

## Order CORACIIFORMES

A morphologically heterogeneous group of birds, with large heads, short necks, short legs and, mostly, large bills. They comprise the kookaburras and kingfishers, todies, motmots, bee-eaters and rollers. Widely distributed, occurring on all continents except Antarctica, but most species occur Asia and Africa. In total, about 143–154 species in about 29–40 genera. Nine families recognized here (after Sibley *et al.* 1988; Sibley & Ahlquist 1990; Fry *et al.* 1992):

(1) **ALCEDINIDAE**: River kingfishers; 22–24 species in 2–4 genera: *Alcedo* and *Ceyx* (sometimes *Ispidina* or *Myioceyx* also recognized); distributed in Africa, s. and e. Asia, Indonesia, Philippines, Melanesia, New Guinea and Aust. Two species of *Alcedo* in HANZAB region.

(2) **HALCYONIDAE** (Dacelonidae of Sibley & Monroe 1990, cf. Sibley & Monroe 1993): Tree (or wood) kingfishers; 56–61 species in 8–12 genera; distributed in Africa, s. and e. Asia, Indonesia, Papuaia, Micronesia, Polynesia and Aust. and NZ. Eight non-vagrant species in four genera in HANZAB region.

(3) **CERYLIDAE**: Water (or belted) kingfishers; nine species in three genera: *Chloroceryle*, *Megaceryle* and *Ceryle*; distributed in Africa, s. and e. Asia, and New World.

(4) **MEROPIDAE**: Bee-eaters; 24–26 species in three genera: *Nyctornis*, *Meropogon*, *Merops*; distributed Africa, s. and e. Asia, Indonesia, Melanesia, New Guinea and Aust. One species, Rainbow Bee-eater *Merops ornatus*, in HANZAB region.

(5) **CORACIIDAE**: Rollers; 12 species in two genera: *Coracias* and *Eurystomus*; distributed Africa, s. and e. Asia, Indonesia, Philippines, New Guinea and Aust. One species, Dollarbird *Eurystomus orientalis*, breeds HANZAB region; another species vagrant.

(6) **BRACHYPTERACIIDAE**: Ground-rollers; five species in three genera: *Atelornis*, *Brachypteracias*, *Uratelornis*. Endemic to Madagascar.

(7) **LEPTOSOMIDAE**: Monotypic Cuckoo-roller *Leptosomus discolor*, endemic to Comoro Is.

(8) **TODIDAE**: Todies; five species in monotypic genera *Todus*; distributed Caribbean islands of Cuba, Hispaniola, Jamaica and Puerto Rico.

(9) **MOMOTIDAE**: Motmots; eight or nine species in six genera: *Aspatha*, *Baryphthengus*, *Electron*, *Eumomota*, *Hylomanes* and *Momotus*; distributed in Neotropics from Mexico to n. Argentina.

Taxonomy of this and related groups somewhat controversial. Monophyly of the Coraciiformes has been variously questioned and supported, and further study needed. Probably polyphyletic (BWP), and have been split into as many as six orders (Stresemann 1959). Current views tend to recognize one order, but treatment of subordinal taxa varies (see Forshaw & Cooper 1983; Sibley & Ahlquist 1990; Fry *et al.* 1992; BWP). Conventionally, all kingfishers have been treated as a single family, Alcedinidae, with three subfamilies (e.g. Fry 1980; Forshaw & Cooper 1983; Schodde & Mason 1997; Peters; BWP); here, these subfamilies elevated to familial level (after Sibley *et al.* 1988; Sibley & Ahlquist 1990; Fry *et al.* 1992; Christidis & Boles 1994). The division into three families supported by DNA–DNA hybridization (Sibley & Ahlquist 1990) and chromosome studies (see Christidis & Boles 1994), but this view has been challenged (Schodde & Mason 1997) since these three groups are also considered as monophyletic with respect to their nearest relatives within Coraciiformes (Sibley *et al.* 1988). The most closely related groups are Trogoniformes (trogons), Upupiformes (hoopoes) and Bucerotiformes (hornbills) (Fry *et al.* 1992). These, too, have also been classified as families within the Coraciiformes (e.g. Peters; BWP). Other distantly allied groups include Galbuliformes (jacamars and puffbirds) and Piciformes (toucans, barbets, honeyguides and woodpeckers) (Fry *et al.* 1992).

Coraciiforms are a diverse group, with few anatomical characters that apply to all families. Palate desmognathous. Feet vary; usually have three toes directed forward and a hallux, but inner front toe reduced or missing in some Alcedinidae, and outer toe reversible in Leptosomidae; forward toes often fused or partly fused. Basipterygoid process absent or rudimentary. Hypotarsus complex. Syrinx tracheo-bronchial. Plumage bright, mainly iridescent or pigmentary greens and blues. Seldom much variation in plumage between ages or sexes.

Not well represented in HANZAB region; four families recorded, with 12 non-vagrant species in seven genera. Extralimital families not considered further here.

Coraciiformes occur in most habitats, from arid and semi-arid zones to tropical rainforest and mangroves. Kingfishers, rollers and bee-eaters all require habitats with at least a few trees, from which to hunt. All breed within hollows in branches or trunks of trees, or in tunnels excavated into banks of earth or termitaria (both arboreal and terrestrial). In HANZAB region, some species (e.g. Laughing Kookaburra *Dacelo novaeguineae*) may benefit from partial clearance of wooded habitats, though most are adversely affected by removal of hollow-bearing trees; others (e.g. Azure Kingfisher *Alcedo azurea*) adversely affected by removal or degradation of vegetation surrounding wetlands.

Generalized predators of arthropods and small vertebrates. Most are sit-and-wait predators; most hunt by sallying. With few exceptions, kingfishers do not pursue prey, unlike bee-eaters, which do. Both kingfishers and bee-eaters regurgitate pellets of indigestible material, such as insect sclerites.

In kingfishers, bee-eaters and rollers, hatching of broods always staggered, with up to 1 week difference between oldest and youngest nestlings. Nestlings squabble for food brought by parents, and nestlings soon learn to move toward entrance of nest when they perceive parent entering with food. If two or more nestlings, eldest (unless replete) usually takes prominent position when food arrives. When food scarce, only older nestlings are fed and others starve and die. Just before fledging, to encourage young to leave nest adults may starve them for 1–2 days. Parents stay near fledgelings, calling and bringing food in response to begging of young (Fry 1980; Fry *et al.* 1992).

Worldwide, 11 species considered threatened. Overall, the major threatening process is the clearance of habitat, though several species are adversely affected by the introduction of predators, particularly the Common Myna *Acridotheres tristis* (Collar *et al.* 1994).

Given the great similarities between Halcyonidae and Alcedinidae in social organization and behaviour and most aspects of internal structure, they are summarized together below.

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## Family CORACIIDAE rollers

Medium to large birds, with large heads, broad bills and very short legs. Little variation in size from smallest to largest: Blue-throated Roller *Eurystomus gularis* c. 25 cm long and weighing 82–110 g; Rufous-crowned Roller *Coracias naevia* 35–40 cm long and weighing 125–163 g. Twelve species in two genera: (1) *Coracias* of s. and central Eurasia and Africa (eight species); and (2) *Eurystomus* of Africa, and s. and e. Asia to Aust. (four species) (Sibley & Monroe 1990; Fry *et al.* 1992). Greatest number of species (seven) in African Region. Two species recorded in HANZAB region.

Sexes similar in size. Neck short; 13–14 cervical vertebrae. Wings, long and paddle-shaped at tip (especially in *Eurystomus*); flight buoyant, with fairly rapid wing-beats in *Coracias*, and especially agile, with much wheeling and gliding, in *Eurystomus*. Ten primaries; p9 longest, p10 slightly shorter; diastataxic. Length of tail varies; long in some *Coracias*, short in *Eurystomus*; 12 rectrices. Oil-gland naked. Well-developed aftershafts. Bills stout, very broad at base in *Eurystomus*; slightly hooked at tip, with a few rictal bristles. Tarsus short; feet syndactylous, with all three toes fused to basal joint (about a third of length of middle toe). Long caeca. Carotids paired.

Plumage usually bright, with brilliant blues, especially on wings. Sexes similar. Irides, pale to dark brown. Bills, red or yellow in *Eurystomus*, blackish in *Coracias*. Adult post-breeding (pre-basic) moult complete, starting soon after breeding, interrupted in migratory species; partial pre-breeding (pre-alternate) moult in some species, involving varying amount of body-plumage and upperwing-coverts. Nestlings altricial; naked at hatching; do not develop natal down, moulting directly into juvenile plumage. Nestlings have characteristic spiny appearance, with feathers remaining ensheathed for some time.

Worldwide, variously sedentary, migratory or partly migratory. In HANZAB region, most Dollarbirds *Eurystomus orientalis* migrate N to spend winter in e. Indonesia and New Guinea. Feed mainly on insects and small vertebrates. Most are sit-and-wait predators. *Eurystomus* almost exclusively aerial insect feeders, catching prey by sallying. Insects taken in air sometimes consumed on the wing. Bills robust, stout, and very broad base in *Eurystomus*, well adapted for aerial feeding.

Mating system and social structure of most species not well known (Fry *et al.* 1992), and what is known of nesting behaviour mainly from studies of European Roller *Coracias garrulus* (Forshaw & Cooper 1993). Most species active, noisy, conspicuous and aggressive (e.g. Fry *et al.* 1988; Forshaw & Cooper 1993). Normally found in pairs for much of year, and in family parties after breeding (Campbell & Lack 1985). In Aust., Dollarbirds may gather in flocks of up to 50 or so before and during migration, when feeding on swarms of insects, or round fires when feeding on rising prey (e.g. Beehler *et al.* 1986; Forshaw & Cooper 1993; see Dollarbird). Pairs essentially monogamous, except for Bluebellied Roller *Coracias coranogaster*, which breeds co-operatively (Fry *et al.* 1992). Both sexes defend breeding territory, incubate and feed young. Fledgelings stay near parents and are fed by them (Jiang & Zhu 1983; Campbell & Lack 1985; Fry *et al.* 1988). Young dependent for several weeks after fledging (Fogden 1969). After parental feeding has stopped, young may stay with parents till departure for wintering grounds (Forshaw & Cooper 1993). Pairs breed solitarily, in territories. Likely that one or both members of a pair return each year to the same site (Forshaw & Cooper 1993). In Aust., same nesting trees or nearby sites often used each year (e.g. Irby 1933; Lord 1942; Forshaw & Cooper 1993; Mathews). Rollers aggressively territorial (Forshaw & Cooper 1993), more so than kingfishers (Fry *et al.* 1992). May

compete for perching as well as nesting sites and probably defend territories on wintering grounds (Campbell & Lack 1985). Defend nesting territory vigorously when it is first established but less so during incubation (Jiang & Zhu 1983). Sometimes parasitize nests of other species: Dollarbirds noted displacing White-bellied Woodpeckers *Dryocopus javensis* with nestlings (Noramly 1984). Rollers roost at night, spending much of day perched conspicuously on dead trees and roadside wires, intermittently hunting. Species of *Eurystomus* largely crepuscular, feeding mostly in late afternoon and early evening but also early in day (Campbell & Lack 1985). In Aust. region, some migration occurs at night.

Those species that migrate long distances start courting during spring migration and begin nesting soon after pairs arrive in breeding territories (Forshaw & Cooper 1993). Rollers advertise their territories with patrolling flights, which shows off their striking plumage, and with spectacular and aerial displays, from which they derive their name. Aerial displays are also characteristic of courtship. They are most conspicuous at the start of breeding and may be accompanied by almost continuous loud calling. **AERIAL DISPLAYS OF CORACIAS:** Bird ascends nearly vertically then performs a series of steep erratic undulations in flapping flight, with much tumbling, nose-diving and rolling from side to side; then bird tips forward and descends steeply with wings closed, pulling out near the ground and flying away or climbing again to repeat display. Sometimes perform rolling in fast flights low over vegetation. The rolling action is also used when chasing intruders from territories or when attacking potential predators (not found in ground-rollers Brachypteraciidae). Aerial displays of *Eurystomus* are swooping rather than tumbling and not so spectacular as those of *Coracias* (Campbell & Lack 1985; Fry *et al.* 1988, 1992; Forshaw & Cooper 1993).

Rollers call periodically several times an hour, perched or flying, often in response to each other; intense calls may be accompanied by lively bowing (Campbell & Lack 1985). Members of a pair perform bowing displays in which birds perch, face each other, point bills up, partly spread tails and intermittently open wings. Often, one bird flies to another perch, where bowing is repeated and tail-wagging may occur. Copulation may occur after aerial displays or, more often, after bowing display (Fry *et al.* 1988, 1992; Forshaw & Cooper 1993).

Breed solitarily. Nest in tree-hollows (invariably in Dollarbird), usually at considerable heights; also in hollow stumps, old walls, cliff-faces, and banks of earth or mud. Eggs usually laid on bare substrate or wood dust, but with no lining. Eggs sub-spherical, glossy, white. Clutch-size usually 3–5; 3–4 in Dollarbird. Eggs laid at intervals of 1 day. Incubation by both sexes; incubation period 18–20 days. Hatching asynchronous; oldest young can be up to 1 week older than youngest. Naked at hatching. Both sexes care for young. Fledging period extralimitally 28–30 days.

Four species considered threatened worldwide. All are adversely affected by destruction of habitat, and two by predation by rats, dogs or humans (Collar *et al.* 1994).

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*Coracias orientalis* Linnaeus, 1766, *Syst. Nat.*, ed. 12(1): 159 — 'India orientali' = Java.

Described by Linnaeus (1766) from 'India orientali' (Latin *orientalis*, eastern). This roller does occur in e. India, but the type-locality is now deemed to be the island of Java, in Indonesia.

**OTHER ENGLISH NAMES** Dollar Bird, Dollar-bird or Common Dollarbird; Roller; Australian, Broad-billed, Eastern, Eastern Broad-billed or Red-billed Roller; Rainbird or Starbird.

**POLYTYPIC** Subspecies *pacificus* (Latham, 1802), breeds n. and e. Aust., and Lesser Sunda and Tanimbar Is, W to Timor and Flores; migrant to n. New Guinea, Bismarck Arch., Sulawesi, Lombok and Sumbawa and Kangean Is. Nine extralimital subspecies recognized here: nominate *orientalis* breeds from s. Himalayas, n. India, Bangladesh, Burma to Indochina, Thailand, Malay Pen., Indonesia, also on Hainan; winters sw. India, Philippines, n. Sulawesi and Moluccas; *laetior*, Sharpe, 1890, s. India; *irisi*, Deraniyagala, 1950, Sri Lanka; *gigas*, Stresemann, 1913, s. Andaman Is; *calonyx*, Sharpe, 1890, breeds se. Russia, Korean Pen., Japan, central and e. China; winters in s. China, Indochina, Thailand, Malay Pen. and Sumatra W to Greater Sunda Is, occurring Taiwan as passage migrant; *oberholseri*, Junge, 1936, Simeulue I. off nw. Sumatra; *waigiouensis*, Elliot, 1871, W. Papuan Is, islands in Geelvink Bay, throughout New Guinea and islands E to D'Entrecasteaux and Louisiade Arch.; *crassirostris*, Sclater, 1869, Bismarck Arch.; *solomonensis*, Sharpe, 1890, Feni, Buku, Bougainville and Solomon Is.

**FIELD IDENTIFICATION** Length 26–29 cm; wingspan 55–65 cm; weight 125–143 g. Only roller in HANZAB region. Distinctive stocky bird with large rounded head, short thick neck, square-ended tail, long broad wings, and short but broad bill. Mostly greenish blue, grading to dark brown on head and neck, with purplish-blue throat-patch, dark purplish-blue on wing, and diagnostic and prominent pale patch (dollar-mark) in outerwing. Juvenile separable. Sexes alike (though see Plumages). Possibly some seasonal variation (see Plumages). **Adult** Head and neck, dark olive-brown with large dark purplish-blue patch on throat; grades to duller olive-brown, faintly suffused with dull blue-green, on saddle and to brighter blue-green on tertials, rump and uppertail-coverts. Uppertail, blue-green basally, grading through dark purplish-blue to black. Folded wing, blue-green, with broad contrasting panel of dark purplish-blue across folded secondaries, grading into blackish on tips of folded primaries, and with conspicuous narrow light-blue patch at base of folded primaries. In flight, show dark blue-green secondary coverts and dark purplish-blue secondaries and outerwing that grade to blackish on wing-tips, and with conspicuous light-blue rounded patch in outerwing. Underbody, dull greenish-blue. Undertail mostly dark blue. Underwing: coverts, dark green-blue, with dark purplish-blue remiges and conspicuous light-blue patches in primaries, as on upperwing. Bill, bright red or orange, with small black tip. Gape, red to

yellowish. Iris, dark brown. Narrow orbital ring, black-brown to dark red. Legs and feet, orange-red to red-brown. **Juvenile** Much duller than adult: head and neck darker brown; chin, whitish; throat-patch, green-blue (not violet); upperparts, duller and darker brown; and foreneck to upper breast finely scaled cream. Upperwing: remiges and outerwing darker, blackish, lacking purplish-blue tone of adult; and conspicuous pale patch in primaries slightly paler, narrower and shaped more like a bar than rounded patch of adult. Underwing appears paler and more uniform: remiges, dull green-blue grading to dark-grey on tips; pale patch in primaries is narrower and more like a bar, as on upperwing. Bare parts duller than adult: bill, black with yellow cutting edges and gape; and some pink markings on base of bill; iris, dark brown; orbital ring, dark grey; legs and feet vary from dusky orange to yellowish or grey-black. **Immature** As adult but easily separated in flight by retained juvenile remiges, rectrices and greater upperwing-coverts, which all look worn and contrast with fresher adult-like plumage of rest of body.

**Similar species** Normally unmistakable. At dusk, when Dollarbird often still active, and pale patches in primaries generally still obvious in flight, might be confused with Spotted *Eurostopodus argus* and Large-tailed *Caprimulgus macrurus* Nightjars, from which Dollarbird distinguished by distinctly bigger head and more thickset body, proportionately shorter tail,

shorter broader and less swept-back wings, and much more dashing, not erratic, flight; calls also very different.

Usually seen singly, in pairs or loose groups of about six; occasionally in larger groups of up to 50 or so on migration. Mainly inhabit open forests or woodlands; often seen in areas with tall dead trees and in vegetation near wetlands. Noisy and conspicuous; typically seen perched upright in open on high dead limbs over forest canopy or water, from where feed mainly by sallying for insects. Most active in late afternoon and at dusk, but also in morning and during and after rain. Perch for long periods, moving only head; oscillate tail back and forth before take-off or just after alighting. Flight varies from slow, leisurely and direct, with deep loose wing-beats, to swift and highly manoeuvrable, with much dipping and fluttering, when in pursuit of food. Flight-silhouette distinctive: thickset body with very short neck, large head and short stout bill, square-ended tail, and long broad wings with carpal joints well forward and wing-tips variously appearing pointed or rounded and 'fingered' according to mode of flight. Usual call loud rasping grating, and accelerating chatter *kek kek kek kek-kek-kek*; often given in flight or when perched high in exposed trees.

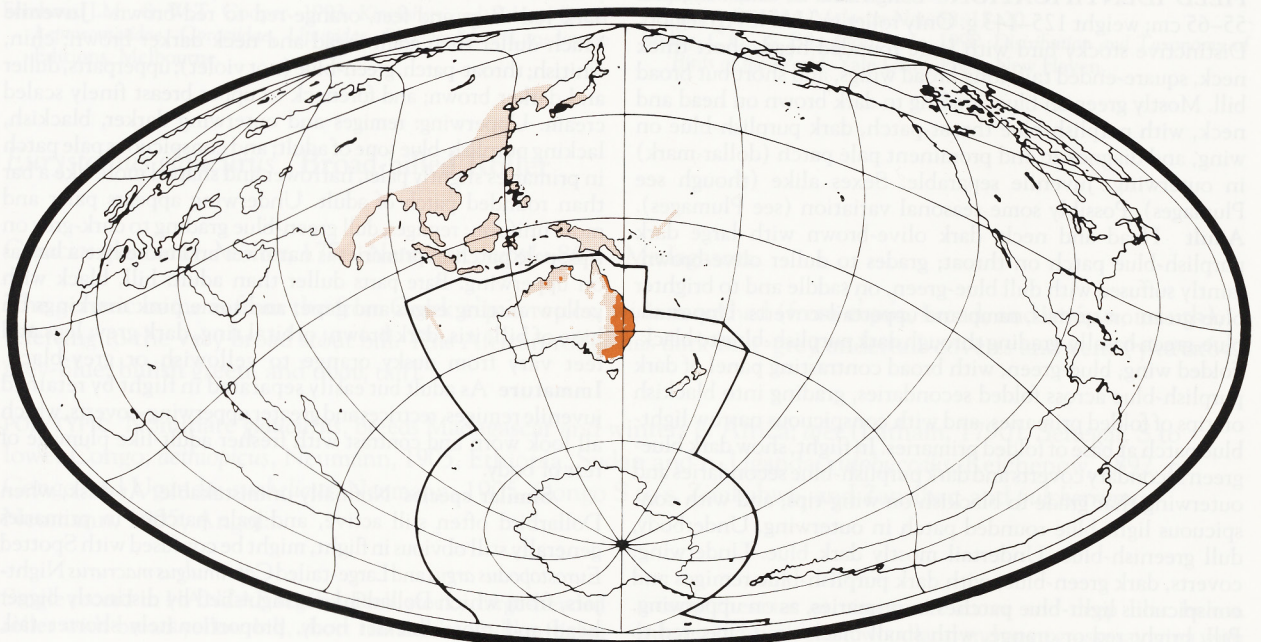
**HABITAT** Mostly open *Eucalyptus* forest or woodland (Humphries 1947; Crawford 1972; Schodde 1976; Jones 1986; Leach 1988; Gosper 1992; Forshaw & Cooper 1993; Leach & Watson 1994; Leishman 1994; Storr 19); sometimes in wet sclerophyll forest; rarely in more densely vegetated forests, such as rainforest or monsoon forest, and then mostly in clearings or at edges (Crawford 1972; Morris 1975; Disney & Stokes 1976; Gosper 1992; Forshaw & Cooper 1993; Woinarski 1993; Griffin 1995; Storr 11); recorded in *Eucalyptus* forest fringing rainforest (Gilbert 1935). Sometimes also occupy woodlands dominated by other species, such as Brigalow *Acacia harpophylla*, Pindan *A. tumida*, *Banksia*, paperbarks *Melaleuca* and casuarinas (Johnstone 1983; Leach 1988, cf. Leach & Watson 1994; P.J. Higgins). On Howards Pen., NT, recorded at densities of 0.24 birds/ha in open cyclone-damaged *Eucalyptus* woodland to 14 m tall dominated by Darwin Stringybark *E. tetradonta* and Darwin Woollybutt *E. miniata*, and 0.08 birds/ha in open low

paperbark woodland to 5 m dominated by *Melaleuca nervosa* and *M. symphocarpa* (Woinarski *et al.* 1988). Often in vegetation near wetlands, such as rivers, creeks, swamps, billabongs or lagoons (Hopkins 1948; Hindwood & McGill 1951; Hobbs 1961; Rowley 1961; McEvey 1965; Ford 1978; Johnstone 1983; Whitmore *et al.* 1983; Traill *et al.* 1996; Storr 7, 11; D.A. Curl), though on Gove Pen., NT, said to be found only rarely at edges of billabongs (Boekel 1980). Often in or at edge of suburbs, especially in gardens, streets or parks (D'Ombra 1933; MacKnight 1942; Hopkins 1948; Thompson 1978; Forshaw & Cooper 1993; P.J. Higgins). Also in pasture with scattered remnant trees, living or dead (Marshall 1935a,b; Clunie 1971; Leach 1988). Sometimes on low, vegetated, sand or coral cays (Smith 1987; McLean 1993); rarely among estuarine mangroves (Ewart 1973; Storr 11). Vagrants sometimes in orchards or vineyards (Sutton 1923; Brathwaite 1956; CSN 31). Not in plantations of pines *Pinus* (Disney & Stokes 1976).

Breed in hollows of trees, often near edges of wetlands; and often in eucalypts (Morse 1922; Mayo 1932; Shanks 1949; Hyett 1967; Roberts 1975; van Bennekom 1975; Costello 1981; Leach & Hines 1987; NRS; D.A. Curl). Sometimes in ringbarked trees in pastoral land (Marshall 1935a,b), or in gardens (Baldwin 1975). Occasionally nest in arboreal termitaria (Hindwood 1959; North; NRS).

Mostly feed aerially, taking insects in air above tree-tops or over water (Lord 1943; Sedgwick 1947; Attiwill 1963; Boekel 1980; Leishman 1994; NSW Bird Rep. 1994). Sometimes forage in gardens (MacKnight 1942) and above grassy parks or other clearings in suburbs (P.J. Higgins). Rarely feed at low levels (Wolstenholme 1922): once seen foraging close to ground during plague of grasshoppers (Lord 1956) and once said to have darted down among grass (Hogan 1925).

Recorded roosting on bare branches of Coolibahs *Eucalyptus microtheca* at edge of river (Boekel 1980); no other information. During daylight, spend much time perched on bare emergent branches at tops of tall trees, including exotic trees; often in or near clearings (e.g. Sedgwick 1947; Thomas 1947; Brathwaite 1956; van Tets 1965; Clunie 1971; Loftus 1976; Lashmar 1978; Longmore 1978; Leach & Hines 1987; Vic. Atlas). Often use



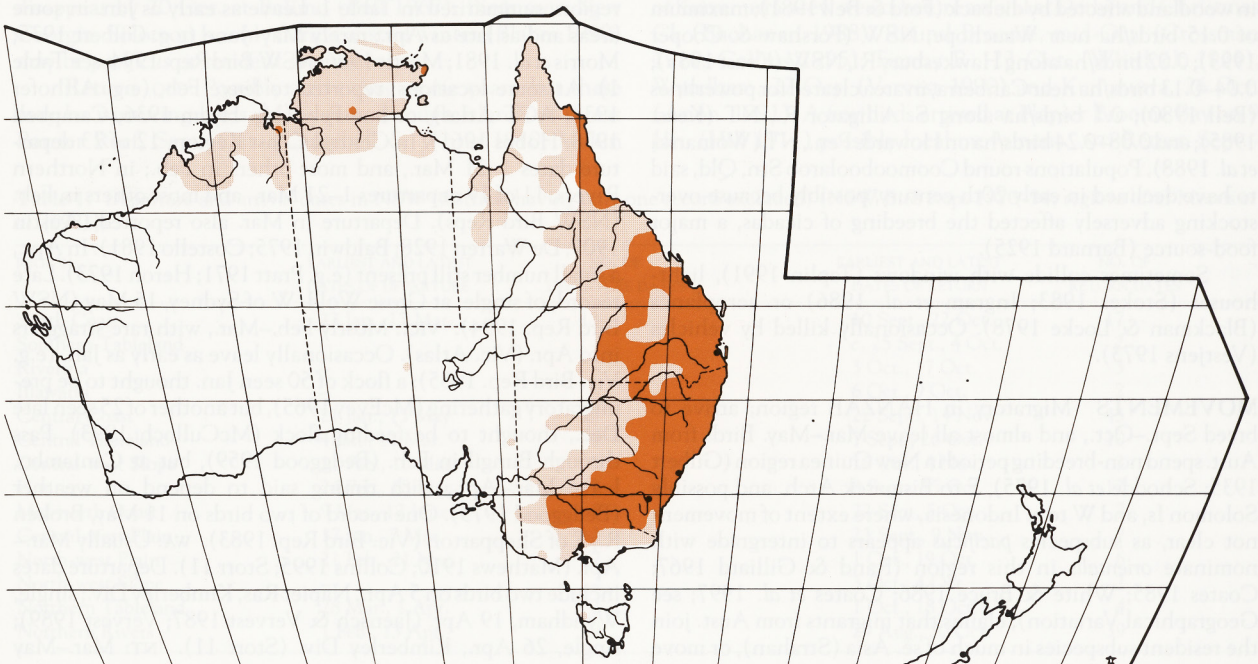
dead trees when available (Storr 1953; Barlow 1967; Boekel 1980; McCulloch 1985; D.A. Curl). Also, often use artificial perches, such as power poles, overhead wires or fences (Attiwill 1963; Barlow 1967; Clunie 1971; Lashmar 1978; Thompson 1978; Sokolowski 1979), on television antennae (Lashmar 1978), and once on wire rigging on sailing vessel (Hogan 1925). Occasionally perch on ground during warm weather (MacKnight 1942); once seen perched on rocks in dry creek bed (Hornsby 1982). Said to have often used dead ringbarked trees in pastoral areas for perching and nesting (Marshall 1935a,b).

**DISTRIBUTION AND POPULATION** Widespread in Asia, in sw. India, Sri Lanka and Andaman Is; widespread from n. India, Nepal and Bangladesh, E through Burma, Thailand and Indochina to e. China (from se. Szechwan and Ningsia E to Kwangtung and ne. Heilingkiang), Maritime Territories in se. Russia, Korean Pen. and s. Japan; and S through Philippines and Malay Pen. to Indonesia, New Guinea, Solomon Is and n. and e. Aust. and sometimes NZ; rarely to Micronesia (Ali & Ripley 1970; Glenister 1971; Gore & Won 1971; Wild Bird Soc. Japan 1982; Engbring 1983; de Schauensee 1984; Flint *et al.* 1984; Coates 1985; White & Bruce 1986; van Marle & Voous 1988; Dickinson *et al.* 1991; Lekagul & Round 1991; Forshaw & Cooper 1993).

**Aust. Qld** Scattered records in Gulf Country, from S of Mt Isa to se. Gulf of Carpentaria; widespread on C. York Pen. and islands in Torres Str. (Horton 1975; Kikkawa 1975; Draffan *et al.* 1983; Garnett & Bredl 1985; Beruldsen 1990; Aust. Atlas). Elsewhere, widespread E of line linking Princess Charlotte Bay, Richmond, Cunnamulla and Dirranbandi (Storr 19; Aust. Atlas). **NSW** Widespread in all coastal areas, W to North-West Plains, Central-West Slopes and Riverina Regions; farther W, more sparsely scattered in Central-West Plains and e. Upper Western Regions, W to Bourke and Cobar; still farther W, isolated records at Tibooburra and in sw. and s. Lower Western Region (Schmidt 1978; Cooper & McAllan 1995; Aust. Atlas; NSW Bird Reps). **Vic.** Mostly N of Great Divide; widespread along Murray R., from upstream of Corryong to near Piangil (and once near Robinvale), and S to near

Pyramid Hill and Eildon. Farther S, scattered records in Gippsland from Mallacoota W to Maffra; a few records in Central District, from near Jindivick N to Marysville and Kinglake and W to e. suburbs of Melbourne. Farther W, isolated records at You Yangs, Lorne, Lismore and Tower Hill near Warrnambool; also singles at Kaniva and Dimboola (Vic. Atlas; Vic. Bird Reps). **Tas.** Single specimen, near Crotty, 1918 (Lord 1918); single, King I., Mar.–Apr. 1985 (Tas. Bird Rep. 15); single specimen, Cygnet, 22 May 1992 (Tas. Bird Rep. 22). Unconfirmed report, nw. Tas., c. 1912 (Lord 1918). **SA** Rare visitor (singles unless stated): Two, including one specimen, Mylor, 24 Jan. 1918 (Zeit 1918; Sutton 1923); two, Netherby, c. early 1921 (Anon. 1921); Witchelina Stn, c. 40 km W of Farina, summer 1925 (Sutton 1927); specimen, Mt Nor'-West Stn, 20 Feb. 1927, 10 Jan. 1967 (Sutton 1927; SA Bird Rep. 1966–67); Fulham, 1934 (Condon 1969); Moyhall, c. 19 km SW of Naracoorte, 2 May 1963 (Attiwill 1963); Eden Valley, 15 km S of Angastown, Barossa Valley, 28 Dec. 1975 (Loftus 1976); Antechamber Bay, Kangaroo I., 21 Apr. to 14 May 1978 (Lashmar 1978); Mabel Ck Cattle Stn, near Coober Pedy, 11 Nov. 1978 (Aust. Atlas); Leigh Ck, late Feb. to 7 Mar. 1980 (Jaensch & Joseph 1980; Aust. Atlas; SA Bird Rep. 1977–81); Wadnaminga Stn, 24 Apr. 1981 (Aust. Atlas); near Clarendon, s. Mt Lofty Ras, 8 Jan. 1982 (Hornsby 1982); Brindana Gorge, Hamilton Ck, n. Flinders Ras, 3 Feb. 1982 (Hornsby 1982); Frome Downs Stn, Feb. 1985 (Ragless 1988); Innamincka, before 1986 (Badman 1989). **WA** Few scattered records in Pilbara Region, with six records since 1950s: single, Winning, June 1953; two, Mt Edgar, Dec. 1960; single, Shay Gap, Dec. 1972; single, Pt Samson, late Nov. to early Dec. 1977; single, Dampier, 16–19 Dec. 1978; two, Karratha, 8–10 Jan. 1979 (Sokolowski 1979; Storr 16; Aust. Atlas). Widespread in Kimberley Div., mostly in S and E, bounded by line joining Shakespeare Hill, Broome and Denison Plains (Storr 11; Aust. Atlas); rarely farther N, at Port Warrender and Mitchell Plateau (Aust. Atlas). **NT** Widespread in Top End, S to c. 16°S (Storr 7; Aust. Atlas). Also on offshore islands, such as Melville I., South Goulburn I., Groote Eylandt and Sir Edward Pellew Grp.

**NZ** Straggler. **NI** Scattered records from Parengarenga



Harbour and Te Kao S to Parihaka and Waiwakaio R. in Taranaki and Havelock North (Stidolph 1927; Watt 1947; Brathwaite 1956; Oliver). Records since 1950, all singles, include: Havelock North, 25–29 Apr. 1956 (Brathwaite 1956); Tikitiki, 20 May 1956 (CSN 7); Waihue Valley, N of Dargaville, 3–16 May 1971 (Clunie 1971). **SI** Scattered records, mostly in N, round Nelson and Blenheim, and in West Coast, from Brunner S to Mikonui R (Stidolph 1927; Moncrieff 1938; Oliver; CSN 31); isolated record in Southland (Barlow 1967). Records since 1950, all singles, include: Fortrose, 29–30 Mar. 1967 (Barlow 1967); Westhaven Inlet, 8 Mar. 1983 (CSN 31); Blenheim, 31 Mar. 1983 (CSN 31); Hokitika, 15 Apr. 1995 (CSN 43).

**Lord Howe I.** Vagrant. All singles unless stated. Specimens, before Feb. 1882 (Hindwood 1940); specimen, Oct. 1892 (Hindwood 1940); specimen, 1903 (Bassett Hull 1909; Hindwood 1940); two, May–June 1944 (Hindwood & Cunningham 1950). Said to have been recorded 'several times' between 1940 and 1950 (Hindwood & Cunningham 1950).

**Norfolk I.** Said to be rare visitor; no recent records (Bassett Hull 1909; Schodde *et al.* 1983; Hermes 1985).

**Christmas I.** Two records: single, Jan. 1963 (Pearson 1966; Stokes 1988); single, 3 Jan. 1997 (P.S. Lansley).

**Cocos-Keeling Is** Single, Home I., 7 Dec. 1995 (Anon. 1996).

**Breeding** Few scattered records in e. Kimberley Div. and Top End, at Kakadu NP, Kununurra, Katherine, Tindal and C. Arnhem. In e. Aust., widespread in much of range, from C. Melville NP S to n. slopes of Great Divide in North-Central Vic., and W to near Winton, Alpha, Morven and St George in Qld; Mungindi, Warrumbungle NP, Forbes, Yanco and Deniliquin in NSW; and Kerang and Bridgewater in Vic. (Aust. Atlas; NRS; D.A. Curl).

**Irruptions** Several specimens collected in w. NZ (near Manukau Harbour; Taranaki; Westland) in 1881 (Oliver). Multiple records in SA in 1978 and 1982 (see above).

**Populations** Recorded at densities of: 0.1 birds/ha along Lockhart R., Qld (Keast 1985); near Armidale, NSW, 0.1 birds/ha in *Eucalyptus* woodland (Ford *et al.* 1985) and 0.14 birds/ha in woodland affected by dieback (Ford & Bell 1981); maximum of 0.15 birds/ha near Wauchope, NSW (Forshaw & Cooper 1993); 0.02 birds/ha along Hawkesbury R., NSW (Keast 1985); 0.04–0.13 birds/ha near Canberra, in area cleared for powerlines (Bell 1980); 0.1 birds/ha along S. Alligator R., NT (Keast 1985); and 0.08–0.24 birds/ha on Howards Pen., NT (Woinarski *et al.* 1988). Populations round Coomoooolaroo Stn, Qld, said to have declined in early 20th century, possibly because overstocking adversely affected the breeding of cicadas, a major food-source (Barnard 1925).

Sometimes collide with windows (Taplin 1991), light-houses (Stokes 1983; Ingram *et al.* 1986) or aeroplanes (Blackman & Locke 1978). Occasionally killed by vehicles (Vestjens 1973).

**MOVEMENTS** Migratory in HANZAB region; arrive to breed Sept.–Oct., and almost all leave Mar.–May. Birds from Aust. spend non-breeding period in New Guinea region (Gilbert 1935; Schodde *et al.* 1975), E to Bismarck Arch. and possibly Solomon Is, and W to e. Indonesia, where extent of movement not clear, as subspecies *pacificus* appears to intergrade with nominate *orientalis* in this region (Rand & Gilliard 1967; Coates 1985; White & Bruce 1986; Coates *et al.* 1997; see Geographical Variation); claims that migrants from Aust. join the resident subspecies in much of se. Asia (Strahan), or move

as far as China and Japan (Collins 1995) unfounded. Appear to migrate directly across Coral Sea, as occur on Great Barrier Reef islands and there are few records in Torres Str. during passage (see below). Scattered records in NZ, from Nov. to May (see Distribution), said to be of immatures or juveniles (NZRD); since 1950 most records Mar.–May (see Distribution). Often migrate at night (e.g. Irby 1933; Makin 1961; Blackman & Locke 1978; Forshaw & Cooper 1993), but possibly sometimes during day (Draffan *et al.* 1983); seem to leave in evening (Gilbert 1935) and to arrive in areas in early morning (Gilbert 1935) or overnight (Boekel 1980). Adults appear to migrate soon after young fledge, and young follow later (Aust. Atlas).

**Departure** In n. and s. Aust., usually leave between Feb. and Apr., commonly Mar.–Apr.; a few recorded leaving May. QLD: Very occasionally leave in late Jan. (e.g. Lord 1939). In SE, from mid-Feb., begin to gather into larger groups (Lord 1943; Templeton 1992); leave se. interior in late Feb. (Storr 19), and by early Mar., migration in full swing, with birds leaving se. coast and beginning to pass through islands off ne. coast and Torres Str. (Hogan 1925; Kinghorn 1928; Serventy 1959; Roberts & Ingram 1976; Drake 1979; Ingram *et al.* 1986; McLean 1996; Storr 19). Most leave Mar., especially from SE, but also from some sites in N (Cohn 1925; Chisholm 1945; Lord 1956; Morgan 1972; Garnett & Cox 1983; Leach & Hines 1987; Dawson *et al.* 1991; Templeton 1992; Storr 19). At Richmond, nw. Qld, recorded till Mar. or first week of Apr.; once as late as 20 Apr. (Berney 1903, 1904, 1906). N of Rockhampton some birds remain till mid- to late Apr. (Bravery 1970; Gill 1970; Domm & Recher 1973; Longmore 1978; Garnett & Bredl 1985; Wieneke 1988; Storr 19; Qld Bird Rep. 1987); at C. York, large groups noted passing through in Apr. (Beruldsen 1990). In SE, some late records in Apr. (Roberts 1979; Qld Bird Rep. 1990) and once near Brisbane, 27 May (Qld Bird Rep. 1989). In May, up to 12 seen at mouth of Batavia R., C. York Pen., in 1921, and recorded in Torres Str. and lowlands of Gulf of Carpentaria (Tindale 1925; Draffan *et al.* 1983; Storr 19). One, assumed to be migrating N, hit by aircraft at night at 2600 m asl, near Binbee, mid-e. Qld, 23 Mar. 1977 (Blackman & Locke 1978). NSW: Range of departure dates, by region, summarized in Table 1. Leave as early as Jan. in some areas and as late as Apr.; rarely May–June (e.g. Gilbert 1935; Morris *et al.* 1981; Morris 1986; NSW Bird Rep. 1994; see Table 1). At some locations, reported to leave Feb. (e.g. Althofer 1934; ACT Atlas), or late Feb. (e.g. Hyem 1936; Campbell 1938; Hobbs 1961). In Central Coast Region, 12 of 23 departure dates 1–21 Mar., and most others in Feb.; in Northern Rivers, 11 of 19 departures 1–21 Mar., and most others in Feb. (NSW Bird Reps). Departure in Mar. also reported (Austin 1907; De Warren 1928; Baldwin 1975; Costello 1981). In Apr., a small number still present (e.g. Pratt 1971; Heron 1973). Late record, of single, at Grose Wold, W of Sydney, 15 May (NSW Bird Rep. 1994). VIC.: Mostly Feb.–Mar., with rare stragglers into Apr. (Vic. Atlas). Occasionally leave as early as Jan. (e.g. Vic. Bird Rep. 1985); a flock of 50 seen Jan. thought to be premigratory gathering (McEvey 1965), but another of 25 seen late Dec., thought to be feeding flock (McCulloch 1993). Pass through Bungil in Feb. (Bedgood 1959), but at Caniambo, leave Mar.–Apr., with timing said to depend on weather (Bedgood 1973). One record of two birds on 11 May, Broken R., E of Shepparton (Vic. Bird Rep. 1983). WA: Usually Mar.–Apr. (Mathews 1910; Collins 1995; Storr 11). Departure dates include two birds on 5 Apr., Napier Ras, Kimberley Div.; single, Wyndham, 19 Apr. (Jaensch & Vervest 1987; Vervest 1989); single, 26 Apr., Kimberley Div. (Storr 11). NT: Mar.–May



(Sedgwick 1947; Storr 7); usually Apr. in Top End (H.A.F. Thompson & D.K. Goodfellow); often by Mar. (Schodde 1976; McKean 1985). Reported to form flocks at Victoria R. Downs Stn before migration on 2 and 23 Feb., with final departure in Apr. (Boekel 1976). Leave Groote Eylandt, Mar.–Apr. (Haselgrove 1975); Keep River NP, Mar. (McKean 1985); McArthur R. area, Mar. (Schodde 1976); last record at Gove Pen., 18 Apr. (Boekel 1980). In Darwin, usually late Apr., once 25 May (n=4), (Crawford 1972).

Records in Tas. and SA in Mar.–May (see Distribution), may be examples of reverse migration.

**Non-breeding** Few in Aust. May–Aug. (e.g. Gilbert 1935; Aust. Atlas). Odd pairs or birds appear to remain n. Qld (Broadbent 1910; Enright 1940; Hopkins 1948; Ingram 1976; Templeton 1992; P.S. Lansley & C.J. Judkins); late records also elsewhere, including NSW (e.g. NSW Bird Rep. 1994) and WA (Shilling 1948; Sokolowski 1979; Storr 16). However, at some locations in n. Aust. may occur year-round, e.g. at Iron Ra., some possibly resident year-round (Forshaw & Muller 1978); and at Adelaide R., NT, small numbers noted all year (Rhodes 1944). Some Qld records in Aug. may be of early arrivals.

Non-breeding distribution of Aust. migrants not well known; recorded e. Indonesia W to Kangean I. and Lombok, N to Halmahera and Morotai, E to New Guinea region including Bismarck Arch. (Coates *et al.* 1997). Migrant *pacificus* from Aust. winter mainly in n. New Guinea and appear to leapfrog resident populations of *waigiouensis* in s. New Guinea; two specimens from Meren Glacier, Irian Jaya, at 4500 m asl, thought to be *pacificus* (Schodde *et al.* 1975; Coates 1985). Birds seen n. Irian Jaya (Biak I., Nabire R., Boemi R.) in early Apr. thought to be Aust. migrants as none present in Mar. and arrival coincided with arrival of other austral migrants (Melville 1980). In PNG, *pacificus* occurs early Mar.–Nov. (Coates 1985); Dollarbirds seen to move in unexpected directions in s. lowlands, i.e. flying E and SE over lowland forest near Port Moresby, mid-Sept. to early Nov., and flying NE over Amazon Bay, mid-Sept. (Coates 1985), but such movements not expressly attributed to *pacificus*. In SE, near Brown R., seen only Apr.–Nov. and assumed to be migrants from Aust. (Bell 1982). Almost all disappear by 20 Oct. at Balimo (Bell 1967). Birds seen New Georgia, Solomon Is, only during austral winter (Blaber 1990) may be *pacificus* or resident *solomonensis*.

**Return** QLD: Possibly arrive Aug. some years, but these may be wintering birds. Many pass through islands of Great Barrier Reef, Sept.–Oct. (Campbell & White 1910; Makin

1961; Domm & Recher 1973; Smith 1987; McLean 1993). S. passage through Torres Str., Oct.–Nov. (Draffan *et al.* 1983; Ingram *et al.* 1986). Most birds arrive late Sept. to early Oct. (e.g. Vernon 1968); in lowlands of Gulf of Carpentaria, late Oct.–Nov. (Storr 19). Usually arrive Sept., and *contra* Storr 19, in both N (e.g. Broadbent 1910; Longmore 1978; Garnett & Cox 1983; Garnett & Bredl 1985; Wieneke 1988) and S (e.g. Cohn 1926; Morgan 1972; Roberts & Ingram 1976; Leach & Hines 1987; Dawson *et al.* 1991; Qld Bird Reps 1989, 1991). In se. Qld, long-term data from Murphys Ck show that dates of return vary from year to year, from 27 Sept. to 8 Oct. (Lord 1956), though average time of arrival also said to be 24 Sept. (Lord 1943); at Urangan, over 14 years, date of return varied from 7 to 30 Sept., with mean 21 Sept. (Christensen 1954). Return may be as late as Oct., in both N (e.g. Berney 1903; Barnard 1904; Barnard 1911, 1926; Campbell & Barnard 1917; Bravery 1970; Gill 1970; Griffin 1995) and S (e.g. Cohn 1925; Chisholm 1936; Sedgwick 1948; Vernon 1968; Roberts & Ingram 1976; Roberts 1979; Dawson *et al.* 1991). Rarely, return recorded as late as Dec. (Griffin 1995). NSW: Range of arrival dates by region summarized in Table 1. Most arrive Oct. but some as early as Sept. and some as late as Nov. (Gilbert 1935; Morris *et al.* 1981; Table 1). Rarely, return late Aug. (e.g. NSW Bird Rep. 1976); did so once in Casino area, though usually arrived Sept. or, rarely, Oct. (Irby 1933). In Central Coast Region, 72% (n=43) of arrivals in Oct. and 26% in Sept. (NSW Bird Reps). Arrival in late Sept. at some sites (Campbell 1938; Pratt 1972; Baldwin 1975; Costello 1981). Arrive Oct. across wide range (Austin 1907; Sullivan 1931; Althofer 1934; Hyem 1936; Hobbs 1961; Heron 1973; Marchant 1981; Morris 1986); consistently arrive ACT first or second week of Oct. (ACT Atlas). VIC.: Mostly Oct.–Nov. but occasionally Sept. and Dec. (e.g. Ford 1909; Howe 1928; Shanks 1949; Bedgood 1973; Vic. Bird Reps; Vic. Atlas). Pass through Bungil in Sept. (Bedgood 1959). WA: Most appear to return Sept.–Oct.; in n. Kimberley, 25 Sept. (Aumann 1991), possibly sometimes Aug. (Officer 1974); in Kimberley, mid-Sept.–Oct. (Storr 11) with early records in early Sept., e.g. one at Parys Ck, 9 Sept. (Mathews 1909a), Mitchell Falls, 4 Sept. (Anon. 1993). Noted arriving N of Kununurra a few weeks before arrival at Derby and Christmas Ck (Buchanan 1988). Round Broome, mid-Oct. (Crossman 1910; Collins 1995); Fitzroy R., 23 Oct. (Whitlock 1925), Wyndham, 22 Oct. (Vervest 1990) and Kununurra, 26 Oct. (Anon. 1991). A few birds arrived at Napier Broome Bay on 9 Jan. (Hill 1911) possibly local movement. NT: Return Sept.–

**Table 1.** Departure and arrival dates in NSW (districts having only one record excluded) (NSW Bird Reps 1970–94; regions after Morris *et al.* [1981]).

REGION	EARLIEST AND LATEST	NO. OF	EARLIEST AND LATEST	NO. OF
	DATES OF DEPARTURE		DATES OF RETURN	
South Coast	23 Jan., 17 Mar.	13	10 Sept., 22 Oct.	17
Southern Tableland	–	–	c. 25 Sept., 4 Oct.	2
Riverina	–	–	3 Oct., 17 Oct.	3
Illawarra	–	–	6 Oct., 9 Oct.	2
Central Coast	21 Jan., 15 May	23	22 Sept., 14 Nov.	43
Central Tableland	4 Jan., 11 Mar.	8	7 Sept., 26 Oct.	10
Central-west Slope	21 Feb., 10 Mar.	3	16 Oct., 4 Nov.	3
Hunter	24 Feb., 18 Mar.	9	8 Sept., 15 Oct.	12
Mid-north Coast	9 Mar., 12 June	5	22 Sept., 5 Oct.	7
Central-west Plain	17 Jan., 7 Mar.	2	23 Sept., 9 Nov.	7
North-west Plain	21 Feb., 21 Mar.	7	1 Oct., 19 Oct.	6
North-west Slope	–	–	3 Oct., 4 Oct.	2
Northern Tableland	28 Mar., 1 Apr.	2	1 Oct., 18 Oct.	4
Northern Rivers	1 Feb., 13 Apr.	19	29 Aug., 30 Oct.	39

Nov. (Storr 7). Generally Sept. in Top End (Boekel 1980; McKean 1985; H.A.F. Thompson & D.K. Goodfellow); noted King R., 28 Sept. (White 1917). In Darwin, return 21 Aug. to 23 Sept. (n=5 years) (Crawford 1972); in Kakadu NP, Sept., and in 1988 first sighted 1 Sept., with many more from 12 Sept. (D.A. Curl). At Mandorah, one on 7 Oct. (Vervest 1990). Records of later arrivals: 15 Oct. in NT (Barnard 1914); once on 20 Oct. at Gove Pen. (Boekel 1976); in Nov. at Groote Eylandt (Haselgrove 1975).

**Breeding** No information on movements during breeding season.

**Banding** Of 165 banded in Aust. and New Guinea, 1953–96, 4 recoveries (3.0%): 1 (20%) <10 km from banding site; 2 (40%), 10–49 km; remaining bird was handled by two rehabilitation groups and distance of natural movement, if any, unclear. Longest lived, 19 months (ABBS).

**FOOD** Mainly flying insects, taken on the wing, particularly beetles, wasps, ants, cicadas, and grasshoppers. General comments in Fry *et al.* (1992) and Forshaw & Cooper (1993) may be at least partly based on extralimital data. **Behaviour** Mostly feed aerially; usually above tree-tops, in clearings, or above water, such as creeks and rivers; sometimes very high (Lord 1943; Sedgwick 1947; Attiwill 1963; Boekel 1980; Leishman 1994); at Victoria R. Downs Stn, observed to feed from a few metres above ground to great heights (Boekel 1980). Feed singly, in pairs, or in loose groups (Wolstenholme 1922; Morris 1975; Boekel 1980; Aumann 1991; Fry *et al.* 1992; Forshaw & Cooper 1993); sometimes congregate to feed at concentrated sources of food, in groups of up to 40 birds (Lord 1943; Boekel 1980; Fry *et al.* 1992; North; NSW Bird Reps 1972, 1994; see Social Organization). In Kakadu NP, NT, not seen to flock to grass-fires or the like (D.A. Curl), though said to do so elsewhere (NZRD). Reported to feed in loose association with White-throated Needletails *Hirundapus caudacutus* (North), Black-faced Woodswallows *Artamus cinereus* and Willie Wagtails *Rhipidura leucophrys* (Boekel 1980). Mainly feed in late afternoon and evening, till after sunset (Lord 1943, 1956; Storr 1953; Attiwill 1963; Fry *et al.* 1992; Forshaw & Cooper 1993; Gould; North; Mathews); also said to be active about sunrise (Gould), and seen hunting during hottest part of day in mid-summer (Forshaw & Cooper 1993). When feeding young, may feed more actively earlier in day (van Tets 1965). One immature was at usual feeding perches 10:00–14:00 and 16:00–18:00, heavy rain making no difference to routine (Clunie 1971). Most foraging by sally-striking prey in air. Spend much of day sitting on elevated perches (see Habitat), from where actively hunt by sallying (e.g. Wolstenholme 1922; Lord 1943, 1956; Sedgwick 1947; Brathwaite 1956; Attiwill 1963; van Tets 1965; Barlow 1967; Clunie 1971; Morris 1975; Fry *et al.* 1992; Forshaw & Cooper 1993; Leishman 1994; North; Mathews); often have favoured feeding perches (Clunie 1971; Storr 1953; Fry *et al.* 1992). When sallying for insects, manoeuvre with some speed and dexterity (Fry *et al.* 1992); when prey caught, usually return to same branch from which sally launched (Fry *et al.* 1992; Gould). Also observed flying swiftly, with strong falcon-like flapping and long fast glides, quartering a piece of ground where insects are swarming; seen to skim close to ground to catch grasshoppers in plague proportions (Lord 1956); and to sally-pounce on small lizards and frogs (Forshaw & Cooper 1993). Large insects brought back to perch to be eaten; often break off and drop elytra of beetles before eating item (Fry *et al.* 1992). Birds seen drinking from billabongs in Top End (D.A. Curl). Possibly swallow pebbles to aid digestion; in ACT, two chicks

found with pebbles in stomachs, and a thumbnail-sized piece of broken glass was found in one (Forshaw & Cooper 1993). For some extralimital information, see Dement'ev & Gladkov (1951), Smythies (1960), Ali & Ripley (1970), Coates (1985), and Fry *et al.* (1992).

No detailed studies. **INSECTS**<sup>4,6,10,17</sup>: Coleoptera: beetles<sup>8,9,11,12,16,17,18,19</sup>; Buprestidae<sup>13,18</sup>; *Stigmodera*<sup>5</sup>; Carabidae: *Calosoma schayeri*<sup>18</sup>; Cerambycidae<sup>18</sup>; Dytiscidae<sup>13</sup>; Chrysomelidae: *Paropsis*<sup>18,20</sup>; Curculionidae<sup>20</sup>; Mordellidae: *Mordella*<sup>18</sup>; Scarabaeidae<sup>1,20</sup>; *Anoplognathus*<sup>18,20</sup>; *Eupaecila australasiae*<sup>18</sup>; Hemiptera<sup>1,20</sup>; Cicadidae<sup>17,21,22</sup>; *Psaltoda*<sup>18</sup>; Cydinidae<sup>20</sup>; Pentatomidae<sup>20</sup>; Hymenoptera<sup>4,20</sup>; Apidae<sup>20</sup>; Formicidae<sup>12,14,18,20</sup>; *Oecophylla smaragdina*<sup>3,5</sup>; Ichneumonidae<sup>20</sup>; Sphicidae: *Bembix*<sup>18</sup>; Tiphidae<sup>18</sup>; Vespidae: *Polistes*<sup>20</sup>; Isoptera: termites<sup>7,12</sup>; Lepidoptera: moths<sup>12</sup>; Noctuidae<sup>18</sup>; Odonata<sup>22</sup>; Orthoptera: grasshoppers<sup>6</sup>; Gryllotalpidae: *Gryllotalpa*<sup>20</sup>. **AMPHIBIANS**: Frog<sup>15</sup>. **REPTILES**: Lizards<sup>15</sup>. **Other matter** Pebbles<sup>15</sup>. (REFERENCES: Mathews<sup>1</sup> 1909a, <sup>2</sup> 1909b; <sup>3</sup> Hill 1911; <sup>4</sup> White 1917; <sup>5</sup> Tindale 1925; Lord<sup>6</sup> 1956, <sup>7</sup> 1961; <sup>8</sup> Thomson 1935; <sup>9</sup> MacKnight 1942; <sup>10</sup> Attiwill 1963; Rose<sup>11</sup> 1973, <sup>12</sup> 1997; <sup>13</sup> Frith & Calaby 1974; <sup>14</sup> Boekel 1980; <sup>15</sup> Forshaw & Cooper 1993; <sup>16</sup> Gould; <sup>17</sup> North; <sup>18</sup> Cleland; <sup>19</sup> Hall; <sup>20</sup> FAB; <sup>21</sup> Strahan; <sup>22</sup> T. Saunders.)

**Young** One fledgeling fed on large beetles (Scarabaeidae: *Anoplognathus*) by both parents (van Tets 1965); another on cicadas and large beetles (NRS).

**SOCIAL ORGANIZATION** No studies within HANZAB region, but much anecdotal information; extralimital studies include Dement'ev & Gladkov (1951), Fogden (1969), and work on territories by Jiang & Zhu (1983); some general comments in Coates (1985), Fry *et al.* (1992) and Forshaw & Cooper (1993) may be based on extralimital material. Generally, said to live solitarily or in pairs (Fry *et al.* 1992; Forshaw & Cooper 1993). In Aust., usually seen singly or in twos (e.g. Lord 1943; Thomas 1947; Boekel 1980; Garnett & Bredl 1985; Aumann 1991; Gould; North; Storr 11) or, for short time at end of breeding, as family group (van Tets 1965; Courtney 1967; Forshaw & Cooper 1993); one party of two juveniles and three adults possibly made up of two families (Courtney 1967); sometimes seen in small parties of up to eight (Wolstenholme 1922; MacKnight 1942; Aumann 1991; McCulloch 1993; Storr 11). Can form flocks before or during migration (see Movements). In Aust., sightings round time of departure include: large numbers, apparently gathering into a flock, late Jan. (Passmore 1982); flock of c. 50, in autumn (McEvey 1965); large flock, mid-Feb. (Lord 1943); in Newcastle area, small flocks or pairs (Morris 1975). During migration seen travelling: in ones and twos (e.g. Campbell & White 1910; Hogan 1925; Draffan *et al.* 1983; Griffin 1995); in small parties of up to 14 (Campbell & White 1910; Gilbert 1935; Griffin 1995; Qld Bird Rep. 1989); when moving through C. York Pen. in Apr., congregated in evening and left in widely scattered groups (Beruldsen 1990). Possible that adults leave breeding grounds first and young follow later (Forshaw & Cooper 1993; Aust Atlas). On return to Aust., 50 seen together on dead limbs, then gradually dispersed over a few days (North); 2–5 seen, apparently migrating (Gilbert 1935); numbers of birds arrived overnight but migratory flocks not seen (Boekel 1980); 9–14 seen moving together (NSW Bird Rep. 1994; Qld Bird Rep. 1990). In Aust., up to 40 or so congregate to feed (Lord 1943; North; NSW Bird Reps 1972, 1994); along Wickham R., nw. Aust., in Feb., loose gathering of c. 17–35 seen in flight chasing insects, and once they roosted together (Boekel 1980); in Vic., in late Dec., flocks of up to 25 seen high in sky, possibly feeding

on insects (McCulloch 1993). Said that non-breeding birds often congregate to feed in evening, during and after rain or in disturbed weather (Fry *et al.* 1992). Congregations seen feeding alongside White-throated Needletails, Black-faced Woodswallows and Willie Wagtails (Boekel 1980; North). In NZ, seen singly or in small flocks; usually subadults (e.g. Stidolph 1927; Barlow 1967; Clunie 1971; Oliver).

**Bonds** Thought to be monogamous. In Aust., members of pair do not appear to arrive together: one bird (possibly male) arrives in nesting territory and mate appears a few days, rarely up to 1 week, later (Forshaw & Cooper 1993). Said to start breeding as soon as arrive (Campbell); after pair selects suitable nesting site, it may be another month before female lays (North). **Parental care** Both members of pair feed nestlings and fledgelings (e.g. Irby 1933; van Tets 1965; van Bennekom 1975; Forshaw & Cooper 1993; NRS). Possibly fledgelings not fed for long, as young birds seen feeding for themselves in mid-summer (Forshaw & Cooper 1993); juvenile with orange bill seen begging from pair in early Jan. (D.A. Curl). Said that adults leave soon after young fledge (Aust. Atlas); also, in se. Aust., that young seem to stay for a few days after adults have left (Forshaw & Cooper 1993). Extraliminally, both members of pair incubate (Forshaw & Cooper 1993).

**Breeding dispersion** Nest solitarily, at Hastings R., NSW; up to three pairs in 40 ha (Forshaw & Cooper 1993); in ACT, three territories per 10 ha (Lenz 1990). Same nest-tree or nearby site used each year (Irby 1933; Lord 1933, 1942, 1956; Shanks 1949; Forshaw & Cooper 1993; North; Mathews; NRS; D.A. Curl), but not known if by same birds. Two territories were occupied annually for at least 10 years, but not known if by same birds (Forshaw & Cooper 1993). **Territories** Breeding territories defended from time both members of pair arrive in nesting area (Forshaw & Cooper 1993). Pair appears to inhabit definite area round nest, excluding other Dollarbirds, and commonly seen escorting intruders to boundaries of territories (Mathews 1909a; Shanks 1949). At least sometimes, exclude many other large species of birds, such as Pied Currawongs *Strepera graculina* and Laughing Kookaburra *Dacelo novaeguineae* (Forshaw & Cooper 1993; Gould), though throughout Top End, territories often overlap with those of Blue-winged Kookaburras *D. leachii* (D.A. Curl). If their chosen nest-site is occupied by other species of birds, Dollarbirds may force them out (see Breeding); once removed incubating Cockatiels *Nymphicus hollandicus*, one Dollarbird staying on nest while other kept Cockatiels away (Lord 1942, 1956). Have favoured perches from which they feed (Fry *et al.* 1992). After young have fledged, families move away quickly (Gilbert 1935; North).

**Roosting** Mainly or wholly at night; one group roosted on bare branches of eucalypt (Boekel 1980). During daylight seem to spend much of time perched atop dead branches of tall trees, but also on artificial perches, such as fences (see Habitat); possible that subadult birds perch lower than adults (Attiwill 1963; Barlow 1967; Clunie 1971), even on ground (Hornsby 1982). When perched, often actively hunting (see Food) or courtship feeding (Campbell & Nicholas 1931); though also said that for much of day when perched, birds inactive and possibly mainly resting, taking only occasional and easily caught prey (Storr 1953; Fry *et al.* 1992); further study needed. Perch in upright stance, moving head occasionally and calling now and then; flick tail after landing or when about to fly (Coates 1985; Fry *et al.* 1992; Forshaw & Cooper 1993). **SUN-BATHING:** In hot weather, bird will flatten itself on ground (grass, gravel or bare earth) for up to 2 min, with wings spread, head and tail spread or lifted, and bill open; sometimes flutter in the dust;

afterwards may fly to low branch to preen or forage (MacKnight 1942; McCulloch 1993). On hot day in late Dec., eight birds sat on high branch, gaping and nodding heads, with single birds performing aerial displays now and then (McCulloch 1993). Said that may loaf in hollows in heat of day (Mathews), but no evidence. Become more active later in day, feeding till after sunset (see Food); at twilight, can become noisier (North; Mathews) and courtship displays often seen (Strahan); sometimes heard after dark (McCulloch 1993). Often travel at night (see Movements).

**SOCIAL BEHAVIOUR** No studies within HANZAB region; some extralimital studies (Jiang & Zhu 1983; Nakamura & Tabata 1988; Mitsch 1990); some general comments in Coates (1985), Fry *et al.* (1992) and Forshaw & Cooper (1993), possibly from extralimital observations. Noisy and conspicuous after arriving at breeding sites, particularly during courtship period and when chasing intruders (Forshaw & Cooper 1993). Before departure at end of season, birds become restless (Gilbert 1935; Forshaw & Cooper 1993); once, five birds perched on a high branch in evening, chattering excitedly before becoming silent and agitatedly moving heads; suddenly all flew off and left with much calling (Gilbert 1935); other migrating birds found to be silent once in air (Beruldsen 1990). Display Flights not so spectacular as those of genus *Coracia* and seem to be less predictable and more spontaneous (Forshaw & Cooper 1993). **DISPLAY FLIGHTS:** Said to be used in territorial and courtship behaviour. Bird flies powerfully, high above territory, then dives at high speed, rolling rapidly from side to side as it levels out; this repeated many times in a series of steep crests and rolling dives; calls almost constantly. Can last for several minutes (Fry *et al.* 1992). When courting, one or both birds said to launch themselves from high branch of nesting or nearby tree, and to give a series of wide circling flights, interrupted by swooping down and then up again; at times, members of pair also pursue each other in undulating flights (Forshaw & Cooper 1993). At times, often fly as pairs, in quick short jerky flights, which seem almost play-like, and call noisily (Mathews).

**Agonistic behaviour** On arrival in breeding areas, both members of pair vigorously and noisily defend territory, calling from high perches and in flight (Shanks 1949; Forshaw & Cooper 1993). After eggs laid, silent and wary, but become more noisy and visible again when young fledge (Forshaw & Cooper 1993). At Parys Ck, nw. WA, two birds fought while third looked on; no chasing, but one aggressor flew at perched opponent and then, using bill, pulled opponent off perch and they tumbled and parachuted together to ground, with wings and tails held rigidly; on ground, birds fought for few seconds then flew into tree; sequence performed many times, with birds calling throughout; finally one left area and remaining two perched side by side (Mathews). At end of breeding season, appeared to be some hostility between three adults gathered before migration in same tree: while one bird looked on, a second stood stiffly upright and jerked up and down vigorously as it approached third bird, which quickly left (Courtney 1967). When one bird displaces another from a perch, Kek call given repeatedly (Boekel 1980). Often mobbed by other species of birds (Forshaw & Cooper 1993), e.g. attacked by nesting Sacred Kingfishers *Todiramphus sanctus*, though seemed undisturbed (van Bennekom 1975); when resting during migration even chased by seabirds (Hogan 1925). **Alarm** When approached by people, weak juvenile Dollarbirds fly only short distances ahead (Attiwill 1963; Hornsby 1982).

**Sexual behaviour** When first member of pair arrives at

breeding site, it spends much time perched at or near nest-hollow that was in use in previous year. When mate arrives, courtship seems to include loud calls and Display Flights, after which pair gradually returns to activities at or near nest-site (Forshaw & Cooper 1993). In pre-laying period, one male flew to perched female and rubbed his bill about her head and called (Mathews). Occasionally, at nest-hole, both birds seen bowing and chattering (probably Kek call) (Lord 1942). In apparent courtship feeding in Nov., one bird sat at top of tree while other bird foraged before flying to feed perched bird; once when food had been passed to sitting bird, hunting bird paraded, arching neck, ruffling feathers of neck, and bobbing and curtsying while giving low gruff calls (Campbell & Nicholas 1931). **Copulation** Seen late Oct. when birds were perched close together; female shook head sideways and up and down, and male mounted (Boekel 1980).

**Relations within family groups** When feeding small nestlings, adults fly straight into hollow, but when leaving usually pause at entrance before flying off. Larger nestlings come to entrance to take food from adults (Forshaw & Cooper 1993). One brood of four nestlings at entrance gave Begging Calls in turn, and when one stopped the next one would start; when parents approached, excitement of young increased; parents fed young in turn, from left to right; this brood also seen to be fed by Sacred Kingfishers (q.v.; van Bennekom 1975). Fledgelings perch at tops of trees and are fed by both adults, which carry prey items singly in bill, crush them and then pass them to fledgeling. Fledgeling seen to beg in upright posture, with apparent rapid lowering and raising of lower mandible, though bill not opened  $>20^\circ$  (Fig. 1a); in another possible begging display, fledgeling assumed almost horizontal posture with bill wide open (Fig. 1b) (van Tets 1965); horizontal posture not seen in all fledgelings (Courtney 1967); also give loud Begging Call, and possibly movement of lower mandible is result of delivering call (Courtney 1967). When people approached, nestlings sitting at entrance to nest became quiet and drew inside (NRS). Juveniles sometimes seen on ground; possibly have fledged early or are unable to maintain flight; when pursued by person, one such young ran, and when picked up gave yapping distress call (Courtney 1967). **Parental anti-predator strategies** On approach of person, parents sometimes leave nest at slightest sound, but at other times do not flush even if rifle shot into nest-hole; sometimes do not attack, but do so at other times (North; Mathews); at nest, or when with fledgelings, may give alarm calls or attack with fury, dive-bombing and sometimes striking (Gould; Campbell; NRS). One adult, with fledgeling, perched high in nearby tree and gave scolding call (Courtney 1967). During nesting, said that adults will dart into holes in trees other than nest-hole to mislead intruder (Le Souëf 1903), but this seems doubtful. Seen attacking goannas *Varanus* near nest, knocking one small one off nest-tree (Lord 1942; North). Also exclude large species of birds from breeding area (see Territories).

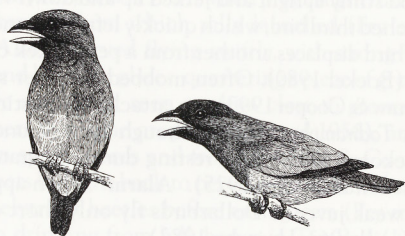
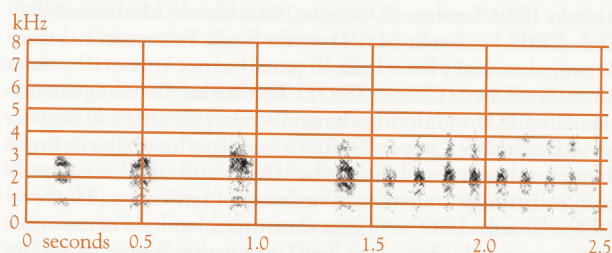


Figure 1 Begging postures of young

**VOICE** Little information from HANZAB region; some extralimital information in Coates (1985), Fry *et al.* (1992), Forshaw & Cooper (1993), and Coates *et al.* (1997). Calls generally rough, hoarse, harsh and discordant; often uttered in flight (Wolstenholme 1922; North). Particularly vocal during early breeding season, especially during courtship and when chasing intruders from territory, and after young fledge; also before n. migration (see Social Behaviour). Said usually to be most vocal just after sunset (North), and quiet in sultry weather (Gould).

**Adult KEK:** Strident, grating, rasping chatter *kek, kek, kek, kek-kek-kek...* or *yap, yapapapap*, with each note becoming louder, slightly higher in pitch and running more rapidly into next note as call builds to crescendo (sonagram A); notes also rendered *tek, kap, yap*; bill opened and closed for each of early notes but held open and moved slightly for later ones. Given often in flight, sometimes incessantly, or from high perches; said to be a contact call (Courtney 1967; Boekel 1980; Pizzev 1980; Forshaw & Cooper 1993). However, widely used in agonistic and sexual behaviour (q.v.). Somewhat more subdued *keek, kek-kek...* given at intervals while resting or feeding (Forshaw & Cooper 1993). Sometimes also uttered singly and at long intervals when feeding (Boekel 1980; P.J. Higgins), then more like contact call. **SCOLD:** Single scolding call, much more drawn out than Kek; uttered in alarm (Courtney 1967). **Other calls** Low gruff calls uttered after presenting food to mate (Campbell & Nicholas 1931).



A D.A. Stewart; Eungella NP, Qld, Dec. 1993; M31-54

**Young** Loud Begging Call of feathered chick that had prematurely left nest, described as prolonged bursts of very rapid high-pitched ticking notes, but implied that this call normal Begging Call. Also gave shrill repetitive squawking distress call when handled; and single high-pitched yapping notes, apparently an attempt at Kek of adult (Courtney 1967).

**BREEDING** Poorly known and no studies; 68 records in NRS to Jan. 1997, mainly from NSW, and mostly records of fledgelings or nests with contents not known, as nests usually very high and hard to reach. Some extralimital information (Baker 1934; Dement'ev & Gladkov 1951; Ali & Ripley 1970). Comparative study across range in Forshaw & Cooper (1993).

**Season** Breeding mainly Oct.–Jan. with no obvious differences between n. and s. Aust. (Irby 1933; Lavery *et al.* 1968; Bravery 1970; Bedggood 1973; Morris *et al.* 1981; Fry *et al.* 1992; North; Storr 7, 11, 19); though claimed breeding in NE possibly starts 1 month later than SE (Bravery 1970; Storr 19). Said that birds start breeding immediately on arrival in nesting areas (Lord 1956; Bravery 1970; Gill 1970; Bedggood 1973; Boekel 1980; Morris *et al.* 1981; Marchant 1992; Forshaw & Cooper 1993; Campbell; Storr 11, 19; D.A. Curl; see Movements for dates). **QLD:** In NE, laying Nov.–Jan. (Lavery *et al.* 1968); in N, two nests with young in Jan.; fledgelings also in Jan. (NRS). **NSW:** Eggs, Oct.–Jan. (Morris *et al.* 1981); of nine

nest with eggs and 19 with nestlings, Nov. (4 with eggs, 0 with young), Dec. (3, 15), Jan. (2, 4); fledgelings seen near nests, Dec.–Feb. (NRS). At one nest in Kakadu NP, young hatched 15 Nov. (D.A. Curl). In some seasons, breeding starts earlier than normal, e.g. a nest with young on 2 Oct. 1892 (North).

**Site** In natural hollows in limbs or trunks of trees; usually quite high (Irby 1933; Shanks 1949; Forshaw & Cooper 1993; Campbell; North; NRS); occasionally in arboreal termitaria, in holes dug by other species of birds (Hindwood 1959; North; NRS). Of 34 nests, 97% were in limbs or trunks of trees, 3% were in arboreal termitaria; of 33 nests in tree-hollows, 18 (54%) in live *Eucalyptus*, 7 (21%) in live unidentified trees (though possibly mainly eucalypts), 3% in *Angophora*, and 22% in dead trees (NRS). In Top End, commonly in Darwin Woollybutt *Eucalyptus miniata* (D.A. Curl). Same nest-sites and hole usually used for several successive years, but not known if same birds involved (see Social Organization). At one site in Murphys Ck, Qld, a nesting pair used same nest for 6 consecutive years (Lord 1942); at another site in Canberra, a nesting pair used same nest for 9 of 10 consecutive years, losing it one year to nesting Sulphur-crested Cockatoos *Cacatua galerita* but regaining it the following year (Forshaw & Cooper 1993). For second broods, said to use different hollows than used for first (Mathews). Share nesting trees with other species, e.g. Galahs *Eolophus roseicapillus*, Laughing Kookaburras, and Sacred Kingfishers (van Bennekom 1975; NRS). Will force other species of birds out of nest-holes (Lord 1956): take over nests of Common Mynas *Acridotheres tristis* (NRS); once expelled Laughing Kookaburras after removing their nestlings (Campbell); once removed incubating Cockatiels (Lord 1942, 1956). **MEASUREMENTS** (m): Height above ground, 14.6 (8.1; 6–35; 34); depth below top of nest-tree, 7.6 (5.1; 1–21; 34) (NRS).

**Nest, Materials** No nest built; eggs laid on decaying wood-dust on floor of hollow (Campbell; North).

**Eggs** Round to ovate; smooth and glossy; pure white; in some clutches, one egg may lose normal gloss (Forshaw & Cooper 1993; Campbell; North). **MEASUREMENTS**: 33.7 (1.2; 31.8–35.7; 14) × 27.9 (0.4; 27.2–28.4) (Campbell; North). One clutch from Clarence R., NSW, 35.7 (34.6–36.8; 4) × 29.1 (28.8–29.6) (Forshaw & Cooper 1993). **Clutch-size** Three or four, commonly four (Forshaw & Cooper 1993; Campbell; North); in Qld, C/3 × 3, C/4 × 6 (Storr 19); no data from acceptable clutches in NRS. C/4 said to be usual in normal years, with C/3 in years when weather dry (North). **Laying, Incubation** No information from HANZAB region. Extraliminally, both sexes incubate (Forshaw & Cooper 1993).

**Young** Poorly known. Fed by both parents; young nestlings fed inside nest, older nestlings come to entrance of nest to be fed (van Tets 1965; van Bennekom 1975; Forshaw & Cooper 1993; NRS; see Social Behaviour). Parents can be quite aggressive when protecting nests and young (see Social Behaviour). **Growth** No information. **Fledging to independence** Fed by both parents; see Social Behaviour. **Success** Monitors *Varanus* said to rob nests (Lord 1942; North); young in one nest drowned during heavy rainfall (D.A. Curl).

**PLUMAGES** Prepared by K. Bartram. Partial post-juvenile (first pre-basic) moult to immature plumage begins soon after leaving nest, but not known when finished. Then undergo complete immature post-breeding (second pre-basic) moult to adult plumage at c. 12 months old. Thereafter undergo a complete post-breeding (pre-basic) moult each cycle, producing successive adult plumages without change in appearance. Sexes differ slightly as adults; sexes alike in juvenile and

immature plumages. Some apparent seasonal variation in colours of bare parts. Only subspecies *pacificus* known to occur in HANZAB region; described below.

**Adult male** (Second and subsequent basic). **HEAD AND NECK**: Forehead, crown, nape, hindneck and sides of neck, brown to olive-brown (28–29); lores slightly darker, dark brown (121). Ear-coverts usually brown to olive-brown (28–29), though some have dark-blue to violet (70–71) wash to tips of central coverts. Chin, brown (28) to dark olive-brown (129). Feathers of throat and foreneck, lanceolate: mostly violet (71) with light-violet (170C) shaft-streaks, tiny white (ne) tips that are easily lost with wear, and dark olive-brown (129) bases; combine to form streaky violet throat-patch, slightly mottled with dark olive-brown. **UPPERPARTS**: Mantle, back and scapulars, brown to olive-brown (29–28) with ill-defined dull greyish blue-green (ne) fringes to feathers; appear brown suffused blue-green. Rump and uppertail-coverts mostly brownish green (ne) with broad, indistinct greyish blue-green (ne) fringes to feathers; appear blue-green tinged brown. **UNDERPARTS**: Mostly dull greenish-blue (ne) with olive-brown (30) bases to feathers, which are sometimes partly exposed. Breast mostly olive-brown (30) with greenish blue (ne) confined to fringes of feathers; centre of upper breast often has diffuse violet (c71) blotches on centres of feathers. **UPPERTAIL**: T1, black-brown (19–20) with faint tinge of blue-black (173) beside shaft on both webs. T2–t6 mostly black-brown (19–20) with broad outer edges grading from blue-black (173) on distal half to two-thirds, to light blue-green (ne) on basal third to half. Shafts, black-brown (19–20) distally grading to brown (123) on basal half. **UNDERTAIL**: Outer halves of inner webs, glossy grey-black (82); rest of inner webs and outer webs, dark blue (c70) becoming lighter green-blue (ne) on basal quarter of inner webs. Shafts, black-brown (19–20) on distal third, cream (pale 54) on rest. **UPPERWING**: Marginal, lesser and median secondary coverts, olive-brown (30) with broad, indistinct greyish green-blue (ne) fringes. Greater secondary coverts, greyish blue (ne) grading to brighter green-blue (ne) on outermost coverts. Marginal primary coverts, greyish green-blue (ne). Rest of primary coverts appear mostly violet (c71); innermost coverts have greenish-blue (ne) streak through centre of inner web that broadens to greenish-blue (ne) tip, and light greyish-brown (45) inner edge; outermost coverts and alula lack greenish-blue colours, so that inner webs, grey-black (82) grading to light greyish-brown on inner edge. Tertiaries, greyish green-blue (ne). Secondaries have black-brown (19) inner webs and tips, and dark-blue to dark-violet (74–72) rest of outer webs. P1–p2, black-brown (19) with dark-violet (72) outer edges. On p3–p10, inner webs mostly black-brown (19), and outer webs mostly dark violet (72) with broad black-brown (19) tip, and with varying light-blue (pale 93) bands between basal third to half of each remex, which combine to form large rounded patch in outerwing (the ‘dollar’); band of light blue not present on inner web and 10–15 mm wide on outer web of p3–p4; c. 15 mm wide on inner web and c. 20 mm wide on outer web of p5; c. 30 mm wide on both webs of p6–p7; c. 30 mm wide on inner web and c. 40 mm wide on outer web of p8; c. 20 mm wide on inner web and c. 35 mm wide on outer web of p9; and c. 35 mm wide on inner web, and not present on outer web of p10. Dark-violet (72) bands on outer webs of p5–p9, between light-blue bands and dark-brown tip, 15–30 mm wide. Shafts of remiges mostly black-brown (19), but cream (54) in light-blue areas. **UNDERWING**: All coverts except greater, greyish green-blue (ne) grading to light grey-brown (45) bases, which are partly exposed. Greater coverts, greenish blue (ne) with dark-blue (70) tinge at tips. On secondaries and p1–p4,

inner webs mostly glossy violet (c71) to dark blue (70); area beside shaft on inner webs and all of outer webs, glossy dark brown (glossy 21); a few have narrow pale-green (c162D) basal inner edges. On p5–p7, most of outer web, inner web beside shaft, and tip of inner web, glossy dark brown (21), and rest of inner web, glossy violet (c71); p8–p10 like p5–p7 but bases of inner webs, dull green-blue (ne); p5–p10 have varying light-blue (c168D) bands between basal third and half of each remige, as on upperwing (q.v.), though bands, and resultant patch, paler (ne); 'dollar patch' appears narrower than on upperwing because pale blue less extensive on inner webs than on outer webs, and overlapping primaries cover most of outer webs. Shafts of remiges mostly dark red-brown (132), but on light-blue bands, pale cream (ne).

**Adult female** (Second and subsequent basic). Differs only subtly from adult male and an unknown proportion possibly inseparable. However, at least some females differ consistently from males: of 13 female and 26 male skins examined (AM, ANWC, MV, QM), all but one female differed in following characteristics; one skin labelled as a female identical to adult male (as above). Differ from adult male by: **UPPERWING**: Greater primary coverts have green-blue (164) outer edges. Primaries also have narrow green-blue (164) outer edges, except over pale blue patches, which extend to edge. On p3–p9, width of dark-violet area on outer web between light-blue band and dark-brown tip tends to be narrower than in males, but considerable overlap: in females, area of violet 5–20 mm wide (cf. 15–30 mm in adult males). **UNDERWING**: Greater coverts wholly greyish green-blue (ne) with no dark-blue tinge at tips. Remiges much like adult male, except that outer webs (except light-blue patch) dark blue (70), never violet, often suffused greenish (ne); secondaries and inner four primaries have pale-green (c162D) inner edges; and outer primaries have pale-green (c162D) edges that extend from base to proximal edge of pale-blue band and from distal edge of pale-blue band toward tip for c. 10 mm; edges usually broader than green edges of adult male (if any).

**Downy young** No information. Probably hatch naked, like related species (see BWP).

**Juvenile** Differences from adult: **HEAD AND NECK**: Forehead, crown, nape, hindneck and sides of neck, darker olive-brown (ne); when fresh, feathers have neat narrow brown (28) fringes. Lores and ear-coverts, as adult. Chin, dull white (ne). Feathers of throat and foreneck not lanceolate: greyish blue-green (ne) with neat cream (54) fringes at tips, and so no violet patch on throat; a few have violet (71) tinge to centre of throat. **UPPERPARTS**: Uniform olive-brown (ne), darker than adult; when fresh, feathers have neat narrow dull light-greenish (ne) fringes. **UNDERPARTS**: As adult male but with cream (54) fringes to feathers of upper breast (continuous with foreneck). **UPPERTAIL**: Like adult male, but edges of t2–t6, green-blue (64). **UNDERTAIL**: As adult male. **UPPERWING**: Secondary coverts and most primary coverts as adult. Greater primary coverts and alula, dark olive-brown (129) with narrow green-blue (64) edges to inner coverts and violet (71) edges to outer coverts and alula. Tertiaries as adult. Secondaries and p1–p3, black-brown (19) in centre grading to light grey-brown on inner edge; outer half of outer webs, violet (71) with narrow green-blue (64) outer edge. P4–p10 mostly dark brown (221) with varying whitish-blue (ne) bands between basal third and half of each remex, which combine to form pale patch in outerwing; whitish-blue band c. 15 mm wide on both webs of p4; c. 30 mm wide on both webs of p5–p7; c. 30 mm wide on inner web and c. 15 mm wide on outer web of p8; c. 25 mm wide on inner web only

of p9; and c. 20 mm wide on inner web only of p10; p4–p10 also have very narrow violet (170B) or green-blue (64–164) outer edges (apart from over whitish-blue patch), which, on p4–p8 distal to whitish-blue band are narrowly bordered inside by dark-blue (70) stripe. Primaryes differ from both adult male and female most obviously in lacking extensive dark violet on outer webs, and with no dark violet distal to pale-blue bands on remiges; pale-blue bands smaller, narrower and much paler (forming smaller patch in outerwing); and bases wholly dark brown (in adults, bases of inner webs darker, black-brown, and bases of outer webs, dark violet); green-blue outer edges similar to those of adult female. **UNDERWING**: All greater coverts, greyish green-blue (ne), but duller than adult female. Rest of coverts like adult but slightly duller. Remiges mostly glossy brownish grey (ne) (paler than in adult, and lacking any violet or dark blue) with broad dull greyish green-blue (ne) inner edges, and, on p4–p10, whitish green-blue (ne) bands to each remige, patterned as on upperwing (q.v.). As on upperwing, pale bands in outer primaries, and resultant patch in outerwing, paler and smaller than in adult. Shafts of remiges wholly light grey-brown (119D), even in pale bands (cf. adults).

**Immature** (First basic). Identical to adult but retain juvenile remiges, rectrices and greater upperwing-coverts, which all look worn (especially tertiaries) and contrast with fresher adult-like plumage. Easily distinguished by juvenile characters of retained tracts.

**BARE PARTS** Based on photos (Wade 1975; Coates 1985; Trounson & Trounson 1989; Lindsey 1992; Flegg & Madge 1995; Rowland 1995; Aust. RD; Strahan; unpubl.: R. Davies) and museum labels (ANWC, HLW, MV). Sexes alike at all ages. **Adult** Bill, red (14–13) to orange-red (15) with small grey-black (82) tip. This consistent in all available photos of Aust. birds and descriptions on museum labels. However, of nine adult skins collected New Guinea (seven in May, one in Aug., and one in Oct.), museum labels of five from May describe bills as orange or orange-red with black shadowing; and label of Aug. bird describes bill as rufous-red with black tip; other three labels had descriptions that matched normal Aust. pattern. This appears to indicate that there is seasonal change in colour of bill, with birds developing varying dark markings to bill in non-breeding areas. Alternatively, those with dark markings on bill may be younger adults, which partly supported by photos of immature or second-year adult (see Immature below). Further study needed. Gape, red (like rest of bill) to pale yellow (157). Inside of mouth, pale yellow (157). Iris, dark brown (21). Orbital ring, black-brown (19) to dull dark-red (ne). Legs and feet, orange-red (15) to red-brown (132A) with pink (dull 108D) soles; claws, black (89). **Downy young** No information. **Juvenile** Bill, glossy grey-black (82) with broad light-yellow (light 157) tomia (not reaching tips of mandibles) and some salmon (106) markings on very base of bill. Gape, light yellow (light 157). Iris as adult. Orbital ring, dark grey (83) with salmon (ne) tinge in front of eye. Legs and feet vary from grey-black (82) with dull salmon (dull 106) between scales to rufous (140) with irregular grey-black (82) blotching over tarsus and toes. Claws, black (89). **Immature** Not fully known, particularly when adult coloration attained. Museum labels of two Aust. skins (Nov.), one New Guinea skin (Apr.), and one photo of Aust. bird (Dec.), all like Aust. adult. Label of one immature collected New Guinea in Apr. described bill as completely black. Photos of a captive bird, c. 18 months old, in late Aug. or early Sept. (R. Davies) show upper mandible mostly black-brown (19) with small irregular cream (ne) patches, and lower

mandible mostly dull orange-yellow (ne) with small black-brown (19) markings; gape, dull orange-yellow (ne); and orbital ring, buff (123D).

**MOULTS** Based on examination of 61 adult skins (including nine from New Guinea), 16 juvenile skins (all Aust.), five immatures (all Aust.), and three birds moulting into adult plumage (including two from New Guinea) (AM, ANWC, HLW, MV, QM). **Adult post-breeding** (Third and subsequent pre-basic). Complete. Primaries outward. No apparent pattern to moult of tail, and replacement usually asymmetrical; t1 replaced first in two skins. Moult of body began on crown in one skin; also finished on head (in three skins). Moult starts with primaries or body; moult of tail appears not to begin till rest of moult advanced. Moult of body finished first in four skins, followed soon after by primaries, and tail last. Moult starts in Aust. after breeding and before n. migration, Dec.–Feb.; finishes after arrival in New Guinea. In Aust., moult recorded: Dec. (2 of 13, with PMS of 3 and 3), Jan. (1 of 3, PMS 12), Feb. (single skin had PMS of 1), Mar. (single skin had PMS of 25); no Aust. skins between Apr. and Aug. Of wintering birds in New Guinea: May (all of 7 in moult; PMS 37–46; moult of body finished or nearly so; and tail from about one-third through to nearly finished), Aug. (one in fresh plumage), Oct. (one in worn plumage). On return to Aust., plumage varyingly worn; no moult recorded in 34 skins between Sept. and Nov. **Post-juvenile** (First pre-basic). Partial; moult all feathers except remiges, rectrices and greater upperwing-coverts. Appears to begin soon after leaving nest. Moult began on throat in two skins, and mantle in one. Of 16 juveniles from Jan. (n=9) and Feb. (n=7), 12 had no sign of moult; two from Jan. had just started moult, and two from Feb. had heavy moult of body. No information from Mar. to Sept. so not known when moult finished (but had by Oct.–Dec.) **Immature post-breeding** (Second pre-basic). Complete. Little information. Possibly occurs at about same time as post-breeding moults of adult. Five from Oct.–Dec. had not started moult. One from nw. WA in Jan. had PMS of 25, some moult of body and juvenile rectrices. Two birds from New Guinea: one from Apr. had PMS of 42, and t1 and t2 in pin, and half of upperparts replaced; one from May had PMS of 37, t1 in pin, right t2 missing and most of body finished.

**MEASUREMENTS** Subspecies *pacificus*: Skins (AM, ANWC, HLW, MV, QM): (1–3) Adults: (1) E. Aust.; (2) NT; (3) N. New Guinea. (4) Aust., juveniles. (5) Aust., immatures.

In e. Aust. sample, juveniles significantly smaller than adults (both sexes) in Wing ( $P < 0.01$ ), Bill S ( $P < 0.01$ ), and Tail ( $P < 0.05$ ); juvenile males also have smaller Tarsus than adult males ( $P < 0.05$ ). When sexes combined, immature smaller than adults in Wing ( $P < 0.05$ ) and Tail ( $P < 0.05$ ). Adult males from New Guinea sample have significantly longer Tails than adult males from e. Aust. ( $P < 0.05$ ), but this may be a sampling artefact.

	MALES	FEMALES	
WING	(1) 192.5 (3.48; 184–199; 36)	193.5 (4.27; 187–200; 13)	ns
	(2) 192.1 (3.46; 186–199; 15)	191.6 (5.83; 180–200; 9)	ns
	(3) 196.0 (5.48; 190–203; 5)	183, 190, 193	
	(4) 179.0 (16.22; 143–195; 9)	177.0 (18.99; 147–198; 7)	ns
	(5) 185, 191	190.3 (2.66; 185–192; 6)	
TAIL	(1) 94.3 (2.58; 88–99; 37)	95.8 (3.61; 88–100; 12)	ns
	(2) 96.1 (2.85; 91–101; 15)	95.4 (3.50; 89–100; 10)	ns
	(3) 96.5 (1.93; 94–100; 8)	95.0 (3.16; 91–98; 4)	ns

	(4) 90.1 (10.75; 65–101; 9)	87.7 (10.84; 73–102; 7)	ns
	(5) 90, 94, 96	96.4 (3.46; 91–102; 7)	
BILL S	(1) 32.4 (1.37; 30.3–35.0; 37)	32.8 (1.01; 30.6–34.0; 12)	ns
	(2) 33.0 (1.96; 28.9–35.3; 15)	32.8 (1.74; 30.5–36.5; 9)	ns
	(3) 33.1 (2.04; 29.6–35.6; 8)	33.0, 34.1	
	(4) 29.0 (3.02; 24.0–32.3; 9)	29.6 (2.29; 26.1–32.5; 7)	*
	(5) 32.6, 34.6, 35.0	33.1 (1.46; 31.3–35.4; 8)	
TARSUS	(1) 19.6 (0.60; 18.3–21.1; 37)	19.8 (0.69; 18.4–20.7; 12)	ns
	(2) 19.5 (0.71; 18.1–20.6; 15)	19.8 (0.43; 19.0–20.7; 10)	ns
	(3) 19.7 (0.71; 18.5–20.5; 8)	19.9 (0.92; 18.6–20.6; 4)	ns
	(4) 19.1 (0.99; 17.8–20.9; 9)	19.8 (0.58; 19.0–20.6; 7)	ns
	(5) 18.3, 19.1, 20.5	19.6 (1.03; 18.3–21.5; 8)	
TOE C	(1) 28.5 (1.19; 26.5–31.4; 30)	28.1 (1.45; 25.9–30.1; 9)	ns
	(2) 28.1 (1.34; 25.1–29.7; 10)	28.6 (0.88; 27.2–29.4; 6)	ns
	(3) 29.2 (0.76; 28.0–30.0; 5)	28.5, 29.2	
	(4) 28.0 (0.94; 26.8–28.9; 5)	26.8 (1.35; 25.7–28.7; 5)	ns
	(5) 30.5	28.9 (1.67; 26.8–30.5; 4)	

Additional measurements in Forshaw & Cooper (1993).

**WEIGHTS** Subspecies *pacificus*: from museum labels (AM, MV, QM): (1) Aust., adults; (2) New Guinea, adults; (3) Aust., juveniles.

	MALES	FEMALES	
(1)	126.4 (23.83; 95.3–180.3; 14)	135.5 (31.48; 105–172; 5)	ns
(2)	144.0 (18.17; 110–170; 8)	131.5 (5.97; 126–140; 4)	ns
(3)	94.6 (26.65; 51–115.5; 5)	107.3 (32.25; 75.4–143; 5)	ns

In Aust. birds, juvenile males lighter than adult males ( $P < 0.05$ ).

**STRUCTURE** Wing long and broad, with rounded tip. Eleven primaries: p9 longest; p10 5–13 mm shorter, p8 0–9, p7 7–13, p6 21–32, p5 33–48, p4 42–57, p3 50–63, p2 56–70, p1 57–77; p11, small (c. 30 mm long) and narrow. Slight emargination on outer webs of p8–p9 and inner webs of p9–p10. Fifteen secondaries, including six tertials; longest tertial extends to between p4 and p6 on folded wing. Tail broad and short, usually slightly forked but sometimes square; 12 rectrices; longest varies, usually t5 or t4, t1 usually shortest (between 0–13 mm shorter). Head large, and broad compared with body; crown flat. Orbital ring narrow but well defined. Bill broad and short with large gape: upper mandible has short hook at tip; lower mandible broad and shallow, triangular when viewed from below. Nostrils horizontal slits (c. 10 mm long) set well back on bill and mostly covered by feathers. Tarsus short and slightly laterally compressed; front of tarsus and toes scutellate; hind tarsus and bottom of toes granulate. Toes syndactylous. Claws moderately long and hooked. Middle toe longest, outer 85% of middle, inner 72%, hindtoe 66%.

**AGEING** Juveniles, immatures and adults readily distinguished by plumage (including colour of shafts of primaries) and bare parts. Possible seasonal change in colour of bill, with adults and immatures in non-breeding areas having darker bills than seen in Aust. Further, in juveniles, feathers of throat and foreneck have rounded tips (lanceolate tips in immatures and adults); in direct comparison, p10 of juveniles (and immatures) narrower and tip more pointed than in adult; and rectrices also narrower and tips slightly more pointed than in adult. Juveniles also differ in size (see Measurements).

**GEOGRAPHICAL VARIATION** No recent taxonomic reviews, and number of subspecies recognized varies. For

convenience, we follow Forshaw & Cooper (1993), recognizing ten subspecies distributed through s., e. and se. Asia, Philippines, Indonesia, New Guinea, Solomon Is and n. and e. Aust. (see masthead). Fry *et al.* (1992) recognized nine subspecies, and Peters 11. Nominate *orientalis* and subspecies *calonyx* intergrade in s. China and n. Indochina (Forshaw & Cooper 1993). Birds from Tanimbar, Sulawesi and Lombok appear intermediate between *pacificus* and *orientalis* (Sharpe 1892; Meyer & Wigglesworth 1898) and have been considered a distinct subspecies, *connectens* (e.g. Stresemann 1913; Peters); others combine these intermediates with *pacificus* (White & Bruce 1986; Forshaw & Cooper 1993; Schodde & Mason 1997).

One subspecies, *pacificus*, breeds Aust., migrating N in austral winter, mainly to n. New Guinea, but also to e. Indonesia and Bismarck Arch. *Pacificus* much duller and paler than all extralimital subspecies, with less blue and green in plumage (Fry *et al.* 1992; Forshaw & Cooper 1993). No geographical variation in plumage within Aust.; also no significant differences in measurements, except that adult males from NT have shorter tails ( $P < 0.05$ ) than adult males from e. Aust. (see Measurements). No evidence to support recognition of subspecies *bravi* (Mathews) from nw. Aust. (this study) and not recognized by Aust. CL or Schodde & Mason (1997).

Subspecific identity of vagrants recorded Christmas and Cocos-Keeling Is (see Distribution) not known. Suggested that possibly *calonyx* (Schodde & Mason 1997), but possibility that *orientalis* or Aust. *pacificus* not completely unlikely. Subspecies *waigiouensis* of s. New Guinea could also occur in HANZAB region on islands of n. Torres Str. but there have been no reports of birds other than *pacificus*. For descriptions of all extralimital subspecies, see Fry *et al.* (1992) and Forshaw & Cooper (1993).

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Volume 4, Plate 54

Rainbow Bee-eater *Merops ornatus* (page 1210)

1 Adult male (fresh); 2 Adult male (worn); 3 Adult female; 4 Juvenile; 5 Juvenile with dark patch on central foreneck; 6, 7 Adult male

Dollarbird *Eurystomus orientalis* (page 1227)

8 Adult male; 9 Adult female with dusky bill (in non-breeding period); 10 Juvenile; 11, 12 Adult male; 13, 14 Juvenile

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