALL: Similar to Titew Call but generally given when perched. Used as a contact call to birds some distance away; also given as warning in defence of nest-hollow. LIK-LIK CALL (= S Call of Pidgeon): Loud warble-like call, given most commonly as a two-syllable *sip-sip* but often in longer series of up to 6–7 syllables (Pidgeon 1981). Two- or three-syllable sound (Rowley 1990). Usually given after bout of resting or preening and often followed by leisurely Wing-Stretches before birds take flight; other birds often repeat Call, leading to several birds flying off together (Rowley 1990); also given in flight. Functions as pre-flight signal and co-ordinates activity of flock (Rowley 1990); also seems to function to help locate groups or individuals, and to co-ordinate activity by attracting birds. ES CALL: Described by Pidgeon (1981) only. Sounds like extended *seep* and like a squeal. Structurally unlike any other call, but similar to Lik-lik at start then becoming like Titew Call. Accompanied by no special posture; seems to be given in appeasement during intense aggression and therefore may simply express fear or slight distress. SCREECH CALL (= Scr Call of Pidgeon): Loud *scree*, varying in length (Rowley 1990) but rarely <0.2 s; has little structure, being mainly noise, with most energy between 2 and 5 kHz (Pidgeon 1981). Always given with crest raised and feathers of head and neck often ruffled (Pidgeon 1981). Given in a variety of situations: as part of Bill-thrust; when inspecting nests at start of breeding season; often during encounters when biting or being bitten; given loudly when caught and held, often with each *scree* lasting up to 0.5 s and repeated; during Mobbing and sometimes during aerobic behaviour; during Heraldic Display (q.v.). Appears to convey threat and to express fear or pain. When injured or in the hand, Screech Call solicited Chet (C) Calls from other Galahs that gathered in response. GREETING CALL: Soft *kwee* sometimes given by parent to nestlings on returning to nest-hollow. FOOD-SWALLOWING VOCALIZATION (= Being-fed Call of Pidgeon): Undescribed. Given during courtship feeding by bird delivering food; recipient is silent (Rowley 1990).

Young FOOD-BEGGING CALL (= Begging Call of Rowley; Fb Call of Pidgeon): Harsh, coarse, droning wheezing, with strongly developed breath-drawing *pip* noise between calls (Courtney 1993, 1996); continuous low rasping noise (Pidgeon 1981); monotonous utterance (Rowley 1990). Call repeated at rate of c. 1/s, with calls 700–770 ms long, and with gaps of about 230 ms between calls, in which breath-drawing *pip* noise made. Energy bands spread to at least 11 kHz but most energy below 8 kHz, mainly in four bands between 1 and 5 kHz (Courtney 1993, 1996), though Pidgeon (1981) said call had little structure, with most energy between 0.5 and 2 kHz. Given by nestlings or fledgelings begging for food; characteristic whinge of recently fledged young. Call and associated sideways swaying Food-begging Posture like those of other juvenile *Cacatua*, but call very short (Courtney 1996). FOOD-SWALLOWING VOCALIZATION (= Being-fed Call of Rowley; F Call of Pidgeon): Described as rapid *ek-ek-ek-ek-ek* following whinge of Food-begging Call (Tavistock 1929). Given when bills locked and parent passing food by pumping action. When being fed, adult and young appear to perform loud duet, recipient interrupting its whingeing in order to swallow, at which time parent calls between pumping actions; sound may last for more than 1 min, stopping only



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when parent withdraws head to rearrange contents of crop before resuming feeding, or at end of feeding bout (Rowley 1990).

BREEDING Well known; detailed studies in Wheatbelt of WA, at Three Springs and Burakin (Saunders & Smith 1981; Saunders *et al.* 1982; Smith & Saunders 1986) and at Manmanning over seven seasons (Rowley 1983, 1990); 438 records in NRS to Dec. 1995. May nest in semi-colonial congregations (Rowley 1990; see Social Organization). Will occasionally hybridize with Little Corella *Cacatua sanguinea* and Major Mitchell's Cockatoo (Forshaw).

Season Eggs, late July or early Aug. to early Nov., with peak in late Aug.; most (72%; $n=198$) between late Aug. and late Sept. (NRS). In Wheatbelt of WA: laying, late July to mid-Nov.; peak of laying, late Aug.; clutches laid after late Sept. probably all replacements (Rowley 1990). Timing of laying influenced by rainfall and availability of food (Rowley 1990). Inland and n. populations may start breeding earlier than those farther S (Rowley 1990). NT: breed, Feb.–June and possibly Aug.–Nov. (Storr 7); Qld: July–Oct., Feb.–Apr. in NW (Storr 16); Vic.: breed, July–Mar. (Vic. Atlas); eggs, early Aug.–early Nov. (NRS); SA: eggs, late July to early Nov.; 74% ($n=108$ records) between late Aug. and late Sept. (NRS); early Sept. to early Nov. (Attiwill 1972).

Site In hollow in trunk or limb of tree, usually a eucalypt, often near water; in River Red Gum *Eucalyptus camaldulensis*, Coolibah *E. microtheca*, mallee eucalypts; also in *Allocasuarina*, *Angophora*, *Callitris*, mangroves (Rowley 1990; Campbell; NRS); at Manmanning: of 223 nests, 201 (90%) in Salmon Gum *E. salmonophloia*, 13 (6%) in Wandoo *E. wandoo*, 9 (4%) in Gimlet *E. salubris* (Rowley 1990). Will also nest among fronds of palms, in crevices and holes in rock-faces or cliffs, in crab-hole in ground; also in logs and wooden nest-boxes hung in trees, inclined iron pipe set in ground, and in vertical concrete pipe used as fence post (Teague 1987; Rowley 1990; Campbell; NRS). No significant differences in aspect of entrance of hollow (Saunders *et al.* 1982). Hollows may have more than one entrance; of 48 hollows at Three Springs, 8 (16.7%) had more than one entrance (Saunders *et al.* 1982). **MEASUREMENTS:** Height of hollow (m): Unspecified type of hollow, 5.4 (4.62; 1.0–19.0; 165); in branch, 5.6 (3.45; 1.5–18.3; 84); in trunk, 4.1 (2.56; 1.0–18.0; 92); three nests in holes in cliff, 4.0, 5.2 and 10.0 m (NRS). Height of nest-tree: live, 13.6 (8.24; 4.0–33.0; 86); dead, 5.0 (1.90; 2.4–12.0; 30) (NRS). In Wheatbelt of WA: height of hollow, 8.86 m (2.28; 4.65–14.00; 48); height of nest-tree, 18.2 m (5.2; 8–29; 48); circumference of nest-tree at breast height, 1.60 (0.534; 0.80–3.20; 48) (Saunders *et al.* 1982). Use same hollow in successive years (Rowley 1990; NRS); of 109 instances of re-use in successive years by individually tagged birds, 60 (55%) were by same pair, 31 (28%) by same male with different female, and 18 (17%) by same female with different male (Rowley 1990). Often re-use hollow after failure of eggs or young; of 18 occasions of re-use by individually tagged pairs, 15 (83%) were in same hollow and 3 (17%) in hollows 20–100 m away (Rowley 1990). On three occasions where female died during incubation, males re-mated and nested in same hollow (Rowley 1990); for more details of re-use of hollows, see Rowley (1990). More than one pair may nest in same tree; also recorded nesting in same tree as Black Kite *Milvus migrans*, Wedge-tailed Eagle *Aquila audax*, Nankeen Kestrel *Falco cenchroides*, Crested Pigeon *Ocyphaps lophotes*, Major Mitchell's Cockatoo, Sulphur-crested Cockatoo, Cockatiel *Nymphicus hollandicus*, Budgerigar *Melopsittacus*

undulatus, Australian Ringneck *Barnardius zonarius*, Dollarbird *Eurystomus orientalis*, Zebra Finch *Taeniopygia guttata*, Tree Martin *Hirundo nigricans*, Australian Magpie *Gymnorhina tibicen*, Little Crow *Corvus mellori*, Common Starling *Sturnus vulgaris* and Common Myna *Acridotheres tristis* (Rowley 1990; NRS; J.M. Peter). Nesting hollows usurped by Australian Shelduck *Tadorna tadornoides*, Nankeen Kestrel, Short-billed Black-Cockatoo *Calyptrorhynchus latirostris*, Regent Parrot *Polytelis anthopeplus*, Australian Ringneck, Barn Owl *Tyto alba*, Southern Boobook *Ninox novoseelandicae* and Owlet Nightjar *Aegotheles cristatus* (Rowley 1990); 5% of hollows used by Galahs in previous years lost to other species; also compete for hollows with Australian Wood Duck *Chenonetta jubata*, Pacific Black Duck *Anas superciliosa*, Major Mitchell's Cockatoo, Sulphur-crested Cockatoo, Little Corella, Western Corella *Cacatua pastinator*, Superb Parrot *P. swainsonii*, Cockatiel, feral bees *Apis* and ants (Rowley 1990; Campbell; North). Southern Boobooks have evicted incubating Galahs and laid in hollow, adding their eggs to Galah's clutch (NRS).

Nest, Materials Hollows can be vertical, inclined or horizontal (NRS). Hollows may have more than one entrance; of 48 hollows in Wheatbelt of WA, 8 (16.7%) had more than one entrance (Saunders *et al.* 1982); extra entrances of one hollow were 'plugged' with leaves and twigs (NRS). Hollows lined with sprays of green eucalypt leaves (Rowley 1990; North; NRS); some lined with bark, parts of seeds, decayed wood; occasionally unlined (NRS); nests sometimes have downy lining if hollows previously occupied by Australian Shelducks (Rowley 1990). Both sexes prepare hollow and collect sprays, cutting and carrying them in bill to hollow (= Lining; see Social Behaviour); of 313 observations, 139 (44%) carried by male and 174 (56%) by female; seldom use feet to manipulate spray; at least 50% of sprays cut are dropped on ground and never retrieved and may litter ground below hollow (Rowley 1990). Sprays may be up to 30 cm long; most collected within 100 m of hollow (Rowley 1990). Lining usually takes place in middle of day; bouts of Lining seldom last more than 20 min (Rowley 1990). Lining of hollows usually begins 5 weeks before laying; once sufficient sprays have been placed in hollow, adults settle them into a bowl-shaped depression (Rowley 1990). May continue to add sprays during laying and after eggs hatch (Rowley 1990; NRS). Unviable eggs or dead young covered with sprays before re-laying (Rowley 1990; NRS). Often chew round entrance to hollow and trunk round nest (see Social Behaviour: Scarring); some pairs chew away at inside of hollow, depositing wood-chips at base of tree (NRS); one record of Galahs excavating hollow in palm (M-E. Talmage). No significant difference in aspect of entrance of hollow (Saunders *et al.* 1982). **MEASUREMENTS (cm):** Depth of hollow: unspecified type, 62.6 (50.33; 20–300; 30); in branch, 54.3 (16.33; 30–100; 13); in trunk, 82.7 (52.86; 23–250; 22); diameter of entrance, 15–27 ($n=5$) (NRS). At Three Springs ($n=48$) (Saunders *et al.* 1982) and Manmanning ($n=243$) (Rowley 1990), respectively: depth of hollow, 106.6 (65.9; 32.5–377) and 118 (88.4; 16–700); horizontal diameter of entrance, 15.9 (8.07; 6.0–41.0) and 20.3 (5.84; 9–38); vertical diameter of entrance, 15.7 (5.42; 6.5–30.0) and 18.5 (5.4; 7–33). At Three Springs, internal diameter at 50 cm below entrance, 17.8 (5.13; 10.0–31.0) (Saunders *et al.* 1982). Lining may be over 1 m deep (Rowley 1990). One pair laid eggs 170 cm down vertical concrete pipe (Rowley 1990).

Eggs Oval to thick elongate oval, pointed at smaller end; smooth, with minute pittings; lustrous; white (North); occasionally have limy nodules (Campbell). **MEASUREMENTS:** Three

Springs, $35.1 (1.6; 32.5-39.9; 45) \times 26.2 (0.8; 24.2-27.9)$; Burakin, $35.0 (1.3; 31.8-39.6; 107) \times 26.9 (0.7; 24.9-29.1)$ (Saunders & Smith 1981); Manmanning, $35.0 (1.9; 29.2-42.4; 329) \times 26.5 (1.0; 23.0-28.8)$ (Rowley 1990); NSW, $35.8 (1.34; 33.6-37.8; 12) \times 26.9 (25.4-27.7)$ (North). **WEIGHT:** For fresh eggs from Three Springs and Burakin (combined total 15 eggs) 13.4 ± 1.06 and 14.04 ± 0.94 respectively. For information on differences between eggs within a clutch and mean daily weight-loss, see Saunders & Smith (1981) and Rowley (1990).

Clutch-size Average 3.7 ($n=80$): $C/2 \times 2$, $C/3 \times 34$, $C/4 \times 33$, $C/5 \times 10$, $C/7 \times 1$. At Manmanning, 4.3 (1.01; 2-8; 536 first clutches): $C/2 \times 12$, $C/3 \times 85$, $C/4 \times 235$, $C/5 \times 142$, $C/6 \times 51$, $C/7 \times 8$, $C/8 \times 3$; two clutches of 10 and one of 11 a result of two females laying in same nest (Rowley 1990). Replacement clutches significantly smaller than those replaced (Rowley 1990). At Manmanning between 1970 and 1976, average annual clutch-size varied from 3.30 to 4.89; variation attributable to prevailing weather: larger when winter rainfall high, lower when winter and spring rainfall low (Rowley 1990).

Laying Mean interval between eggs, 2.66 days ($n=141$ intervals) (Rowley 1990). In one hollow, egg laid while others in clutch hatching (NRS). One record of Galahs and Short-billed Black-Cockatoos laying in same hollow at same time (Rowley 1990); a Galah nestling was raised by Major Mitchell's Cockatoos after they usurped nest in which Galah had laid (Rowley & Chapman 1986). Will re-nest after failure of eggs or small young; from study of marked birds in Wheatbelt: one pair began laying second clutch 12 days after first destroyed; a female who smashed her first egg started another clutch 18 days later; in two nests where young died, a new clutch was laid 14 days later; no records of Galahs raising two broods in a season (Rowley 1990). McGilp (1923) claims Galahs can raise at least two broods in good years, but this disputed by Rowley (1990).

Incubation By both sexes (Rowley 1990). Incubation shared equally; for seven pairs, males incubated 50.5% (40.1-71.7) time and females 49.5% (28.3-59.9) (Rowley 1990). Generally starts with third or fourth egg; most eggs in clutch hatch on same day; at Manmanning: for 146 eggs, 72 (49.3%) hatched within 24 h, and 120 (82.2%) within 48 h; order of hatching not always same as order of laying (Rowley 1990). Mean duration of stints of incubation by males and females, 64.6 min (4-220; 83) and 67.5 min (4-220; 78) respectively; females tend to incubate more soon after laying; some males incubated more near hatching (Rowley 1990). At Manmanning, during 25,233 min of observation at seven nests: birds absent from hollows during change-over for only 546 min (2.16% of total time); periods of absence seldom lasted longer than 5 min; most change-overs take place inside hollow (Rowley 1990). **INCUBATION PERIOD:** Affected by variation in intensity of incubation by parents; from last egg laid to last hatched, median 23.4 (22.2-25.9; 20) (Rowley 1990); for details of incubation period for eggs within clutches and between different clutch-sizes, see Rowley (1990). At Manmanning, first egg in a clutch of eight hatched 36.1 days after laying; in a clutch of five completed in two bouts of laying over a 3-week period, one egg hatched 45 days after laying (Rowley 1990). One added clutch incubated for 44 days; one pair continued to incubate for 9 days hatching eggs from which young unable to break out (Rowley 1990). Eggshells disappear within 2 days of hatching; not seen to be removed by adults and are probably eaten (Rowley 1990).

Young Hatch with orange skin and sparsely covered in pink down and with eyes closed (Courtney 1985; Rowley 1990; NRS). Some tracts visible at 7-8 days; pins of scapulars emerge at 9-10 days; of feathers of head at 11-12 days; of primaries at

13-15 days; of rectrices at 18-23 days. Eyes open at 15-18 days. Young feathered at 4 weeks (Rowley 1990). **Growth** At Manmanning, weight at hatching, c. 5 g; reach asymptote of 295 g at c. 35 days; mean weight at 45+ days old, 309.8 g (26.83; 260-365; 100) (Rowley 1990); for more information, see growth-curves in Rowley (1990). Weight at fledging (g): At Three Springs, 276.5 (35.14; 210-355; 31) or 91% adult weight; at Burakin, 295.9 (25.36; 250-355; 18) or 97% adult weight (Smith & Saunders 1986). Length of folded left wing: at hatching, 10 mm; at 14 days, 25 mm; seventh primary grows at rate of 4.3 mm/day, central rectrix at 3.7 mm/day (Rowley 1990). For more information on increase in weight, and length of wing, see growth-curves in Rowley (1990). **Parental care, Role of sexes** Both parents brood, closely for first 8-10 days; continuously in morning, intermittent during middle of day; intensity and duration depend on ambient temperature and age of young (Rowley 1990). Both parents feed young; at hatching, young fed a clear liquid, dribbled to hatchling by adult; on second day, fed solid, regurgitated food, once per visit during feeding bout lasting 48-125 s; as young grow, length of feeding visits increase, each consisting of one or more bouts, during which each chick receives 2-9 brief feeds; by 14 days, each chick again receiving only one feed per visit; brooding often resumes after feeding. From 8 days, young fed on average every 53 min; more feeds delivered in morning (0.94/h; $n=248$) than in afternoon (0.82/h; $n=165$) (Rowley 1990). See Social Behaviour for more details of feeding of chicks. Nestling faeces accumulate in bottom of hollow (Rowley 1990).

Fledging to independence **FLEDGING PERIOD:** At Manmanning, 49.4 days (2.1; 45.6-59.1; 24 known-age birds) (Rowley 1990); at Three Springs and Burakin, 52 days (45-62; 46 birds, age estimated) (Smith & Saunders 1986). Last chick to fledge may leave nest up to 12 days after rest of siblings (Rowley 1990). Young usually fledge in morning. One chick leapt from nest after being handled when 42 days old (Rowley 1990). Able to fly strongly upon leaving nest; form crèches, which may persist for several weeks (Rowley 1990; NRS). Parents continue to feed young for 6-7 weeks after fledging; young begin foraging within 1 month of fledging; remain partly dependent till c. 100 days old (Rowley 1990; NRS).

Success From 290 eggs in 80 nests, 235 (81%) hatched; for 28 nests where outcome known: from 98 eggs, 61 (62%) hatched, 47 (48%) fledged; for 18 nests where one or more chicks hatched: from 70 eggs, 61 (87%) hatched, 47 (67%) fledged (NRS). At Manmanning, from 2601 eggs, 1816 (69.8%) hatched, 1068 (41.1%) fledged; 19% of fledgelings died before reaching independence (Rowley 1990); at Burakin and Three Springs, from 246 eggs, 190 (77.2%) hatched, 88 (35.8%) fledged; for 37 first clutches at Burakin: from 4.0 ± 0.73 eggs/clutch, 3.1 ± 1.49 hatched, 1.6 ± 1.57 fledged; for 10 second clutches at Burakin: from 3.2 ± 0.79 eggs/clutch, 2.4 ± 1.58 hatched, 1.6 ± 0.81 fledged (Smith & Saunders 1986). For details of hatching success compared with clutch-size, see Smith & Saunders (1986). Nests failed after nest-tree blown down in storm; knocked down for road works; adult killed (NRS). At Manmanning, clutches abandoned following loss of a parent, inclement weather, interspecific competition and usurpation of hollow by bees and ants; eggs also taken by reptiles, mammals and egg-collectors; one clutch accidentally destroyed by researcher (Rowley 1990); Lace Monitors *Varanus varius* take eggs (North). Nestlings die following inclement weather (Rowley 1990); disease, with most (80%; no N) chicks dying at 2-3 weeks old; others died of infected and fly-blown wounds (Smith & Saunders 1986). At Manmanning, fledgelings taken

by Wedge-tailed Eagles; hit by moving vehicles; four fledgelings wearing wing-tags became entangled on branches (Rowley 1983); young taken for aviculture (Rowley 1990; NRS).

PLUMAGES Prepared by D.I. Rogers. Fledge in juvenile plumage, and soon begin partial post-juvenile (first pre-basic) moult. Resultant immature (first basic) plumage similar to adult plumage except for retained juvenile remiges. Adult plumage attained with complete second post-breeding (pre-basic) moult when about 1 year old. Thereafter, perform one moult annually. Subspecies *albiceps* from se. Aust. described below.

Adult (Second and subsequent basic). Sexes similar (but see Bare Parts). **HEAD AND NECK:** Forehead, crown and nape, white; feathers grade to pink (108C–108D) at base, and partial exposure of bases can cause faint pink tinge. Feathers of crown and nape elongated, 25–35 mm long, forming crest that, when fully raised, looks roughly triangular, with anterior apex meeting base of bill and rear apex meeting crown well behind eye; when fully folded, crest still makes forehead look slightly raised. Chin, throat, cheeks, ear-coverts, sides of neck and hindneck, dark pink (108B); feathers have white bases, which are usually concealed but, in some, are partly exposed as a small white smudge immediately below periphthalmic ring; at most marked extreme, pale mark below eye rather striking, formed by small pinkish-white (ne) feathers that have pink (c108B) shaft-streaks and tips; this condition rare in se. Aust. Demarcation of white crest and dark-pink hindneck and ear-coverts sharp; lores appear intermediate between pinkish-white forehead and dark-pink throat. **UPPERPARTS:** Mantle and scapulars, mainly grey (c84); feathers are large and range from medium grey (84–83) (especially at tips of feathers) to light grey (c85) (especially at bases), causing uneven appearance. Back paler and more even grey (85–86), grading to very pale grey (ne) or grey-white (ne) on rump and uppertail-coverts. **UNDERPARTS:** Breast, belly and anterior flanks, dark pink (c108B–c108C) with concealed white bases to feathers and, in some fresh individuals, a faint greyish-white (ne) tinge at tips of feathers that is only visible on close examination. Rear-flanks, light grey (c85) grading to pale grey (86) on most of vent and undertail-coverts. Longest undertail-coverts grade to slightly darker grey (84–85) in centre of tips; and on vent and thighs, pink (c108C) fringes to feathers give pink tinge or mottling. **UPPERTAIL:** Grey (c84) on distal third, grading to pale grey (c86) on basal third. **UNDERTAIL:** Dark grey (c83); feathers grade to grey (c84) or light grey (c85) at bases; light-grey areas typically concealed by undertail-coverts. **UPPERWING:** Looks grey, with slightly darker outerwing and large diffuse white central panel. Marginal, lesser and median secondary coverts, light grey (c84–c85) grading to slightly darker grey (c84–c83) on primary coverts and alula. Greater secondary coverts, mainly light grey (c85), grading to silvery white (ne) on distal half of each outer web and at tip of each inner web; these diffuse but large white areas form anterior half of pale wing-panel. Primaries and secondaries have dark-grey (83) inner webs and tips that grade to darker grey (c83) or grey-black (82) on emarginated tips (i.e. fingers) of outer five primaries. Outer webs of inner secondaries and outer primaries, otherwise grey (84). On outer seven or so secondaries, basal half or more of outer webs, silvery white (ne), forming rear half of pale wing-panel and grading to dark grey (83) at tips of feathers; pale markings sharply demarcated from inner webs by grey-black (82) shafts. Pale wing-panel extends onto inner five or so primaries, which have smaller and slightly duller areas of silvery white on outer webs. **UNDERWING:** Greater coverts and remiges,

dark grey (83) grading to grey-black (82) at wing-tip and on trailing edge; all greater coverts narrowly fringed dark pink (108B). Median, lesser and marginal coverts, uniformly dark pink (108B) except that grey (84) bases are partly exposed on marginal coverts outside carpal joint.

Nestling Down, fine and very sparse, restricted mainly to upperparts; usually said to be pink (–) or pale pink (e.g. Courtney 1965, 1993; Schodde 1988; Rowley 1990; Forshaw; J.M. Forshaw; I.C.R. Rowley); also described as whitish in captive birds (Sindel & Lynn Undated) and may not occur in wild.

Juvenile Sexes similar. Differences from adult: **HEAD AND NECK:** Cap from crown to nape less clean white than adult, with slight pink (c108D) tinge throughout always stronger than in adult; also sides of crown have diffuse but broad grey-white (86–ne) tips to feathers, imparting grey tinge that is most reliable ageing character. Throat, ear-coverts and sides of neck slightly duller than adults, an effect caused by diffuse brownish-grey (c80) shaft-streaks and fine brownish-grey (c80) fringes at tips of feathers; fringes broadest on sides of neck and hindneck but can be wholly lost with wear. **UPPERPARTS:** As adult except that feathers slightly smaller. **UNDERPARTS:** Have varying dirty-grey suffusion on breast; commonly extends over much of breast and slightly onto belly and flanks but can be restricted to extreme sides of breast; rarely absent. Caused by feathers having varying brownish-grey (c80) shaft-streaks and brownish-grey (c80) fringes at tips. On flanks, only shafts and extreme tips of feathers brownish grey (c80), so these areas look pink (c108C) but slightly duller than in adult. **TAIL:** As adult except that feathers slightly narrower. **UPPERWING:** Primaries slightly narrower at tips than in adults, but age-related differences far less marked than in corellas or black-cockatoos. **UNDERWING:** Pink fringes to greater coverts narrower than in adults and more readily lost with wear. Grey bases to marginal coverts outside carpal joint larger and more exposed than in adults.

Immatures (First basic). Differ only by retained juvenile primaries, which are slightly narrower at tips and, in autumn and winter, often slightly more worn than in adults; differences difficult to assess objectively, and accurate ageing often not possible.

Aberrant plumages Two schizochroistic mutations occasionally reported in wild: (1) Grey of dorsal plumage replaced by white but pink areas normal; (2) Pink areas replaced by white but dorsal plumage normal (Forshaw). Four other types of mutations have been reported (Sindel & Lynn Undated), possibly only occurring in captivity.

BARE PARTS From museum labels (ANWC, HLW, MV, QM, SAM, WAM) and photos (Rowley 1990; Sindel & Lynn Undated; Aust. RD; Crome & Shields; unpubl.: J.N. Davies; R. Davies). **E. SUBSPECIES ALBICEPS: Adult male** Bill, bone-white, often grading to pale grey (c86) at base (sometimes with faint greenish [ne] tinge). Iris, black-brown (119). Periphthalmic ring broad, oval; usually pink (7) to dark pink (c9) or pinkish red (c13, 116); generally uneven in texture, with concentric wrinkles, and is often warty, with carunculations that can be up to a third of width of periphthalmic skin and flattened on top. Some have duller and smoother periphthalmic ring, e.g. pale yellowish-pink (pale 5); possibly related to immaturity or non-breeding condition. Periphthalmic ring encloses inconspicuous and narrow pale-grey (c86) orbital ring and lower eyelid. Tarsus and toes, light grey (85) to grey (84, c80) or dark grey (c83) with narrow and inconspicuous areas of white skin between scales; claws, grey-black (82). **Adult female** Bill and feet as adult male. Iris, typically pink (c3) or orange-pink (106,

c116) to red (13, 14) (see Immature female). Carunculations of periophthalmic ring typically smaller than in males (Rowley 1988), this especially noticeable in mated pairs. **Nestling** Bill: at first, pink (c7) with yellowish-white (ne) tomtia; later becomes predominantly white except for pink (c7) or grey-mauve (c77) tinge at base of both mandibles and yellowish (ne) tinge, which is most marked at tip and on cutting edges. Iris, black-brown (119). Periophthalmic region, dark grey (83–84) becoming grey-mauve (c77) before fledging. Skin, including legs, varying shades of orange-pink (c3) at first; legs attain adult colour before fledging. **Juvenile** Bill similar to that of adult, but recently fledged birds can have slightly yellower tinge (especially at cutting edges and tips) and faint grey-mauve (c77) tinge at base; older juveniles may be less apt than adults to show grey tinge at base; in most but not all birds bill also tends to be smoother in texture. Iris: at first, black-brown (119) in both sexes; some, but not all, females begin to develop orange-pink tinge to iris before post-juvenile moult. Periophthalmic ring initially pale yellowish-grey (ne) and smoother than in adults; some develop strong pink tinge like that of adult before fledging. **Immature male** As adult male. **Immature female** Iris possibly black-brown (119) like adult males immediately after post-juvenile moult. When 6 months old, iris has begun to get paler and sexing is possible, though fully pink iris of adult female not attained until 2–3 years old (Rowley 1990; Syndel & Lynn Undated). Photographs of birds with adult plumage and greyish-brown (c119B) irides possibly immature females with eye-colour at a transitional stage.

MOULTS Based on study by Rowley (1988) in Wheatbelt of WA, and skins of 240 adults and 48 subadults (ANWC, HLW, MV, QM, SAM, WAM). **Adult post-breeding** (Second and subsequent pre-basic). Complete. In Wheatbelt, moult of primaries centrifugal, starting at p6; p5 moulted next, and outward wave often completed after inner; typically 1–2 primaries grow concurrently in each wing. Moult of tail probably centrifugal but sequence much obscured by accidental loss of feathers and other sources of individual variation; sequence of moult of secondaries complex, poorly understood; moult of feathers of body complete, lasting about 200 days. In nominate *roseicapillus* in Wheatbelt, on average, moult of primaries in males starts early Nov., when nestlings about 3 weeks old, and is finished at end Apr., with mean duration 165 days; females begin moult around mid-Nov. but finish at about same time as males, with average duration of moult 155 days (Rowley 1988). Elsewhere in s. WA, including Nullarbor, and se. Aust., including Eyre Pen., pattern similar: in skins collected S of 25°S: earliest records of start of moult of primaries, 13 Sept. in e. subspecies *albiceps* and 20 Sept. in w. nominate *roseicapillus*; latest records of adult yet to start moult of primaries, 12 Dec. in *albiceps* and 19 Dec. in *roseicapillus*; earliest specimens that have finished moult of primaries, 12 Mar. in *albiceps* and 20 Apr. in *roseicapillus*; latest specimens still moulting primaries, 24 May in *albiceps* and 2 May in *roseicapillus*. In Tropics (Kimberley Div., WA, and Top End, NT; subspecies *kuhli*), moult complete and similar in sequence to that in temperate Aust., except that seven of nine birds in first stages of moult of primaries had started at p5 (almost always start at p6 in temperate Aust.). Timing of moult in Tropics differs markedly and is probably centred round dry season: in Mar., two examined had early moult (PMS 1–5) and nine had yet to start moult; in May, six of eight had started moult of primaries (PMS 0–15). Timing of finish in Tropics poorly known as only eight specimens available June–Dec.; one specimen had active moult of primaries

(PMS 25) in Dec., but wear of other specimens in this period suggested moult had been completed early in wet season. In arid centre (most specimens from L. Eyre region, Pilbara and Barkly Tableland) moult appears to be centred round summer; nine of 18 examined Sept.–Apr. were in active moult (50%), while none of 20 examined May–July had active moult (0%). Of 44 examined from arid centre, 12 (27%) showed irregular sequences of moult or patterns of wear, either because moult had been interrupted or because moult of one or two primaries had been skipped or performed out of sequence; such irregular patterns of moult or wear less common in temperate Aust. (8.2%; n=109) and Tropics (11.4%; n=35). Even in arid centre, irregular patterns of moult and wear much less common than in most other species of cockatoo. **Post-juvenile** (First pre-basic). Partial, involving feathers of head, body and sometimes tail; does not include remiges. Occurs in autumn in temperate Aust.; recorded in Apr. and May; finished in most, but not all, by May. Timing in Tropics poorly known; recorded in one specimen in early Feb. (late stages) and in another in late June (early stages). In arid Aust., recorded in Apr. (n=3) and June (n=1). **Immature post-breeding** (Second pre-basic). Complete. Generally similar to adult post-breeding, but in Wheatbelt, moult of primaries begins earlier (in Oct.) and takes longer (185 days) than in adults (Rowley 1988). Too few data to tell if similar difference from adults occurs in other parts of range.

MEASUREMENTS All skins except sample 4 (ANWC, HLW, MV, QM, SAM, WAM). Nominate *roseicapillus*: (1–2) SW. Aust. and Wheatbelt of WA: (1) Adults; (2) Juveniles. (3) Pilbara district, WA, adults. (4) Manmanning, Wheatbelt of WA, adults (Rowley 1990).

	MALES	FEMALES	
WING	(1) 267.3 (3.92; 262–273; 8)	259.1 (5.56; 246–268; 29)	**
	(2) 263, 264, 269	247, 248	
	(3) 270.3 (4.97; 261–275; 6)	256.3 (9.07; 242–269; 8)	**
	(4) 261.8 (6.3; 245–278; 185)	254.1 (6.5; 230–271; 118)	
TAIL	(1) 146.1 (6.79; 139–156; 8)	144.9 (4.16; 136–151; 29)	ns
	(2) 140, 147, 151	137, 150	
	(3) 148.0 (6.97; 135–155; 6)	143.1 (7.51; 132–153; 8)	ns
	(4) 142.7 (4.2; 133–155; 185)	140.9 (4.8; 125–152; 118)	
BILL	(1) 25.3 (0.97; 23.7–26.9; 8)	24.2 (0.66; 23.1–25.6; 29)	**
	(2) 24.2, 24.3, 26.5	23.2, 24.3	
	(3) 25.7 (0.61; 25.1–26.8; 6)	25.0 (1.92; 23.3–29.2; 8)	ns
	(4) 25.4 (0.87; 23.0–28.5; 185)	24.4 (0.78; 22.0–26.5; 118)	
TARSUS	(1) 22.4 (0.94; 21.2–23.8; 8)	21.9 (0.98; 19.5–23.6; 29)	ns
	(2) 21.6, 23.2, 23.8	23.2, 23.7	
	(3) 22.8 (1.11; 21.4–24.1; 6)	22.3 (0.88; 21.2–23.9; 8)	ns
	(4) 29.7 (1.17; 28.3–31.6; 7)	28.3 (0.95; 26.3–30.1; 23)	**
TOE	(3) 30.6 (1.21; 29.2–32.3; 5)	28.6 (0.54; 27.7–29.2; 6)	**
TOE C	(1) 38.1, 40.8, 41.3	39.4 (1.39; 37.3–42.7; 20)	
	(3) 38.2, 42.7	40.7 (1.02; 39.7–42.4; 6)	

Subspecies *albiceps*: (5–6) SE. Aust., including Murray–Darling Basin and Adelaide district: (5) Adults; (6) Juveniles. (7) Eyre Pen., SA, adults. (8) L. Eyre Basin, SA.

	MALES	FEMALES	
WING	(5) 266.1 (6.64; 256–279; 19)	260.3 (7.13; 244–274; 20)	*
	(6) 253.2 (2.93; 249–258; 6)	252.6 (3.21; 247–255; 5)	ns
	(7) 262.0 (4.64; 255–267; 5)	251.8 (6.42; 242–258; 5)	*
	(8) 263.1 (6.30; 249–269; 12)	255.9 (8.23; 235–265; 17)	*
TAIL	(5) 137.8 (5.22; 131–150; 16)	136.7 (5.30; 129–148; 19)	ns
	(6) 128.5 (2.65; 125–131; 4)	132.6 (6.03; 123–138; 5)	ns
	(7) 132.3 (7.93; 122–139; 4)	132.4 (3.36; 127–136; 5)	ns
	(8) 138.4 (5.15; 126–142; 8)	133.9 (5.36; 127–141; 11)	ns

BILL	(5)	25.5 (0.98; 23.8–27.0; 19)	25.0 (1.15; 23.6–27.2; 20)	ns
	(6)	25.2 (0.90; 24.2–26.3; 6)	25.2 (1.06; 23.7–26.7; 4)	ns
	(7)	25.2 (0.69; 24.8–26.4; 5)	24.3 (0.88; 23.1–25.2; 4)	ns
	(8)	24.9 (1.39; 22.3–27.1; 11)	24.9 (0.92; 22.8–26.3; 17)	ns
TARSUS	(5)	22.4 (0.84; 20.5–23.6; 16)	21.8 (0.95; 20.6–24.1; 19)	ns
	(6)	21.6 (0.78; 20.5–22.3; 4)	22.0 (0.77; 21.0–22.8; 6)	ns
	(7)	21.1 (0.71; 20.5–21.9; 4)	21.0 (0.65; 20.3–21.8; 5)	ns
	(8)	21.7 (0.46; 20.8–22.4; 8)	21.2 (0.89; 19.7–22.7; 13)	ns
TOE	(5)	28.7 (1.29; 26.8–31.3; 9)	28.3 (0.93; 27.1–30.0; 11)	ns
	(6)	29.1, 29.1, 30.0	26.1, 29.6, 30.0	
	(8)	26.2, 27.3, 30.4	27.7 (2.36; 24.5–30.0; 5)	
	(8)	26.2, 27.3, 30.4	27.7 (2.36; 24.5–30.0; 5)	
TOE C	(5)	38.3 (1.20; 37.0–40.5; 9)	37.4 (1.81; 34.3–40.0; 11)	ns
	(6)	36.3, 38.0, 39.1	35.5, 35.8, 37.9	
	(8)	39.4 (1.60; 38.2–41.8; 5)	37.2 (1.74; 35.5–40.5; 6)	ns
	(8)	39.4 (1.60; 38.2–41.8; 5)	37.2 (1.74; 35.5–40.5; 6)	ns

Subspecies *kuhli*: (9–10) Kimberley Div., WA, and Top End, NT: (9) Adults; (10) Juveniles.

		MALES	FEMALES	
WING	(9)	260.8 (7.01; 248–272; 13)	253.7 (7.30; 243–268; 19)	*
	(10)	254.6 (5.32; 247–261; 5)	248.5 (4.23; 241–252; 6)	ns
TAIL	(9)	136.2 (5.00; 130–144; 13)	133.2 (5.98; 122–145; 19)	ns
	(10)	127.4 (3.21; 123–130; 5)	129.5 (4.46; 124–137; 6)	ns
BILL	(9)	24.5 (1.07; 22.9–26.0; 14)	23.9 (0.85; 22.4–25.8; 19)	ns
	(10)	23.2 (1.17; 21.8–24.9; 5)	24.1 (0.72; 23.5–25.5; 6)	ns
TARSUS	(9)	21.9 (1.03; 19.8–24.2; 14)	21.2 (0.80; 19.5–22.4; 19)	ns
	(10)	21.9 (0.65; 20.8–22.3; 5)	22.6 (0.83; 21.5–23.4; 6)	ns
TOE	(9)	29.0 (1.23; 26.4–30.8; 12)	28.0 (1.16; 25.5–30.1; 18)	ns
TOE C	(9)	39.6 (1.71; 36.5–43.3; 13)	38.1 (1.37; 34.8–40.5; 19)	ns

Where samples adequate, males significantly larger than females (especially in length of wing); and wing, tail, and bill of juveniles significantly shorter than adults.

WEIGHTS (1–2) Nominate *roseicapillus*: (1) Throughout range, including specimens from Pilbara, from museum labels (ANWC, MV, QM, SAM, WAM); (2) Manmanning, sw. WA (Rowley 1990). (3–5) From museum labels (ANWC, MV, QM, SAM, WAM): (3) Subspecies *albiceps*, se. Aust., including Murray–Darling Basin. (4) Subspecies *albiceps*, L. Eyre Basin. (5) Subspecies *kuhli*, Kimberley Div., WA, and Top End, NT.

		MALES	FEMALES	
ADULTS	(1)	324.2 (26.74; 273–380; 14)	299.3 (30.48; 200–356; 26)	*
	(2)	345.0 (25.8; 275–430; 185)	311.4 (25.2; 255–400; 118)	
	(3)	363.0 (32.84; 320–432; 9)	345.5 (21.47; 307–371; 10)	ns
	(4)	335.3 (14.86; 321–350; 4)	292.9 (31.86; 225–321; 8)	ns
	(5)	286.0 (17.14; 259–312; 10)	257.3 (19.88; 227–305; 15)	**
JUVENILES	(3)	323.3 (18.46; 305–346; 4)	305.8 (52.96; 253–372; 4)	ns
	(5)	253.3 (8.30; 248–260; 4)	260.2 (14.15; 240–280; 5)	ns

Available data suggest no striking seasonal variation in weights, e.g. in adult *albiceps* in se. Aust., weights in winter (May–Aug.) 350.7 (34.67; 307–432; 10), in summer 348.4 (24.74; 301–382; 9).

STRUCTURE Wing, rather narrow and pointed for a cockatoo, with rather long primaries and short secondaries. Ten primaries: p8 longest; p10 16–30 mm shorter, p9 0–7, p7 2–8, p6 12–30, p5 40–58, p4 68–84, p3 78–96, p2 97–108, p1 97–116; outer webs of p6–p8 emarginated, of p5 slightly so; inner webs of p6–p10 emarginated. Ten secondaries, including two tertials; there is also a small inner feather that may be a tertial or may be an inner greater secondary covert. Tail short, rather square at tip; 12 feathers. Bill rather small but otherwise typical of

cockatoos, with upper mandible protruding past tip of lower in hook of 7–8 mm; upper mandible c. 16 mm wide at base, and lower mandible c. 0.5 mm narrower; lower mandible c. 18 mm long. Tarsus short and stout, granulate. Zygodactyl; outer front toe longest, outer hind c. 88%, inner front c. 67%, inner hind c. 43%; claws strong and curved, c. 13 mm long on outer front, 9–11 mm long on other toes. Distinctive aspects of skull morphology (well-developed maxillary processes, reduced temporal fossae, crescentic rather than semicircular auditory meatus) discussed by Holyoak (1970), Schodde (1988) and Boles (1993). Further information on pterylography of wing in Miller (1915).

GEOGRAPHICAL VARIATION Substantial but not well known; there have been no detailed studies of intraspecific variation, though there has been much discussion about whether Galahs should be placed in *Cacatua* or a monotypic genus *Eolophus* (Holyoak 1970; Adams *et al.* 1984; Schodde 1988; Boles 1993; Courtney 1993; Christidis & Boles 1994; Forshaw); *Eolophus* is used in this work, following Schodde & Mason (1997) and advice that recent molecular analysis supports this treatment (L. Christidis). Schodde (1988) and Rowley (1990) show that correct name of w. subspecies is *roseicapillus* (nominate) and of e. subspecies is *albiceps* (e. birds were treated as nominate subspecies and w. birds as subspecies *assimilis* in much previous literature). Three subspecies recognized here following Aust. CL and on the basis of examination of c. 250 skins in ANWC, HLW, MV, QM, SAM and WAM. Subspecies differ in colour and texture of periophthalmic ring; shape and colour of crest; size of white patch below eye; ground-colour of upperparts and underparts; and, slightly, in size. Many of these differences difficult to assess accurately in skins, and analysis further complicated by changes in distribution of Galahs since European settlement. More detailed study required.

Key features of *albiceps* in se. Aust. (described in Plumages, Bare Parts) are: warty red periophthalmic ring; moderately small white crest sharply demarcated from deep pink hindneck; rather dark ground-colours to most of upperparts and underparts but with a grey-white rump; and measurements.

Nominate *roseicapillus* from WA (excluding Kimberley Div.) differs by: (1) Periophthalmic ring slightly larger and typically pale grey (86) to white; sometimes shows faint pink tinge (but is never deep pink); (2) Periophthalmic ring more warty, with crusty, larger and more raised caruncles (those of *albiceps* usually flattened on top); most warty extreme shown by many adult males looks unpleasantly scabrous, with largest caruncles in front of eye almost as large as eye itself, concealing much feathering of lores; (3) Crest, pale pink (108D) and not sharply demarcated from hindneck or hindmost ear-coverts because these tracts have pale-pink (108D) tips of feathers; (4) Auriculars, pink (c108C–c108B) without pale-pink tips of hindmost ear-coverts and so often stand out as contrasting darker patch; (5) Crest, longer, especially on nape; when fully raised, rear edge of crest runs smoothly into line of hindneck; other feathers of head, neck and body also slightly longer, so *roseicapillus* typically appears stouter and bigger-headed; (6) Ground-colours of underparts and most of upperparts within range of variation shown by *albiceps* but not usually so dark; ground-colour of breast usually light pink (108C); (7) Rump, usually pale grey (86) (cf. grey-white in *albiceps*); (8) Tail c. 10 mm longer (see Measurements) and difference significant ($P < 0.01$).

Subspecies *kuhli* of Kimberley Div., WA, and Top End, NT, is a much smaller and paler version of *albiceps*; differs by: (1) Periophthalmic ring, pink to red-pink; available photographs

suggest skin round eye may be slightly darker and larger than in *albiceps*, but not enough information to assess effects of possible seasonal variation; (2) Crest, pinkish white; pinker on average than *albiceps* but not comparable in pinkness to *roseicapillus*; unlike nominate, fairly clearly demarcated from pale-pink (108D) hindneck and rear ear-coverts; (3) Crest shorter than in other subspecies, especially on hindcrown and nape; when fully raised, it appears as a steep peak on forecrown, with rear edge meeting crown at about level of eye; (4) Smaller than *albiceps* in all measurements; differences significant for wing and bill in both sexes, and tarsus in females. Though difference in size is slight, *kuhli* looks markedly smaller and more slender (especially on head) because feathering of head and body is shorter than in other subspecies; (5) Always a large white blaze below periophthalmic ring, typically >3 mm wide; this marking varies considerably in other subspecies but almost always smaller than in typical *kuhli*; (6) Underparts, paler pink (usually 108D, rarely 108C) than other subspecies; rear-flanks to undertail-coverts also paler grey (c86); (7) Upperparts, upperwing and uppertail, mainly light grey (85) with only small grey (84) smudges; grades to grey-white (ne) or white on rump and uppertail-coverts.

Distributional limits of subspecies, and the nature of contact zones between them, poorly known. In N of its range, *roseicapillus* separated from *kuhli* by Great Sandy Desert; no specimens available from this region (though there are field records; see Distribution). Hall identified birds observed at Derby as *roseicapillus*, but large recent collections from w. Kimberley appear to be typical *kuhli* (Ford 1987; this study). Nominate birds from Pilbara do not differ in size or plumage characters from those of sw. WA, suggesting little genetic input from *kuhli* in this area. Nominate *roseicapillus* occurs through Gibson and Great Victoria Deserts to Central Ras of SA and NT; few specimens available from Central Ras, but typical *roseicapillus* have been photographed as far E as Harts Ra., NT (Howard 1990). Nominate birds of Central Ras possibly at least partially separated from e. *albiceps* by Simpson Desert but Tanami Desert and Barkly Tablelands possibly not major barrier to n. *kuhli*, e.g. specimens from Tennant Creek (MV) are pale and rather small (e.g. wing of unsexed adult 252) and probably intermediate with *kuhli*. The type of subspecies *howei*, Mathews 1917 (not now considered a good subspecies) is from Central Ras (c. 100 km NE of Alice Springs); it was reported to be similar in size to se. Aust. *albiceps* (Mayr 1951) but with very pale grey upperparts and pale pink underparts (Mathews); this combination of characters could also be interpreted as intermediate between *roseicapillus* and *kuhli*. More information needed from Central Ras. E. and se. limits of range of *kuhli* also poorly known. It occurs across n. coastal Qld to C. York Pen. (Aust. CL; this consistent with the few skins available in this study). Ford (1987) assumed intergradation with e. *albiceps* to occur in region of Barkly Tableland, but the few specimens from this region (18°–20°S, 138°–139°E) available in this study were rather similar to *kuhli* (e.g. in males, wing 259.6 [7.50; 5]; dorsal and ventral plumage as pale as in typical *kuhli*; size of white blaze below eye also within usual range shown by *kuhli*). Subspecies *kuhli* or intermediates with it may also occur well to S of Barkly Tablelands. Indeed, Hall considered small samples from L. Eyre Basin and Eyre Pen. to be *kuhli*. Larger series now available indicate that birds best regarded as *albiceps* on basis of large size (see Measurements) and shape of crest, but they do show features (including plumage characters scored systematically for 14 skins from Eyre Pen. and 24 from L. Eyre Basin) suggestive of intermediacy with *kuhli* rather than *roseicapillus*: (1)

upperparts mainly pale grey (85–86) like *kuhli*; (2) rump typically grey-white to white like *kuhli*; (3) underparts in both regions paler than typical *albiceps*; in Eyre Pen. difference is slight (and rather similar to *roseicapillus*), but in L. Eyre Basin, underparts almost as pale as *kuhli*; (4) in L. Eyre Basin but not Eyre Pen., white patch below periophthalmic ring larger than in typical *albiceps*, possibly as large as in *kuhli*; (5) all adequately labelled specimens from these regions had pink to pinkish-red periophthalmic rings, with no indication of grey-white colour of *roseicapillus*; (6) arguably slightly smaller than typical *albiceps*, though differences only significant for wing-lengths and weights of adult females (possibly a reflection of small sample sizes); significantly smaller than *kuhli* from NT and Kimberley Div. and tail significantly shorter than in *roseicapillus*. Farther E, *albiceps* seems uniform through its range, though few data available from n. and ne. Qld.

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Volume 4, Plate 5

Gang-gang Cockatoo *Callocephalon fimbriatum* (page 94)

1 Adult male; 2 Adult female; 3 Juvenile male; 4 Juvenile female; 5 First immature male; 6 Adult male; 7, 8 Adult female

Galah *Eolophus roseicapillus* (page 104)

SUBSPECIES ALBICEPS: 9 Adult male; 10 Adult female; 11 Juvenile; 12 Adult

NOMINATE ROSEICAPILLUS: 13 Adult male

SUBSPECIES KUHLE: 14 Adult male

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