

Order PASSERIFORMES

The largest and most diverse order of birds, commonly called passerines or perching birds, and comprising some 5712 species in 45 families (based on Sibley & Monroe 1990; Sibley & Ahlquist 1990), and well over half the world's known bird species. In the HANZAB region, Passeriformes represented by some 382 species in 39 families. Tiny to large: smallest passerine is Pygmy Tit *Psaltria exilis* of Java, with a total length c. 8 cm; largest is Greenland Raven *Corvus corax principalis*, with a total length c. 64 cm and weighing up to 1.7 kg. Superb Lyrebird *Menura novaehollandiae* of e. Aust. probably second largest in Order, with a total length (in adult male) of c. 103 cm, including tail of c. 70 cm, and weight up to c. 1.1 kg. Cosmopolitan except Antarctica and some oceanic islands; and occupying all terrestrial habitats.

Overall, Passeriformes are characterized by (based on Raikow 1982; Sibley & Ahlquist 1990; and DAB [=Schodde & Mason 1999]): Palate aegithongnathous (except Conopophagidae [gnateaters]). Intestinal caeca rudimentary. Single left carotid artery (except paired in *Pseudocalyptomena* and possibly other broadbills [Eurylaimidae]). Aftershaft reduced or absent. Neck short, with 14 cervical vertebrae in most, but 15 in Eurylaimidae (broadbills); atlas perforated; metasternum usually two-notched (rarely four-notched). Bicep slip absent. Expansor secundariorum often present (Berger 1956; Raikow 1982; *contra* Beddard 1898; Ridgeway 1901). Pelvic muscles AXY (AX in *Dicrurus* [drongos]). Ambiens absent. Iliofemoralis externus usually absent, but present in some groups as 'developmental anomaly' (Raikow 1982). Tensor propatagialis brevis tendon present. Hypocleideum present (except Menuridae [lyrebirds]). Wings eutaxic. Usually ten primaries, but p10 often reduced or absent; 11 primaries in Menuridae (lyrebirds), most Eurylaimidae (broadbills), most Furnariidae (ovenbirds), and some Passeri (oscines [see below]). Usually nine secondaries (ten in Menuridae [lyrebirds]). Usually 12 rectrices, but from six (*Stipiturus* [Maluridae]) to 16 (Menuridae). Lesser primary and secondary coverts usually reduced or absent (Zeidler 1966; Morlion 1985; Winkler & Jenni 1996), but a few well-developed lesser primary coverts are present in Superb Lyrebird (Morlion 1985). Uropygial preen glands naked. No basipterygoid process. Nasal glands minute. Foot anisodactyl. Hallux incumbent, large and directed backwards; toes 2, 3 and 4 directed forward; digital formula 2-3-4-5. Deep plantar tendons usually of type VII (lacking vinculum), but often type I in Eurylaimidae (broadbills). Spermatozoa bundled with coiled head and large acrosome.

The DNA-DNA hybridization studies of Sibley & Ahlquist (1985a, 1990) revealed much about the relationships within the Passeriformes and resulted in fundamental changes to the higher level taxonomy of passerines, not least to the taxonomy of the Australo-Papuan oscine passerines. Importantly, these studies showed that many elements of the Australo-Papuan avifauna (e.g. the A'asian wrens [Maluridae], robins [Petroicidae], babblers [Pomatostomidae], and so on), represent an endemic radiation of forms that bear an external resemblance to Eurasian families. Many of the findings of DNA-DNA hybridization studies regarding the Australo-Papuan oscines have since been broadly corroborated by studies using protein allozymes (e.g. Christidis 1991; Christidis & Schodde 1991) and microcomplement fixation (e.g. Baverstock *et al.* 1991, 1992), though there are also many points that remain uncertain and many familial relationships within the Passeriformes are unresolved (Christidis & Boles 1994). (For discussion of historical taxonomic arrangements preceding results of DNA-DNA hybridization studies, see BWP, and Sibley & Ahlquist [1985a,b, 1990]).

The Passeriformes divide into two main groups:

SUBORDER TYRANNI (SUBOSCINES): The distribution of the suboscines is centred in the American and Afro-asian Tropics, with a massive radiation in South America (Sibley & Ahlquist 1990; DAB). Suboscines characterized by mesomyodian syrinx, with or without a single pair of intrinsic syringeal muscles (van Tyne & Berger 1976; Campbell & Lack 1985; DAB). Suborder sometimes named Oligomyodi (e.g. Sibley & Ahlquist 1985a,b), Deutero-Oscines (e.g. Morony *et al.* 1975; Voous 1977), or Clamatores (Campbell & Lack 1985). Poorly represented in the HANZAB region: only TYRANNIDAE (tyrant-flycatchers), with two species, both accidental to South Georgia; ACANTHISITTIDAE (NZ wrens), with four species (one extinct) in three genera, endemic to NZ; and PITTIDAE (pittas), with four species in one genus in HANZAB region (three breeding, one accidental). Tyranni formerly included the Menuridae and Atrichornithidae (e.g. Wetmore 1960; Storer 1971), though subsequently shown that these two families should be included in Passeri (e.g. Sibley 1974; Sibley & Ahlquist 1985, 1990).

SUBORDER PASSERI (OSCINES OR SONGBIRDS): Cosmopolitan in distribution. Within the HANZAB region there are 36 families of Passeri. The Australo-Papuan Passeri can be subdivided into several supra-familial groups, but those recognized differ between authors (for further information, see Sibley & Ahlquist 1985, 1990; DAB). Oscines are

characterized by acromyodian syrinx, with three or four pairs of intrinsic syringeal muscles (van Tyne & Berger 1976; Campbell & Lack 1985; Sibley & Ahlquist 1990; DAB).

Suborder Passeri comprises the major element of the Aust. and NZ passerine avifauna. The families recorded in the HANZAB region, and the representatives in the region, are (following Christidis & Boles [1994] for Aust., with additional species for wider region added as appropriate):

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- MENURIDAE (lyrebirds): two species in one genus; endemic to Aust.;
- ATRICHORNITHIDAE (scrub-birds): two species in one genus; endemic to Aust.;
- CLIMACTERIDAE (A'asian treecreepers): six species in two genera breeding in Aust.;
- MALURIDAE (Australopapuan fairy-wrens, emu-wrens and grasswrens): 22 breeding species in three genera in Aust.;
- MELIPHAGIDAE (honeyeaters and Aust. chats): 76 species in 26 genera in Aust. and NZ, all breeding;
- PARDALOTIDAE (pardalotes, scrubwrens, thornbills and allies): 51 species (one extinct) in 15 genera in HANZAB region, all breeding;
- PETROICIDAE (A'asian robins): 23 species in eight genera in HANZAB region, all breeding;
- ORTHONYCHIDAE (logrunners): two breeding species in one genus in Aust.;
- POMATOSTOMIDAE (A'asian babblers): four breeding species in single genus in Aust.;
- CINCLOSOMATIDAE (whipbirds, wedgebills, quail-thrushes and jewel-babblers): eight breeding species in two genera in Aust.;
- NEOSITTIDAE (sitellas): single species breeding in Aust.;
- PACHYCEPHALIDAE (whistlers, shrike-thrushes and allies): 17 species in seven genera in HANZAB region, all breeding;
- DICRURIDAE (monarchs, flycatchers, fantails and drongos): 19 species in seven genera in HANZAB region, all breeding;
- CAMPEPHAGIDAE (cuckoo-shrikes, trillers and minivets): eight species (one extinct) in two genera in HANZAB region, all breeding;
- ORIOLIDAE (Old World orioles and figbirds): three species in two genera in Aust., all breeding;
- ARTAMIDAE (woodswallows, butcherbirds and currawongs): 14 species in four genera in HANZAB region, all breeding;
- PARADISAEIDAE (birds of paradise): five breeding species in two genera in Aust.;
- CORVIDAE (crows and jays): six breeding species in single genus in Aust. and NZ, including one introduced to NZ;
- CORCORACIDAE (Aust. mudnesters): two species in two monospecific genera, endemic to Aust.;
- CALLAEIDAE (NZ wattlebirds): three species (one extinct) in three monospecific genera, endemic to NZ;
- LANIIDAE (shrikes): two species in HANZAB region, one accidental to Prince Edward Is, the other accidental to Christmas I.;
- PTILONORHYNCHIDAE (bowerbirds): ten species in seven genera in Aust. (nine species) and NZ (one species), all breeding; Piopio of NZ probably extinct (Heather & Robertson 1997);
- ALAUDIDAE (larks): two breeding species in HANZAB region (including one successfully introduced to Aust. and NZ);
- MOTACILLIDAE (wagtails and pipits): eight species in two genera in HANZAB region, only two breeding (one on South Georgia), the rest non-breeding visitors or accidentals;
- PRUNELLIDAE (accentors): one species successfully introduced to NZ;
- PASSERIDAE (Old World sparrows and A'asian finches): 22 species in nine genera (including four successful introductions) in HANZAB region, all breeding;
- FRINGILLIDAE (Old World finches): seven species in four genera in HANZAB region, all introduced except one naturally occurring vagrant to South Georgia;
- EMBERIZIDAE (buntings, cardinals, tanagers and allies): two successfully introduced species, occurring NZ and Lord Howe I.;
- NECTARINIIDAE (sunbirds and spiderhunters): single breeding species in Aust.;
- DICAEDIDAE (flowerpeckers): single breeding species in Aust.;
- HIRUNDINIDAE (swallows and martins): eight species in four genera in HANZAB region, including four breeding species in Aust. and NZ, one non-breeding visitor and three accidentals;
- PYCNONOTIDAE (bulbuls): one successfully introduced species in Aust.;
- SYLVIIDAE (Old World warblers): 13 species in eight genera in HANZAB region, including ten breeding species (one extinct) in Aust. and NZ, and three accidental to region;
- ZOSTEROPIDAE (white-eyes): seven species (one extinct) in single genus in HANZAB region, all breeding;
- MUSCICAPIDAE (Old World flycatchers, thrushes and chats): eight species in six genera in HANZAB region, including five breeding species (two introduced), and four accidentals (including one on Prince Edward Is);
- STURNIDAE (starlings and mynas): five species in four genera, four breeding in HANZAB region (including two species successfully introduced, and one species now extinct), and one accidental.
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The Aust. oscines fall into two distinct clusters, each with at least three major supra-familial lineages (DAB): One cluster is the Passerida, comprising the Muscicapoida (including true thrushes and allies), Sylvioidea (true warblers and babblers, and swallows, and others), and Passeroidea (including larks, pipits, sunbirds, flowerpeckers and all finches and their allies). The other cluster is the Corvida, which is centred on the Australo-Papuan region (though its origins are not certain) and which also comprises three main lineages: Menuroidea (lyrebirds, scrub-birds, treecreepers and bowerbirds), Meliphagoidea (A'asian wrens, pardalotes, acanthizid warblers, and honeyeaters), and Corvoidea (A'asian robins, logrunners, A'asian babblers, whipbirds and quail-thrushes, sitellas, whistlers, fantails and monarchs, birds of paradise, butcherbirds and woodswallows, cuckoo-shrikes, Old World orioles, crows and mudnesters).

Throughout this volume, arrangement of families follows that of Christidis & Boles (1994) except that the Meliphagidae precedes the Pardalotidae. This change was made to ensure the Meliphagidae were dealt with in a single volume, rather than split between volumes, and because the switch meant no change to the positioning of Meliphagidae relative to the Pardalotidae (including Acanthizidae), one another's closest relatives, and because there is little overriding evidence of the exact taxonomic positioning of all families within the Meliphagoidea; Sibley & Monroe (1990) also placed the Meliphagidae between the Maluridae and Pardalotidae. However, DAB points out that based on structure of humeral fossa, positioning of Meliphagidae between the Maluridae and Pardalotidae is not correct.

DAB, however, varies from the familial arrangement of Christidis & Boles (1994) in several ways. The main differences are: (1) recognition of Pardalotidae and Acanthizidae as separate families (combined in Pardalotidae in Christidis & Boles); (2) minor rearrangement of the sequence of the families Paradisaeidae–Artamidae–Campephagidae–Oriolidae between the Dicuridae and Corvidae (cf. Dicuridae–Campephagidae–Oriolidae–Artamidae–Paradisaeidae–Corvidae in Christidis & Boles); (3) and use of the more traditional muscicapoid (flycatcher) – sylvioid (warbler) – passeroid (finch) sequence of Sibley *et al.* (1988), Sibley & Ahlquist (1990) and Sibley & Monroe (1990) and much contemporary literature of n. hemisphere, with families in the sequence Muscicapidae–Sturnidae–Hirundinidae–Pycnonotidae–Zosteropidae–Sylviidae–Alaudidae–Dicaeidae–Nectariniidae–Passeridae–Motacillidae–Estrildidae–Fringillidae and noting recognition of the Estrildidae as a separate family (cf. the reversed sequence of Christidis & Boles, as given above, and which submerges the Estrildidae within the Passeridae). For discussion of the reasons for these changes, see DAB (and discussion under these families in future volumes of HANZAB).

Arrangement of genera and species within families also follows Christidis & Boles (1994), which was in turn largely based on Schodde (1975) unless there were specific reasons for change. Lastly, with few exceptions, which are discussed in individual species accounts, taxonomy of subspecies follows DAB.

Passerines are extremely diverse in body form and plumage, and vary greatly in rates of maturation. Some attain adult plumage within months or weeks of fledging; others can take up to 9 years to attain adult plumage (e.g. Superb Lyrebird). Degree of sexual dimorphism also varies greatly: some monomorphic, others vary in either size, plumage or both. Common pattern of annual moult is a single complete post-breeding (pre-basic) moult, but some groups (e.g. Maluridae) or species (e.g. Banded Honeyeater *Certhionyx pectoralis*) also undergo a partial pre-breeding (pre-alternate) moult annually. Moult of primaries usually outward. Secondaries moult from innermost and outermost toward s5. Moult of tail usually centrifugal (outward from centre). Young altricial, nidicolous and dependent on adults for food; usually hatch with sparse to very sparse covering of down, mainly on dorsum; Menuridae (lyrebirds) have heavy natal down. Juvenile plumage usually duller than adult, and in many sexually dimorphic species, often similar to that of adult female.

There are few common features of food, feeding behaviour, social organization and behaviour, voice or breeding in such a large and diverse group of birds.

Volant; extinct Stephens Island Wren *Traversia lyalli* probably the only flightless passerine (Millener 1988). Movements vary greatly: some species long-distance migrants (e.g. Barn Swallow *Hirundo rustica*, Nightingale *Luscinia megarhynchos* and many Old World warblers, such as *Acrocephalus* and *Locustella*, breed in temperate Palaearctic and migrate to Africa or Indian subcontinent [BWP]; Acadian Flycatcher *Empidonax virescens* breeds North America and migrates to South America [Ridgely & Tudor 1994]), others sedentary in small territories (e.g. Cactus Wren *Campylorhynchus brunneicapillus* of sw. USA and Mexico [Ricklefs 1975; Ehrlich *et al.* 1988]). In HANZAB region, movements also vary widely: e.g. Yellow-faced Honeyeater *Lichenostomus chrysops* regular annual migrant in parts of e. Aust.; Rifleman *Acanthisitta chloris* of NZ sedentary in small territories. In Aust., movements often poorly known and unstudied; many species often said to be nomadic, with such claims often based on no or very poor knowledge of actual movements and based only on apparently irregular occurrence in an area (see General Introduction [Movements] for fuller discussion of this point).

Arboreal or terrestrial or both; some strictly arboreal (e.g. Hirundinidae), others strictly terrestrial (e.g. Menuridae, Pittidae); most combine both arboreal and terrestrial foraging to varying degrees, but usually with one predominating. Feed on almost all known food, from plant material to vertebrate animals, but most show some specialization for certain food, such as feeding on nectar (Nectariniidae), seeds (Passeridae), fruit (Zosteropidae), small vertebrates (Artamidae) and, commonly, insects (e.g. Maluridae, Pardalotidae, Petroicidae and others). Mostly feed by gleaning

and probing, including probing flowers for nectar; and other substrates for invertebrates; also feed by sallying, including various sallying techniques (sally-hovering, sally-striking and sally-pouncing), each suited for one group of prey, particularly moving animals.

In passerines, parental care in both sexes is well developed. However, a few species are parasitic, e.g. cowbirds *Molothrus* (Campbell & Lack 1985). Young are dependent on parents for food. Young beg by gaping, typically exposing brightly coloured inside of mouth, often with contrasting pale or dark spots; in non-passerines, bright gape present only in hoopoes (Upupidae), mousebirds (Coliiformes) and cuckoos (Cuculiformes) (BWP). See Boles & Longmore (1985) for descriptions of colours and markings inside the mouths of some Aust. passerines.

Anting is a highly specialized behaviour: ants are held in the bill and applied to the plumage, usually to the underside of the wing-tip (direct or active anting, or ant-application), or ants are allowed access to the plumage (indirect or passive anting, or ant-exposure), or both, e.g. anting recorded in Regent Honeyeaters *Xanthomyza phrygia* in HANZAB region, with bird then seen eating ant. Thought to be unique to Passeriformes (e.g. Simmons 1966; Campbell & Lack 1985; BWP). Suggested this may be comfort behaviour related to maintenance of feathers, by perhaps reducing ectoparasite load, removing stale or excess lipids, or adding supplementary essential oils (Campbell & Lack 1985); some secretions of ants are antibiotic, inhibiting growth of both fungi and bacteria, and the secondary acquisition of these antibiotic secretions would be an important advantage of anting (Ehrlick et al. 1986).

Other behavioural characters include head-scratching indirectly (or over the wing) in most families, with the foot brought up above the lowered wing. Head oiled indirectly, as seen in most taxa, but passerines also oil head by head-scratching, in which bird oils the bill directly, then transfers the oil first to one foot by scratching the bill, and then to the head by scratching the head with foot. To oil the undersurface of the wings, use bill or bill and head together, extending one wing at a time sideways and forward, carpus uppermost, and often alternating rapidly from one wing to the other. The stretching of one wing as a comfort movement seems common to all birds, but in passerines it is often accompanied by sideways fanning of tail. After both wings are stretched, passerines often give a two-leg stretch as they straighten the tarsal joints and lift the body. Heat is dissipated by gaping and panting (not by gular-fluttering, so far as known) (Campbell & Lack 1985; BWP). Bathing widespread, mainly by standing in shallow water, but some groups jump into and out of water repeatedly, or flight- or plunge-bathe, while others bathe only or mainly in rain or among wet foliage; for further details of bathing, see Campbell & Lack (1985). Passerines do not flap wings in the manner of non-passerines to dry, but perform various shaking movements, as well as preening (Campbell & Lack 1985). Dusting confined to only a few groups, but sunning, both for gaining heat (sun-basking) and other purposes (sun-exposure), is widespread, and of two distinct types: (1) lateral posture, in which sunning bird squats or sits down, usually on ground, and leans to one side exposing the flank or the 'sun-wing', which has been lowered and partly unfolded, and the fanned tail, which has been brought round to the same side; and (2) spread-eagle posture, in which bird squats or lies flat with both wings open and tail fanned (details in Campbell & Lack 1985; Simmons 1986).

There is a high incidence of co-operative breeding in Aust. and NZ, and it is especially common and well-studied in the Maluridae but is more widely recorded, including within the Acanthisittidae, Meliphagidae, Petroicidae, Pomatostomidae and Corcoracidae (see Dow 1978, 1980; Brown 1987; Ford 1989; Rowley & Russell 1997).

In vocal abilities, species of Passeriformes are more accomplished than those of any other order, but songs may be simple or highly complex, and repertoires small or large. Mimicry of calls of other species is practised by many species; c. 15% of Australian passerine species have been reported to mimic (Marshall 1950). The Superb Lyrebird and the Tui *Prosthemadera novaeseelandiae* have been classed among the best seven of the world's songsters (Hartshorne 1973). Oscines, or songbirds, have specialized forebrain song nuclei, and, through auditory feedback, learn their songs from those of adults, in much the same way as human young learn their spoken language from adults. In contrast, the songs of suboscines are relatively simple (like the non-learned call-notes of songbirds), repertoires are small, geographical variation is minimal, and development of song appears to take place without any imitative or feedback process. Some oscine species use vocal learning to generate large song repertoires and may vary them geographically, even locally. Other oscine species forgo these possibilities and have song repertoires more like those of suboscines; how the learning process maintains stereotypy of song over the range of such species is a mystery (Kroodsma 1996).

Apart from the five families discussed hereunder, syringeal structure of passeriform species of our area is similar, there being four pairs of intrinsic muscles. Pittidae have no intrinsic muscles (Ames 1971); calls are mostly loud strong whistles (Pizzey 1980). Acanthisittidae also have no intrinsic muscles, but the presence of a well-developed drum (fusion of posterior tracheal elements) suggests they may have once been present; vocal repertoire is not great (Ames 1971). Menuridae and Atrichornithidae have similar syringeal structures, with three pairs of intrinsic muscles; songs are highly developed, and there can be much mimicry (Ames 1971). Climacteridae, with four pairs of intrinsic muscles, exhibit gross asymmetry of the extrinsic muscles, unusual directions of muscle fibre in the intrinsic muscles, and an exceptionally robust sternotracheal muscle (Ames 1987); calls are brisk, sharp and piping (Pizzey 1980).

Extended tracheae are found in the genus *Manucodia* (Paradisaeidae), the calls of which are deep, loud or far-carrying (Frith 1994). In the only species occurring in our area, the Trumpet Manucode *M. keraudrenii*, the trachea forms a flat coil between the skin and the pectoral muscles, sometimes extending over the abdominal muscles as well,

and may be up to 828 mm in length, compared with body-length, from bill to pygostyle, of c. 150 mm (Ames 1971; Clench 1978).

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Family HIRUNDINIDAE swallows and martins

A fairly large family of familiar and morphologically similar small to medium-sized insectivorous passerines, adapted to aerial feeding, with distinctive slender bodies, short necks, long pointed wings, short broad bills, small weak feet and, often, deeply forked tails. The family comprises 83–89 species in 14–20 genera, and is cosmopolitan in distribution other than polar regions and many oceanic islands, occurring throughout Europe, most of Asia, including the Indian subcontinent, Africa, A'asia, islands of the sw. Pacific Ocean, and N., central and S. America (Turner & Rose 1989; Sibley & Monroe 1990; Monroe & Sibley 1993; Turner 2004; Sheldon *et al.* 2005). Nine, and possibly ten, species in four genera recorded in HANZAB region. Some early authors associated swifts (Apodidae) and swallows (see Sibley & Ahlquist [1990] and HANZAB 4 for discussion). Sharpe (1885) first termed the family Hirundinidae, and this has been maintained since. Opinion concerning nearest relatives varies. Sharpe (1885) thought Old World flycatchers (Muscicapidae) to be nearest relatives. Several authors (Stresemann 1927–34; Mayr & Amadon 1951; Bock 1962; Voous 1977; Peters) place swallows immediately after larks (Alaudidae) at the beginning of the oscine sequence. Berndt & Meise (1953) placed Hirundinidae between white-eyes (Zosteropidae) and waxwings (Bombycillidae). Beecher (1953) suggested affinities with Old World flycatchers and true thrushes (Muscicapidae) and starlings (Sturnidae) based on jaw musculature. Sibley (1970) suggested affinities with sylviid warblers (Sylviidae) and Muscicapidae based on electrophoresis of egg-white proteins. Wolters (1975–82) placed them after starlings at the end of the passerine sequence. DNA–DNA hybridization studies (Sibley & Ahlquist 1982, 1990) indicate swallows and martins are a distinctive group with no particularly close relatives. They are, however, part of the superfamily Sylvioidea, a major lineage of oscine passerines that includes the true warblers, Old World babblers, white-eyes, nuthatches, tits and bulbuls among others. Sibley & Ahlquist (1982) indicate that swallows and martins shared a common ancestor with sylviid warblers and Old World babblers, the divergence occurring c. 50 million years ago. More recent analyses based on nuclear DNA-sequences (Barker *et al.* 2004) supports Hirundinidae being part of the sylvioid lineage of songbirds.

The following two subfamilies are recognized by most authors (Turner & Rose 1989; Sibley & Monroe 1990; Monroe & Sibley 1993; Turner 2004; Sheldon *et al.* 2005): PSEUDOCHELIDONINAE (river-martins): Two species in single genus *Pseudochelidon*: African River-Martin *P. eurystomina* of Zaire; and White-eyed River-Martin *P. sirintarae* of Thailand; and HIRUNDININAE (typical swallows): Comprising 81–87 species in 13–19 genera, with cosmopolitan distribution. Nine species in four genera accepted for HANZAB region, seven of which, in two genera (*Hirundo*, *Delichon*), recorded in Aust. Pacific Swallow *Hirundo tahitica* possibly also occurs in Aust., but no formally accepted records of the species as yet (Christidis & Boles 1994; BARC). Red-rumped Swallow combined here with *Hirundo*, but often considered as *Cecropis*. Tree *H. nigricans* and Fairy *H. ariel* Martins also combined here with *Hirundo*, but often considered as *Petrochelidon* (see below for discussion).

Taxonomic relationships between genera within typical swallows (Hirundininae) were first clarified by Mayr & Bond (1943) who defined the following ten groups, based mainly on construction of nests and patterns of plumage (with number of species currently recognized following Turner [2004]): (1) PHEDINA (one species in w.-central Africa, and one in Madagascar and on Mascarene Is); (2) SAND MARTINS *Riparia* (five species, four with Afro-Asian distribution and one also in Americas); (3) MUD-NESTING SWALLOWS, comprising barn swallows *Hirundo* (14 species, cosmopolitan), crag martins *Ptyonoprogne* (three species, distributed in Africa and Eurasia), red-rumped swallows *Cecropis* (seven species, distributed in Africa and Eurasia, one species reaching Australo-Papuan Region), cliff swallows *Petrochelidon* (11 species, distributed through much of Africa, the Americas, India, e. Lesser Sundas and Australo-Papuan region), and house martins *Delichon* (three species, with Afro-Asian distribution, one species reaching HANZAB region); (4) WHITE-BACKED SWALLOW *Cheramoeca leucosternus* (endemic to Aust.); (5) GREY-RUMPED SWALLOW *Pseudhirundo griseopyga* (endemic to Africa); (6) AFRICAN SAW-WINGS *Psilidoprocne* (five species, Africa); (7) ROUGH-WINGED SWALLOWS comprising *Stelgidopteryx* (two species in Americas), *Alopocheilidon* (one species in S. America) and *Neochelidon* (one species in S. America); (8) ATTICORA GROUP, of the Americas, comprising *Notiochelidon* (four species in central and S. America, including Blue-and-white Swallow *N. cyanoleuca* which sometimes placed in monotypic genus *Pygochelidon*), *Haplochelidon* (one species, S. America) and *Atticora* (two species, S. America); (9) TREE SWALLOWS *Tachycineta* (nine species, the Americas); and (10) AMERICAN MARTINS *Progne* (nine species, the Americas). These genera and groupings are largely supported by molecular analyses, but the New World rough-winged swallows and Neotropical *atticora* group form a monophyletic cluster, with *Tachycineta* probably forming a sister-group to these (Sheldon *et al.* 2005). Several authors (Turner & Rose 1989; Sibley & Monroe 1990; Christidis & Boles 1994) do not recognize *Cecropis* or *Petrochelidon*, instead combining these with *Hirundo*; we follow their treatment here, but accept that the rigorous DNA-sequencing studies of Sheldon *et al.* (2005) provide empirical evidence for accepting *Cecropis* and *Petrochelidon*. Several other authors also accept latter two genera (Mayr & Bond 1953; Sheldon & Winkler 1993; Dickinson & Decker 2001; Turner 2004;

DAB). Basal relict lineages include White-backed Swallow, Grey-rumped Swallow and river martins, with disjunct distributions in Africa and Aust. (Sheldon *et al.* 2005).

Size varies from small (e.g. Fairy Martin: total length 11–12 cm, weight 9–14 g; and White-thighed Swallow *Neochelidon tibialis*: total length 12 cm, weight 10 g) to medium-sized (e.g. Purple Martin *Progne subis*: total length c. 19 cm, weight 48–64 g; and Mosque Swallow *Hirundo senegalensis*, total length c. 24 cm, weight 38–54 g). In HANZAB region, smallest is Fairy Martin and largest is migrant Barn Swallow *Hirundo rustica* (total length c. 18 cm, weight 16–24 g) or Red-rumped Swallow (total length 16–17 cm, weight c. 33 g). Species in the family share the following morphological characteristics (summarized from Beecher 1953; Bock 1962; Warner 1972; Moreno 1986; Turner & Rose 1989; Turner 2004; BWP; DAB): Body slender. Neck short. Wings long and pointed at tips. Ten primaries, with outermost (p10) vestigial; p9 often longest; two genera, *Stelgidopteryx* and *Psalidoprocne*, unique in having series of fine serrations (barbules) along outer edge of outer primaries. Nine secondaries, including three tertials. Tail varies from short and rather square or slightly notched at tip (e.g. cliff swallows, including Fairy and Tree Martins) to rather short with obvious fork or deep notch at tip (e.g. *Progne* and *Riparia* martins) or long and deeply forked, with elongated outermost rectrices (e.g. most *Hirundo* swallows); one species, White-eyed River Martin, is unique in having highly elongated central rectrices. Bill short, broad and flattened; tomia notched near tip. Nares usually operculate, but semi-operculate in house martins (*Delichon*) and red-rumped swallows (*Cecropis* [here considered *Hirundo*]), and non-operculate in cliff swallows; nostrils usually lateral slits, but sunken rounded apertures in cliff swallows (including Tree and Fairy Martins). Gape broad. Rictal bristles present, but usually vestigial. Loral feathering directed forward to act as lens shade for eyes; act under muscular control. Tongue broad, tapering to short, bifid tip. Legs and feet short; foot musculature rather weakly developed; front toes nearly united at base. Tarsus sharply ridged at rear (acutiplantar); tarsal scaling laminiplantar. Tarsi and toes usually naked, but partly or nearly fully feathered in some species (e.g. house martins). Claws rather strong. Jaw musculature distinctive, with enlarged protractors allowing bill to be opened widely. Syrinx unique among passerines, having complete bronchial rings (except in subfamily Pseudochelidoninae which have large syrinx with half bronchial rings and large internal membrane running length of bronchial tubes). Humerus short with single pneumatic fossa at head and vestigial second tricipital fossa. Maxillo-palatine processes pin-like. Double ectethmoid foramina. Aust. species have multiple orbital perforations at front of cranium. Temporal fossae narrow.

Following summarized from Turner & Rose (1989) and Turner (2004). Upperparts typically glossy, blackish, dark bluish or dark greenish, and underbody pale, often with dark streaking; some species (e.g. rough-winged swallows, crag martins) have much duller, brownish plumage, while others (e.g. some African saw-wings) have uniformly blackish plumage. Many species (e.g. red-rumped swallows, Tree and Fairy Martins) have contrasting colour to rump–uppertail-coverts or forehead or both. Many species have white markings, such as patches or spots, on rectrices. A few species (e.g. White-backed Swallow) have distinctive pattern to head and upperbody. Bare parts typically blackish or grey in adults. Sexes usually alike in plumage, but in some species (e.g. *Progne* martins) female duller; adult male *Hirundo* have longer, more deeply forked tails than adult females. Nestlings mostly naked at hatching, with a few patches of down; denser down develops after c. 1 week. Nestlings lack markings of mouth or tongue. Fledge in juvenile plumage, which is usually duller and less glossy than that of adults, and usually also have shorter, less deeply forked tails (particularly in *Hirundo*). Nestlings and juveniles of most species have swollen yellow gapes. Usually undergo a complete post-juvenile (first pre-basic) moult to adult (definitive basic) plumage, but a few species (e.g. Tree Swallow *Tachycineta bicolor*) acquire a distinct, brownish first immature (first basic) plumage in this moult. Adults usually undergo one complete post-breeding (pre-basic) moult annually, with no change in appearance; in migratory species (e.g. Barn Swallow), moult usually starts on wintering grounds, but sometimes (e.g. Collared Sand Martin *Riparia riparia*) starts on breeding grounds and is then suspended till arrival on wintering grounds. A few species (e.g. Asian House Martin *Delichon dasypus*) also undergo a partial pre-breeding (pre-alternate) moult, involving mainly feathers of head and body, and resulting in breeding plumage that usually appears little or no different from non-breeding plumage; sometimes pre-breeding and post-breeding moults overlap. Primaries moult outward, starting at p1; moult usually slow. Moult of secondaries inward; moult of tertials starts with central feather. Moult of tail centrifugal, usually starting during early stage of, or about halfway through, moult of primaries. Moult of body usually starts at about same time as moult of primaries.

Habitat usually includes open areas suitable for aerial foraging for insects. Generally found over open or sparsely wooded areas, and often near or over water (e.g. Pale Martin *Riparia diluta*), though sometimes inhabit open areas well away from water (e.g. Red-rumped Swallow in its wintering ranges in Africa and India). Often use open modified habitats, such as farmland (e.g. Grey-rumped Swallow), roadsides, airstrips and sewage ponds (e.g. Red-throated Swallow *Hirundo rufigula*). Also commonly over grassland, savanna and at edges of woodlands or forests (e.g. saw-wings *Psalidoprocne*). Often near settlement including residential areas, though densely built-up areas often avoided. Densely wooded habitats mostly avoided, but some species occur over forests (e.g. Pacific Swallow and Asian House Martin). Roost and nest in sand, dirt or gravel banks (e.g. Collared Sand Martin), crags, cliffs and caves, or artificial structures, such as culverts, bridges and buildings (e.g. Eurasian Crag Martin *Pytonoprocne rupestris*). Found from sea level to c. 4000 m asl. In Aust. and NZ, mostly over open habitats, including farmland,

airfields, grasslands, coastal areas, and wide range of wetlands; less often in or over mangroves and open woodland; some species associated with more heavily treed dry and wet eucalypt forests and rainforest, often at edges or clearings such as those created by logging (e.g. Tree Martin and Welcome Swallow *Hirundo neoxena*). Also common round settlements and cities (Heinzel *et al.* 1977; King *et al.* 1978; AOU 1998; Coates 1990; Keith *et al.* 1992; Ridgely & Tudor 1994; Orn. Soc. Japan 2000; Robson 2000, 2002; Turner 2004; BWP; see species accounts).

Many highly migratory. Extraliminally, range from sedentary or resident (e.g. Nepal House Martin *Delichon nipalensis*), predominantly resident with altitudinal movements (e.g. Eurasian Crag Martin, Black Saw-wing *Psalidoprocne pristoptera*), partly migratory (e.g. Blue-and-white Swallow) to total long-distance migrants (e.g. Barn Swallow). Several species more sedentary at lower latitudes, and migratory at higher latitudes (e.g. Red-breasted Swallow *Hirundo semirufa*, Lesser Striped Swallow *H. abyssinica*, Grey-breasted Martin *Progne chalybea*). This trend reflected across family as a whole, with tropical or subtropical breeding species more likely to be sedentary or resident (e.g. Congo Sand Martin *Riparia congica*) though many of these make local seasonal movements (e.g. Brazza's Martin *Phedina brazzae*), and most others, especially Holarctic breeding species, making at least some movement away from higher latitudes during winter (e.g. Collared Sand Martin and Northern House Martin *Delichon urbicum*). In HANZAB region, breeding species resident (White-backed Swallow) to partly migratory, with strong N-S pattern of movements (e.g. Tree Martin); Barn Swallow a regular non-breeding visitor to n. Aust. and vagrant elsewhere, mainly Sept.–Apr. (de Schauensee 1970, 1984; AOU 1998; Keith *et al.* 1992; Robson 2000; Griffioen & Clarke 2002; Turner 2004; BWP; see species accounts).

Aerial insectivores. Diet consists almost entirely of flying insects, but other invertebrates (e.g. spiders, small crustaceans) eaten occasionally, and a few species also take fruit or seeds in autumn–winter when insects scarce; other matter, such as gravel, shell fragments and pieces of fish bone, are also ingested. Most prey taken in flight by screening or sallying; usually involves pursuit of aerial prey, but items may also be snatched from surface of water or other substrates. When chasing aerial prey, use one of two general methods: (1) for agile prey, flight is rapid and involves much banking and turning; (2) for less manoeuvrable prey, which often occur in swarms, flight punctuated by gliding and fluttering. Also forage occasionally by sally-hovering; and sometimes seen hovering or fluttering in vegetation to flush insects. Despite preference for aerial feeding, food sometimes gleaned on ground or while perched, usually in adverse weather (when few insects in flight) or when non-aerial prey abundant. Foraging heights vary between species according to location of preferred prey items, but all species tend to feed at low levels in poor weather, when insects are scarce at higher altitudes (see above). Opportunistic; readily attend sites that attract insects or provide rich sources of prey (e.g. frequent fires, and associate with livestock or tractors ploughing fields to take advantage of flushed insects). Forage selectively: usually seek largest prey available, though all species take some smaller prey, and some (e.g. Northern House Martin, Red-throated Swallow *Hirundo rufigula*, Cliff Swallow *Hirundo pyrrhonota*) specialize on small prey; and generally avoid stinging insects. Many species forage singly or in pairs during breeding season; otherwise, forage in flocks that can be quite large at sites where food abundant. Drink regularly, by dipping bill into water while flying low over surface of creeks, lakes, rivers or the like (Keith *et al.* 1992; Turner 2004; BWP; see species accounts).

During breeding season, most species usually seen singly, in pairs, or in small flocks, but some gregarious when breeding (e.g. Collared Sand Martin *Riparia riparia*). When not breeding, most are gregarious, with some species occasionally gathering in large flocks of hundreds of thousands, especially near roosting sites (see below). Nearly all socially monogamous, but extra-pair copulation common. Some Tree Swallows occasionally polygynous. In most species, pair-bonds usually last only for duration of breeding season. Incubation by both sexes in some species, but only by female in others. Both sexes feed nestlings and fledgelings. Many species defend only nest and its immediate vicinity, but some species highly territorial and defend large all-purpose territories (e.g. Mangrove Swallow *Tachycineta albilinea*). Many nest solitarily, but some colonial. In colonial species, colonies vary greatly in size from just a few individuals, up to colonies of thousands (e.g. Cliff Swallow). Some colonial species build nests so close as to be in contact with those of neighbours (e.g. Streak-throated Swallow *Hirundo fluvicola*). Many species roost communally, but at start of breeding season, pair often roost at nest-site, and when nest active, female often roosts in nest. Flocks of some species perform spectacular aerial manoeuvres when flying to and from communal roosts, and sometimes large communal roosts consist of more than one species. Swallows and martins spend much time maintaining plumage. Often perch and preen after foraging in early morning and late evening, and often scratch both while perched and in flight. Scratch head indirectly. Usually bathe by skimming over water and briefly hitting surface to splash themselves, but occasionally wade into shallow water. Often also sunbathe. At start of breeding season, males usually choose a nest-site which they defend from other males. Threat displays often include calling and sometimes ruffling of feathers of head or vibrating of wings. Also lunge at or chase intruders, sometimes resulting in fights. Fights between males can be rather violent, with combatants beating each other with wings, pecking each other, pulling out feathers or grappling with feet. Once paired, both members of pair aggressively defend nest-site. In order to attract female, male usually sings in front of chosen nest-site, and in some species, male also performs visual displays, e.g. male Purple Martins fly up, circle over site and then dive back down and enter hollow. In some other species (e.g. Cliff Swallow), courtship behaviour almost lacking apart from singing, and the pair do little more

than tolerate each other at the nest-site. Pair-formation usually occurs at nest-site when female accepts a site that has been chosen and defended by a male. Copulation often occurs in or near nest, and is sometimes preceded by a short invitation display (Keith *et al.* 1992; Taylor 2004; BWP).

Song usually consists of a series of twittering or grating notes. Also utter variety of other calls, including alarm calls, contact calls, aggressive calls, submissive calls, copulation calls and begging calls. Often also produce non-vocal sounds, such as bill-snapping and fluttering or swishing sounds made by wings (Keith *et al.* 1992; Taylor 2004; BWP).

Socially monogamous, but extra-pair copulation common; rarely polygynous. Most species nest solitarily or in loose groups, but some are colonial, and colonies of some species (e.g. Cliff Swallow) may contain thousands of pairs (see above). **SEASON:** In temperate regions, breed mainly in late spring and summer, though season sometimes longer, e.g. Welcome Swallow recorded breeding throughout year in parts of Aust. Season shorter at higher latitudes (where laying may not begin till early summer), but can extend throughout year in tropics and subtropics; sometimes with peaks during rains. Breeding can also follow rains in arid regions. Breeding potential of some species may be limited by lack of mud for nests, particularly during extended dry periods or drought. **SITE:** Species that nest in pre-existing holes, or in burrows that they excavate themselves, use sites such as tree-hollows, termitaria, crevices in cliffs and caves, burrows in banks and cuttings, holes in artificial structures, and nest-boxes. Others build mud nests (see below), attached to trees, riverbanks, cliffs and caves, and a multitude of artificial structures, including bridges, culverts, wells, dams, mine shafts and exteriors and interiors of buildings. Use of unusual sites, generally artificial, is not uncommon in some species. Nests usually placed some distance above ground or often above water, and mud nests often built just beneath overhead cover. Nest-sites, especially mud nests, commonly re-used. Some species, such as Purple Martin, may usurp nests of other hirundines. **NEST, MATERIALS:** Nesting burrows comprise an entrance-tunnel, sometimes >1 m long, with an enlarged nest-chamber at the end. Mud nests vary in form, from open cups or half-cups to retort- or bottle-shaped structures with entrance spouts. Structure of mud nests often varies according to nest-site, e.g. nests of Welcome Swallow cup-shaped on horizontal surfaces, and usually half-cup if fixed to vertical surface or built in angle; when nesting in crevices, some species (e.g. South African Swallow *Hirundo spilodera*) simply add mud to reduce diameter of entrance to nest and to create tunnel. Most mud-nesting species build nests from pellets of pure mud, but some mix mud with grass, rootlets or other material. Both nesting burrows and mud nests have bowl-shaped lining, most commonly of grass, rootlets, leaves, twigs, hair and feathers. Nesting materials (including mud) sometimes stolen from nests of conspecifics. Both sexes build, which can take several days or several weeks. **EGGS:** Varyingly oval or subelliptical, usually smooth and somewhat glossy. Typically white and unmarked, though in some mud-nesting species, eggs spotted and blotched with reddish, brownish, grey or purple markings, usually concentrated at large end. Size of eggs does not vary substantially between smaller species (e.g. Blue-and-white Swallow, 17.2 × 12.5 mm, 1.4 g) and larger ones (e.g. Purple Martin, 24.3 × 17.4 mm, 4.1g). **CLUTCH-SIZE:** In tropics, usually two or three. In temperate regions, typical range 3–6, and in many species, clutch-size usually 4–5; clutches of 1–2 or 7–8 recorded occasionally, but may result from disruption of laying or egg-dumping. Clutch-size declines as breeding season progresses; and, in widely distributed species, tends to be smaller at lower latitudes. **LAYING:** Eggs laid early in morning, usually on successive days. Some species (e.g. Purple Martin, Cliff Swallow) engage in egg-dumping. Some species (e.g. Cliff Swallow) usually rear one brood per season, while others (e.g. Barn Swallow) often rear two, or sometimes three; multiple broods occur most commonly in lower latitudes. **INCUBATION:** By both sexes or, in some species, by female only. Begins with last or penultimate egg when by female only, and usually before penultimate egg when by both sexes. Incubation period in most species 14–18 days, but ranges from 10 to 21 days. **YOUNG:** Hatch over 1, 2 or sometimes 3 days. Nestlings usually fed by both parents, often almost equally; in cases of polygyny, one brood occasionally fed by female parent only. Helpers may also feed young in some species (e.g. Barn and Welcome Swallows). Nestlings usually brooded by both parents. Adults remove or swallow faecal sacs for c. 1 week after hatching. **FLEDGING TO INDEPENDENCE:** Fledging period usually 3–4 weeks. Fledging usually synchronous, with entire brood usually fledging on same day or within 24 h (and sometimes much less), but broods occasionally leave over >1 day. Young return to nest often during day, and roost in nest at night, for several days, and sometimes several weeks, after fledging. Both sexes feed fledgelings. Young dependent on adults for 1–4 weeks after fledging. **SUCCESS:** Causes of breeding failure include extreme or adverse weather, and depredation of nests by a variety of avian, reptilian, mammalian and even invertebrate predators. Nests also susceptible to infestation by a wide variety of blood-sucking and other parasites, which can reduce breeding success (Keith *et al.* 1992; Turner 2004; BWP; see species accounts).

Seven species considered globally threatened. White-eyed River Martin of Thailand, discovered only in 1968, is critically endangered, mainly as a result of loss and degradation of habitat at their unknown breeding sites and wintering grounds, exacerbated by hunting and trapping at roosting sites. Six other species considered vulnerable: Bahama Swallow *Tachycineta cyaneoviridis* (Bahamas), Golden Swallow *T. euchrysea* (Jamaica, Haiti, Dominican Republic), Galápagos Martin *Progne modesta* (Galápagos), Peruvian Martin *P. murphyi* (Peru, Chile), Blue Swallow *Hirundo atrocaerulea* (e. Africa), and White-tailed Swallow *H. megaensis* (Ethiopia) (Stattersfield & Capper 2000; BirdLife International Species Factsheets, available at <http://www.birdlife.org/datazone/species/index.html> [accessed Sept. 2005]).

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Hirundo ariel Fairy Martin

COLOUR PLATE FACING PAGES 1529, 1560

Collocalia ariel Gould, 1842, *Birds Australia*, pt. 9: pl. 15 and text in vol. 2 — all southern portions of Australia = New South Wales.

Named after Ariel of mediaeval folklore, a spirit or sylph of the air.

OTHER ENGLISH NAMES Bottle, Cliff or Land Swallow.

MONOTYPIC

FIELD IDENTIFICATION Length c. 12 cm; wingspan c. 22 cm; weight 10.5 (9–14) g. Small, short-tailed swallow with large round head, small short bill with wide gape, short neck, stocky body, short tail (slightly forked when closed, squarish when spread) and long, broad wings with pointed tips that extend slightly past tip of tail. Similar in shape to Tree Martin *Hirundo nigricans* but slightly smaller and with slightly less forked tail; in flight, wings shorter than most other

swallows, but similar to Tree Martin. Sexes similar. Juveniles differ mainly by duller plumage without gloss. Juveniles moult into adult plumage. No geographical variation. **Adult** Lower forehead, pale rufous-orange; upper forehead, crown, orange-rufous with faint darker mottling or streaking. Most of lores, dull white; rear lores to eyes, black, forming contrasting small eye-patch. Ear-coverts, duller rufous than top of head, heavily streaked black, grading darker on hind ear-coverts, where

almost blackish. Upper hindneck and upper sides of neck, orange-rufous with faint darker mottling or streaking, concolorous with top of head, and extending behind hind ear-coverts in half-crescent. Lower hindneck and lower sides of neck, cream or white, streaked glossy blue-black and buff, sharply cut off from rufous upper hindneck; mantle mostly glossy blue-black with narrow buff, cream or white streaking; scapulars and back, uniform glossy blue-black; rump and all but longest uppertail-coverts, dull white with cream or buff tinge, faintly streaked dark brown, forming large, distinct pale rump-patch; longest uppertail-coverts, brown or dark brown with narrow cream or buff fringes, contrasting with pale rump-patch. Uppertail, blackish brown with faint bluish or greenish gloss. On upperwing, most marginal and all median secondary coverts, brownish black with glossy blue tinge; greater secondary and primary coverts, dark brown, apart from whitish strip along leading edge of outerwing. Remiges, black-brown with faint blue gloss, becoming dark brown with wear; tertials also have narrow, distinct off-white to cream fringes to tips when fresh, lost with wear. Chin and throat, dull white with rufous tinge and fine blackish streaking; sides of breast, dark grey-brown with faint blackish streaking; rest of breast and flanks, dirty buff, with diffuse white streaking; belly, vent and undertail-coverts, white with cream tinge. Undertail, dark grey with narrow white inner edges, difficult to see in flight. Underwing mostly dirty buff with slight rufous tinge and broad blackish mottling along leading edge of primary coverts; dark-grey remiges contrast and form broad dark trailing edge. Bill, black; iris, blackish brown; orbital ring, dark grey. Legs and feet, dark pinkish-grey. **Juvenile** Similar to adult, but differs by: forehead, crown, nape, sides of face, upper hindneck and upper sides of neck, much duller rufous, with slightly stronger blackish streaking or mottling than adult, present over all except upper hindneck; ear-coverts concolorous with top of head. Eye-patch, grey, not black, less well defined, and more diffuse in front of eye. Lower hindneck and sides of neck, brown with dull-rufous or dull-white streaking, barely contrasting with top of head and neck. Mantle, scapulars and back, blackish brown, not black, with faint greenish-blue gloss. Uppertail lacks gloss. Upperwing dark, much like adult, differing subtly by: dark brown (less blackish), not glossy, with broader buff fringes to feathers (difficult to see in field); tertials have broad cinnamon-buff tips (lost with wear); primaries and secondaries have narrow buff-grey edging and fringing (difficult to see in field). Malar area, chin and throat, dull white (no rufous tinge) with fainter dark streaking on chin and upper throat (on whole area in adult). Rest of plumage as adult. Bill, grey-black with dull-yellow or flesh-yellow base to lower mandible and gape.

Similar species Most similar species is closely related Tree Martin (q.v.). Easily distinguished from **Welcome Swallow** *Hirundo neoxena* and **Barn Swallow** *H. rustica* by: reddish top of head and neck (dark, glossy blue-black on Welcome and Barn Swallows); whitish rump-patch (entire upperparts dark, glossy blue-black on Welcome and Barn Swallows); short tail with shallow fork and blunt tips to outer rectrices (tail deeply forked on Welcome and Barn Swallows, with elongated outer rectrices, though in moult these may be missing); and size (Welcome and Barn Swallows larger). See **Asian House Martin** *Delichon dasypus* and **Red-rumped Swallow** *H. daurica* for differences from those species.

Often occur in flocks, largest when on migration or roosting; sometimes seen singly. Form feeding flocks with Tree Martins and Welcome Swallows, and perch on overhead wires and fences with them; occasionally also feed with woodswallows *Artamus*. Take insects in air, by screening or sallying. Flight like that of Tree Martin, but perhaps faster and more buoyant; have identical fluttering pattern: fly low to ground, quickly twisting and turning effortlessly with rapid wing-beats,

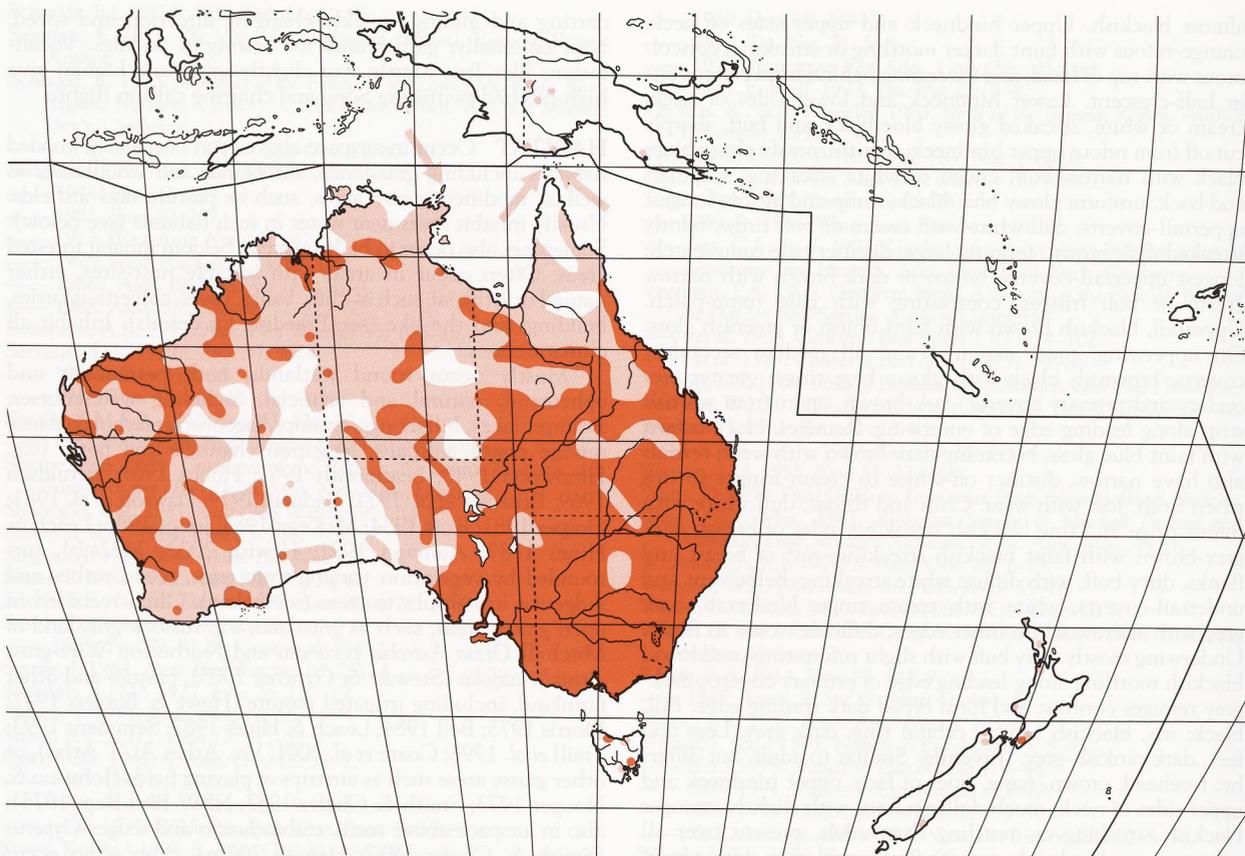
darting and gliding, quickly changing direction and speed. Nest colonially; gather mud for nesting at puddles. Vocalizations like Tree Martin, but slightly softer and higher; give high-pitched twittering Song and churring calls in flight.

HABITAT Occur in airspace above open or sparsely wooded habitats including grasslands, shrublands and woodlands, as well as modified grassy areas, such as pasture and airfields. Usually inhabit areas near water in such habitats (see below). Sometimes also occur in built-up areas. Seldom inhabit forested areas. Often occur in areas with suitable nest-sites, either natural or artificial, such as cliffs, banks, caves, culverts, quarries, buildings and the like (see Breeding for details). Inhabit all climatic zones.

Mostly occur round wetlands, both permanent and ephemeral, natural and artificial, including watercourses, swamps, lakes, billabongs, swamps, lagoons, waterholes, dams, sewage ponds, saltpans, irrigation channels and bores (e.g. Hindwood 1940; Learmonth 1951; Hobbs 1961; Beruldsen 1969; Bristowe *et al.* 1971; Badman 1979; Dawson *et al.* 1981; Gosper 1981; Ross 1984; McKean 1985; Jones 1986; Leach & Hines 1987; Aumann 1991; Hewish 2000, 2002a,b), surrounded by vegetation varying from grass, reeds, rushes and sedges or low shrubs to trees (see below). Often recorded in open grassy areas, such as grassland, e.g. tussock grassland of Mitchell Grass *Astrebala pectinata* and Feathertop Wire-grass *Aristida latifolia* (Stewart & Gynther 2003), pasture and other farmland, including irrigated pasture (Howe & Burgess 1942; Morris 1975; Bell 1984; Leach & Hines 1987; Semmens 1993; Traill *et al.* 1996; Coate *et al.* 2001; Vic. Atlas; ACT Atlas), or other grassy areas such as airstrips or playing fields (Johnson & Hooper 1973; Smith & Chafer 1987; NSW Bird Rep. 1975); also in airspace above reeds, rushes *Juncus* and sedges *Cyperus* (Smith & Chafer 1987; Hewish 2002a). Also often occur above shrublands, including low coastal saltmarsh dominated by *Sarcocornia*, coastal or near-coastal heathlands, chenopod shrublands dominated by saltbush *Atriplex*, *Rhagodia* and bluebush *Maireana* in arid and semi-arid areas, and low open shrubland dominated by various acacias in semi-arid areas (Recher 1975; Klau 1988; Mitchell *et al.* 1996; Brandle 1998; Ashton 2001; Stewart & Gynther 2003). Sometimes also occur above open woodlands, dominated by eucalypts such as Yellow Box and Blakely's Red Gum in foothills (Er & Tidemann 1996, 2001; Er 1997; Er *et al.* 1998), Bimble Box *Eucalyptus populnea* on plains (Jones 1986), and riparian woodlands of River Red Gums, Black Box or Coolibahs on plains (McGilp 1931; Cornish & Ellis 1974; Jones 1986; Brandle 1998; Stewart & Gynther 2003); also in woodlands dominated by acacias, including Mulga, Gidgee, Dead Finish or Mineritche *Acacia cyperophylla*, or mixed low woodland of Broad-leaf Hopbush *Dodonaea viscosa*–Sandhill Wattle *Acacia ligulata* (Brandle 1998). In Great Sandy Desert, recorded on sand-dunes with Coolibah and Hard Spinifex *Triodia basedowii* growing in swales, and dune crests vegetated with Sandhill Bloodwood *Eucalyptus chippendalei* and Feathertop Spinifex *Triodia schinzii* (Read 1998). Occasionally recorded round dry sclerophyll forests, usually round edges (Gepp & Fife 1975; Traill *et al.* 1996). Very occasionally recorded in built-up areas, including railway yards (D'Ombra 1931; Sedgwick 1958; Jones 1981; Read 1999).

DISTRIBUTION AND POPULATION Widespread on mainland Aust., with a few records in Tas., NZ and on offshore islands; very occasionally recorded in New Guinea (Coates 1990).

Aust. Widespread on mainland. **Qld** Generally widespread (Aust. Atlas 1, 2; Storr 19), except on islands in Torres Str. and C. York Pen., where recorded at sparsely scattered sites, e.g. a few islands in w. Torres Str., C. York, Weipa and



Iron Ra. (Johnson & Hooper 1973; Draffan *et al.* 1983; Beruldsen 1990; Aust. Atlas 1, 2; Storr 19). **NSW, Vic.** Widespread (Morris *et al.* 1981; Cooper & McAllan 1995; Aust. Atlas 1, 2; Vic. Atlas; NSW Bird Reps). **Tas.** Vagrant; though occasionally seen crossing Bass Str. from Wilsons Prom., s. Vic. (Sutton 1998), not recorded on islands in the Strait, but unconfirmed historical report from Furneaux Grp in early 20th century (Le Souëf 1902). All singles unless stated: evidence of breeding, Bridport, 1883 (Littler 1910a); unknown number, round Launceston, Oct. 1893 (Littler 1910a); nests, near Tunbridge, 1966–67 (Vincent 1968); Clear Lagoon, Sandford, 24 Oct. 1971 (Vincent 1972; Tas. Bird Rep. 1); two nests, near Wynyard, 1975 (Tas. Bird Rep. 5); Legana, 11 Sept. 1983 (Tas. Bird Rep. 13); Blackmans Bay, near Kingston, 12 Jan. 1998 (Tas. Bird Rep. 27). Single unconfirmed report from near C. Bruny, 1999 (Tas. Bird Rep. 28). **SA** Widespread W to line joining Rocky Pt, near Ceduna, and Moolalpinna Hill in e. Great Victoria Desert; very occasionally recorded farther W, e.g. Yalata Mission, Head of the Bight, Cook and Serpentine Ls (Klau 1988; Stove 1994; Horton 2000; Aust. Atlas 1, 2; SA Bird Rep. 1977–81). **WA** Widespread in all regions, though generally sparsely scattered in desert areas, from s. Great Sandy Desert, S through Gibson and Great Victoria Deserts, to Nullarbor Plain (Johnstone *et al.* 1979; Storr 1981; Storr 11, 16, 21, 22, 26, 27; Aust. Atlas 1, 2), but observations of old nests in North-Eastern Interior Region suggest that possibly more widespread than these records indicate (Storr 1981; Start & Fuller 1983); also sparsely scattered in s. Wheatbelt and in extreme SW (Saunders & Ingram 1995; Storr 28, 35). **NT** Widespread, especially in W (Goodfellow 2001; Storr 7; Aust. Atlas 1, 2); sparsely scattered records in Arnhem Land and Simpson Desert may reflect the distribution of birdwatchers rather than birds, though nevertheless may occur infrequently in these areas, e.g. considered rare vagrant to Groote Eylandt and

adjacent areas of Arnhem Land, with no published records other than those in Aust. Atlas (Noske & Brennan 2002), and considered rare in Simpson Desert (Gibson & Cole 1988).

NZ Vagrant. **NI** Two nests, Te Hopei, Dec. 1978 (Bell 1984); single, C. Reinga, 30 Nov. 1983 (Riddell & Taylor 1984); unknown number, Leigh, Nov. 1984 (NZCL); single, Red Hill, Papakura, 23 Jan. 1985 (CSN 33); single, Greytown, 1 July 1997 (CSN 47); four, Pungaereere Stream, Rahotu, 5 Sept. 2001, and single on 24 Sept. 2001 (CSN 50). **SI** Single, Puponga, Farewell Spit, 18 Nov. 1982 (Bell 1984); one or two, L. Holm, 17 and 26 Feb., 28 Mar. and 29–30 Dec. 1983 (Nevill 1984; CSN 32); five, Totaranui, Abel Tasman NP, late Feb. 1983 (Bell 1984); single (probably same bird as at L. Holm), Berwick, 28 Mar. 1983 (Nevill 1984); five, Abel Tasman NP, 27 Feb. 1999 (CSN 48).

Lord Howe I. Vagrant. Single, 25 May 1975 (NSW Bird Rep. 1975); 8–10, c. 1978–80 (McAllan *et al.* 2004); two, 28 Jan. 1986 (NSW Bird Rep. 1986); two, 6 Mar. 1988 (McAllan *et al.* 2004); single, July 1992 (McAllan *et al.* 2004); four, 28–29 Aug. 2001 (Aust. Atlas 2); unknown number, late Oct. 2002 (Aust. Atlas 2).

Norfolk I. No confirmed records. Two unconfirmed reports, 21 June–15 July 1985 (Hermes *et al.* 1986) and Mar. 1994 (Andrew & Eades 1994).

Breeding **E. AUST.:** In n. Qld, few records N of 20°S, except in coastal and subcoastal areas, where recorded N to Mossman, with a few other records in Gulf Country, near Lorraine Stn (on both Alexandra and Leichhardt Rs) and Lawn Hill NP. Widespread elsewhere in e. Aust., S of 20°S, E of line from Mt Isa, Qld, to Wudinna Rock, SA (Aust. Atlas 1, 2; NRS). **s., CENTRAL AND W. AUST.:** Widespread but scattered at many sites in inland SA and s. NT, from 30°S N to 23°S, and mainly W to line from Tarcoola, SA, to Longs Ra., W of Watarrka (Kings Canyon) NP, with record farther W at Serpentine Ls. In WA, very occasionally recorded at a few

scattered sites in Great Victoria Desert and on Nullarbor Plain, e.g. Neale Junction, Yeo Ls and Rawlinna; farther W, occasionally recorded in S, e.g. Esperance and Tenterden, but more widespread in area W of 122°E, and from Purnta Rock (N of L. King) and near Brookton in South-Western Div., N to Whim Ck and De Grey Stn in Pilbara Region (Brooker *et al.* 1979; Black & Badman 1986; Aust. Atlas 1, 2; NRS). N. AUST.: Recorded at a few scattered sites N of 20°S: in Kimberley Div., WA, from Broome E to Mt Bell, Geikie Gorge and Fitzroy Crossing, N to Charmley Gorge and S into n. Great Sandy Desert, and also in e. Kimberley Div., round Kununurra, Dunham R. and Argyle Diamond Mine. Scattered records in Top End of NT, from Keep R. NP E to Larrimah; other records on Sir Edward Pellew Is and lower reaches of McArthur R., at Calvert Hills Stn and Alroy Downs in Barkly Tableland, and in e. Tanami Desert (Schodde 1976; McKean 1985; Aumann 1991; Chapman *et al.* 1993; Coate *et al.* 1998, 2001; Aust. Atlas 1, 2; NRS). TAS.: Three records (including one historical) (Littler 1910a; Vincent 1968; Tas. Bird Rep. 5). NZ Two inactive nests observed at Te Hopai, s. Wairarapa, and three apparent juveniles at Totaranui, Abel Tasman NP, possibly indicate local breeding (Bell 1984).

Change in range, population Population round Roxby Downs, inland SA, has increased since 1980s (Read 1999), and range has expanded into nw. SA, where first recorded in 1972 (Close & Jaensch 1984). Range possibly expanded onto Swan Coastal Plain, WA, in early 20th century, with nests recorded near Mogumber in 1903 (Whitlock 1905) and Gingin in 1928 (Serventy 1928). Suggested that population in Wheatbelt of s. WA may have declined since 1950s (Saunders & Ingram 1995), while that in Gascoyne Region has increased, with first record in Carnarvon Basin in 1970 (Johnstone *et al.* 2000; Storr 21); population in Pilbara Region has also increased since c. 1960s (Storr 16), though previously recorded as 'fairly common' in early 20th century (Whitlock 1909). Breeding range expanded inland to include sites near Kalgoorlie in c. 1970s (Storr 26).

Populations RECORDED DENSITIES: 0.1 birds/ha (mean, wet season 1997) (Jones & Wieneke 2000); maximum 0.16 birds/ha, Archerfield Airport, Brisbane (Woodall 1999); 0.08–0.72 birds/ha, Howards Pen., NT (Woinarski *et al.* 1988).

Anomalies Small irruptions recorded on Redcliffe Pen., se. Qld, in Dec. 1991 and Aug. 1994 (Bielewicz & Bielewicz 1996).

THREATS AND HUMAN INTERACTIONS Said to have benefited from creation of artificial water sources (Johnstone *et al.* 2000); and instalment of culverts has provided bounteous extra, now favoured, nest-sites (see Breeding). Very occasionally collide with vehicles (Vestjens 1973; Tarburton 1991). Nests sometimes vandalized or otherwise destroyed by people or their activities (see Breeding). Suggested that young eaten by Foxes (Caldwell 1918).

MOVEMENTS Migratory, part-migratory and resident in mainland Aust. Broad-scale analysis of bird atlas and count data from e. Aust. found strong evidence for seasonal N–S pattern of movement, moving N in autumn and S in spring (Griffioen & Clarke 2002); much published data from e. and s. Aust., but little from n. Aust. A few occasionally overwinter in s. Aust., and described as resident in some areas. Occur irregularly in some parts of SA (see below). Possibly migratory in WA, but movement less distinct, with no specific N–S pattern evident (Aust. Atlas 1; see below). Vagrants recorded in Tas.; birds seen crossing Bass Str. from Wilsons Prom. (Sutton 1998). Elsewhere in HANZAB region, vagrants recorded in NZ and on Lord Howe I., and extraliminally, in New Guinea (see Distribution and Population).

Considered resident or present throughout year (probably sedentary of HANZAB) in various areas, e.g. Charters Towers, n. Qld (Britton & Britton 2000), Innisfail and elsewhere in Atherton Region (Wet Tropics) (Gill 1970; Nielsen 1996), parts of se. Qld, such as Rockhampton, Maryborough and Logan Reserve, near Brisbane (Longmore 1978; Jones 1981; Dawson *et al.* 1991), South Coast Region of NSW (e.g. Whiter 1995), Gemmills Swamp, near Mooroopna, n. Vic. (Roberts 1975), and, in s. Top End (Goodfellow 2001), such as in Keep R. NP and lower reaches of McArthur R. (Schodde 1976; McKean 1985).

Partial migrant in some areas, with local resident or sedentary populations augmented seasonally by birds moving in from elsewhere, e.g. Murphys Ck, Redcliffe Pen. and Cooloola NP in se. Qld (Lord 1939, 1956; Roberts & Ingram 1976; Bielewicz & Bielewicz 1996), Cobar, Hunter Valley, Richmond and Sydney in NSW (D'Ombra 1931; Hindwood 1934; Schmidt 1978; NSW Bird Reps), ACT (Clark 1975; Wilson 1975; Taylor 1984; Er & Tidemann 1996; Veerman 2003), and n. Vic. (Bedgood 1973; Vic. Atlas); small numbers that overwinter are bolstered by influx of birds in spring.

Seasonal visitor to many parts of Aust., with general trend of summer visitor in S (e.g. Bedgood 1972; Smith & Chafer 1987), leaving after breeding finished, and winter visitor in N (e.g. Goodfellow 2001), though pattern not always clear (see below). Though vagrant in NZ, some seasonality apparent; of 14 records, 11 were mid-Nov. to late Mar.; similarly, in Tas, of four records where timing known, three Sept–Oct., and one in Jan. (see Distribution and Population).

Departure S. AND E. AUST.: Mostly leave at conclusion of breeding season. SA: Depart L. Frome, in NE, by Nov. (McGilp 1923, 1930). Leave areas in S Jan.–Mar., e.g. depart Port Wakefield, Jan. (Taylor 1987), Sellicks Beach, Jan.–Feb. (Ashton 1985, 2001), Mt Lofty Ras, Feb., though once remained till Apr. (Paton & Paton 1980), Adelaide, early Mar. (Whatmough 1978; Paton & Pedler 1999), and Mannum, Murray–Mallee Region, Mar. (Cox 1973). VIC.: Mostly depart Mar.–Apr. (Vic. Atlas). In S, present round Geelong till Mar. (Hewish 1999; Hewish *et al.* 1999) or Apr. (Belcher 1914), and E. Gippsland, Apr. (Bedgood 1970); depart Ballarat area, mid-Apr. (Thomas & Wheeler 1983). Farther N, depart Caniambo, W of Benalla, mid-Apr. (Bedgood 1973). In w. Vic., recorded on n. passage through Ararat area, mid-Dec. to mid-Mar. (Semmens 1993). ACT: Mostly depart Jan.–Mar. (Lenz 1981, 1982; Taylor 1983; ACT Atlas); depart Canberra mainly Feb., some remaining till Apr. (Frith 1969; Anon. 1974, 1990, 2002; Taylor *et al.* 1987; Veerman *et al.* 1988). NSW: Depart NSW mainly Mar. (Morris *et al.* 1981; NSW Bird Reps). *E OF GREAT DIVIDE:* In Northern Rivers Region, depart Grafton, late Mar. (NSW Bird Rep. 1982). Mostly depart Hunter Region in Apr. (Morris 1975), though sometimes early Mar. (NSW Bird Rep. 1987), and once left Tuggerah in late Jan. (NSW Bird Rep. 1990). Usually leave Sydney in Mar. (Hoskin 1991; NSW Bird Rep. 1994), though once departed Homebush Bay mid-Feb. (NSW Bird Rep. 1988); leave Richmond Mar.–Apr. (Hindwood 1934). Leave Illawarra Region in early autumn (Elliott 1934), Mar. (Gibson 1977). *ON GREAT DIVIDE:* Leave Northern and Central Tablelands early Mar. to mid-Apr. (Campbell 1938; Heron 1973; Baldwin 1975), but in Southern Highlands, recorded at Khancoban till early May (Rowe 1973); see also ACT, above. Farther W, in Central-west Slopes Region, mostly depart Gilgandra in Mar., though a few remain till May (NSW Bird Rep. 1981); and in South-west Slopes Region, occur round Wagga till late Apr. (Gubanyi 1910). *W OF GREAT DIVIDE:* Round Coonabarabran, departed late Feb. and mid-Mar., 1981–82 (NSW Bird Reps 1981, 1982); and left L. Brewster, N of Griffith, late Mar. (NSW Bird Rep. 1992). Depart sw. NSW Jan. to early Mar. (Hobbs 1961); and left Torriwangee, c. 120 km NW

of Broken Hill, Feb. (Campbell 1938). **SE. QLD:** Said to move N, Feb.–May. (Roberts 1979; Storr 19). Depart Nanango in Mar. (Templeton 1992) and Murphys Ck in Apr. (Lord 1939, 1943, 1956). **N. QLD:** Round Richmond, two populations occur: a summer group, departing in Mar.; and a winter group, departing late Aug. to Sept. (Berney 1903, 1904). Depart Mt. Isa, Mar.–Apr. (Horton 1975). Seen passing over C. York in Apr. 1989, in flocks mixed with Tree Martins, at intervals of 15–20 minutes (Beruldsen 1990).

Non-breeding NT: Occur in n. Top End mainly in winter (Clarke *et al.* 1999; Goodfellow 2001; Storr 7), arriving in Darwin Mar.–May and remaining till late June, though very occasionally remain till Oct. (Crawford 1972). **QLD:** Arrive Atherton Tableland, early Jan., remaining till mid-Sept. (Bravery 1970).

Arrival S. AND E. AUST.: Spring–summer visitor. **N. QLD:** Arrive Mt. Isa July–Aug. (Horton 1975). Round Richmond, two populations: a summer group, arriving in Nov.; and a winter group, arriving Apr.–May (Berney 1903, 1904). **SE. QLD:** Move S, Aug.–Sept. (Roberts 1979; Storr 19); arrive Emu Vale, early Sept. (Cohn 1926), Murphys Creek, Sept.–Oct. (Lord 1939, 1943) and Nanango, Oct. (Templeton 1992). **NSW:** Usually arrive July–Sept., mostly Aug. (Morris *et al.* 1981; NSW Bird Reps). **E OF GREAT DIVIDE:** In Northern Rivers Region, most returns Aug., but recorded as early as 17 July and as late as 14 Sept. (NSW Bird Reps). In Hunter Region, mostly arrive Aug. (Morris 1975); at Tuggerah, arrived 9 Aug.–2 Sept., with mean date 18 Aug. (NSW Bird Reps); and once returned to W. Maitland 20 Oct. (Campbell 1938). Round Sydney, sometimes return July, usually Aug. (Hindwood 1934; Hoskin 1991; NSW Bird Reps); sometimes as early as 17 July (NSW Bird Rep. 1988) and as late as 5 Sept. (NSW Bird Rep. 1993); once arrived Richmond, 8 June (NSW Bird Rep. 1997). In Illawarra Region, summer visitor (Smith & Chafer 1987), returning late Aug. or early Sept. (Elliott 1934; Campbell 1938; Gibson 1977). **ON GREAT DIVIDE:** At Inverell, N. Tableland, return in Aug. (Baldwin 1975). In Central Tableland, return to Orange, 7 Aug. (Heron 1973). In South-west Slopes Region, arrive in early spring (Gubanyi 1910), e.g. Wantabadgery, 27 Aug. (NSW Bird Rep. 1997). **W OF GREAT DIVIDE:** Return to sites round Coonabarabran, mid- to late Aug. (NSW Bird Reps 1981, 1982, 1996). In Riverina, said to arrive in first week in Aug. (Hobbs 1961); at Fivebough Swamp, near Leeton, arrived 3–26 Aug., with mean date 14 Aug. (NSW Bird Reps); and in 1985, arrived at Barham 10 Sept. (NSW Bird Rep. 1985). Return to Torrawangee, c. 120 km NW of Broken Hill, Aug. (Campbell 1938). **ACT:** Mostly arrive Aug.–Sept. (Anon. 1969b, 2002; Frith 1969; Wilson 1970; Lenz 1981, 1982; Taylor 1983; Veerman *et al.* 1988; ACT Atlas); though sometimes return in July (Anon. 1969b), return in second week of Aug. considered very early (Taylor *et al.* 1987). **VIC.:** Arrive Aug.–Sept. (Vic. Atlas). In N, arrive early Aug. round Caniambo (Bedggood 1973) and late Aug. in NE (Campbell 1902). Arrive Ballarat, mid-Aug. (Thomas & Wheeler 1983). Farther S, arrive round Geelong, 1–23 Aug. (Dedman *et al.* 1998; Hewish 1999, 2000; Hewish *et al.* 1999) or Sept. (Belcher 1914); early to late Aug. elsewhere round Port Phillip Bay (Vic. Bird Reps 1983, 1987); and Aug. in E. Gippsland (Bedggood 1970). Near Ararat, s. passage observed mid-Aug. to mid-Nov. (Semmens 1993). **SA:** Usually arrive at L. Frome in NE in Aug. (McGilp 1923, 1930). Farther S, arrive July–Sept., e.g. first arrivals round Sellicks Beach, Fleurieu Pen., in late July (Ashton 1985) and Mannum, in July (Cox 1973); round Adelaide, arrive late July or early Aug. (Whatmough 1978); Aug. in Mt Lofty Ras (Paton & Paton 1980); and do not arrive at Port Wakefield till Sept. (Taylor 1987).

WA Though seasonal trends apparent in S, pattern of movements unclear. **DEPARTURE:** S. WA: Leave Mid-eastern

Interior Region, Nov.–Dec. (Storr 22), South-eastern Interior Region, Dec. (Storr 26), and Eucla Div., Dec. (Storr 27). Most depart South-West Div. in Feb., but some remain till early June (Storr 35). **RETURN:** N. WA: Arrive in Broome, Mar. and Apr. (Collins 1995). S. WA: A few arrive in South-West Div. late Aug., but most late Sept. (Storr 35), and at Northam, returning early Oct. in some years (Masters & Milhinch 1974). Arrive Eucla Div., July (Storr 27), and late Aug. 1982, formed part of a 'massive movement' E at Eyre Bird Observatory (Congreve & Congreve 1985). Return to South-eastern Interior and Mid-eastern Interior Regions, late Aug. (Storr 22, 26).

Sometimes described as nomadic, e.g. in Illawarra Region of NSW (Chafer *et al.* 1999) and Kimberley Div. (Storr 11), or as irregular visitor, with birds arriving in some years and not others (Morgan 1916; Boehm 1957; Paton & Paton 1980), e.g. common at L. Frome and n. Flinders Ras in some years, absent in others (McGilp 1923, 1930; Hornsby 1997) and similarly sporadic in Wheatbelt of WA (Masters & Milhinch 1974; Saunders & Ingram 1995); described as appearing occasionally throughout year on plains W of Geelong (Russell 1921).

Nature of passage Sometimes migrate in mixed flocks with Tree Martins (Beruldsen 1990; Semmens 1993; Collins 1995; Nielsen 1996); gather in large flocks before departure (Belcher 1914; Campbell 1938; Lord 1939, 1943, 1956; Templeton 1992; Vic. Atlas). On migration, often move along tree-lined watercourses or roads, flying above height of tree-tops (Semmens 1993). In w. Vic., regularly migrated along corridors created by valleys between ranges of hills, with flocks moving in roughly spherical formation, individuals weaving within group as it moved S, lowest birds c. 20–30 m above ground (Semmens 1993). Migrating flocks call in flight (Beruldsen 1990).

Banding Of 9896 banded in Aust., 1953–June 2003, 1465 recoveries (14.8%), of 979 birds. Of these, 1460 (99.7%) were <10 km from banding place; four (0.3%) were 10–49 km; and one (0.1%) >100 km (ABBBS). Long-distance recovery: Bird banded near Ingleburn, NSW, recovered at Coutts Crossing, NSW (502 km, 23°, 19 months, Jan., J) (ABBBS). **LONGEVITY:** Adult banded near Bundaberg, Qld, 26 June 1994, retrapped near banding site over 5 years 3 months later (ABBBS). Some site-fidelity suggested by banding study at Broke, NSW, where birds left breeding area when young able to fly; of 257 banded 1960–65, 41 (29%) retrapped at banding site, with no recoveries elsewhere (Lane 1965).

FOOD Insects, including beetles, bugs, flies and ants. **Behaviour** Aerial insectivore; most prey taken in air by screening or sallying; seldom taken from ground. Often forage with other martins and swallows (see below). No detailed studies. **FORAGING ASSOCIATIONS:** Forage mainly in small flocks (Alexander 1923; Sedgwick 1947; Storr 1953), though sometimes recorded in larger flocks (Brandon 1951), e.g. c. 50 feeding, with several other species, on swarm of flying termites at Murphys Ck, Qld (Lord 1961), and flock of 150 foraging over Lake Eda, WA (Collins 1995). Often forage with other aerial insectivores, especially Welcome Swallows (Le Souëf 1918; Carter 1924; Lord 1939; Wilson 1975; Hewish 1999) and Tree Martins (Ashby 1932; Chisholm 1940; Wilson 1975), and occasionally with White-breasted Woodswallows *Artamus leucorhynchus* (Campbell 1920), White-backed Swallows *Cheramoeca leucosternus* (Lord 1939), Barn Swallows (Klapste 1977; Wren 1982) or White-throated Needletails *Hirundapus caudacutus* (Learmonth 1951; Lord 1961). Sometimes attracted to swarms of insects, where forage with various other species; for details of composition of three such mixed-species feeding flocks, see Le Souëf (1918), Ashby (1932) and Lord (1961). **FORAGING HEIGHTS AND SITES:**

Take most prey in air, at various heights; sometimes forage low over open or grassy areas or water (Campbell 1905; Alexander 1923; Carter 1924; Barnard 1926; Learmonth 1951; Wilson 1975; Semmens 1993), sometimes in canopy (>10 m) of eucalypt woodland (Er 1997; Er *et al.* 1998), and sometimes above tree-tops (Templeton 1991; J.M Peter); at Garradunga, n. Qld, foraged 1–15 m over cane fields (Klapste 1977). Very occasionally take food from ground (Baldwin 1965); and suggested, without substantiating evidence, to take insects from surface of water (Aust. RD). Often recorded foraging on lee side of grassy paddocks (Semmens 1993). **FORAGING METHODS:** Forage by sallying and screening (Campbell 1905; Alexander 1923; Carter 1924; Barnard 1926; MacGillivray 1929; Chisholm 1940; Howe & Burgess 1942; Sedgwick 1947; Brandon 1951; Storr 1953; Matheson 1976; Klapste 1977; Wren 1982; Duff 1988; Templeton 1991; North; Hall). Once recorded gleaning injured moths from ground (Baldwin 1965). **DRINKING:** Drink in flight by skimming low over water (Boekel 1979).

No detailed studies. **Animals INSECTS**^{1,3,4,6,10,12,13,14,15}: Coleoptera^{11,13,14,16}: Buprestidae¹⁶; Carabidae¹¹; Chrysomelidae¹⁶; Coccinellidae: *Scymnus notescens*¹³; Curculionidae^{9,11,16}; Dytiscidae¹¹; Histeridae: *Chlamydopsis epipleruralis*¹⁴; Hydrophilidae¹³: *Berosus australiae*^{11,16}; Lucanidae^{11,16}; Scarabaeidae^{13,14}: *Heterorhynchus*¹⁶; Staphylinidae^{11,13,16}; Diptera^{11,13,14}: Brachycera: *Cyclorhapha*^{9,16}; Nematocera¹⁶: Culicidae^{3,13}; Ephemeroptera¹¹; Hemiptera^{9,13,14,16}: Corixidae¹¹; Pentatomidae^{9,13,16}; Hymenoptera¹³: Formicidae^{9,13,16}: alates^{2,5}; *Camponotus*^{9,16}; *Iridomyrmex*¹⁶; Ichneumonidae¹⁶; Isoptera: alates⁷; Lepidoptera: moths⁸. **Other matter** Charcoal⁸.

REFERENCES: ¹ Campbell 1905; ² Le Souëf 1918; ³ McKeown 1923; ⁴ Carter 1924; ⁵ Ashby 1932; ⁶ Brandon 1951; ⁷ Lord 1961; ⁸ Baldwin 1965; ⁹ van Tets *et al.* 1969; ¹⁰ Klapste 1977; ¹¹ Vestjens 1977; ¹² North; ¹³ Cleland; ¹⁴ Lea & Gray; ¹⁵ Hall; ¹⁶ FAB.

Young Both parents feed nestlings (see Breeding). In Yarra R. Valley, broods received mean 13.5 feeding visits/h (4.2; 58) over nestling period. Rate of visits increased with size of brood ($r=0.73$, $P<0.001$, $n=42$), though number of visits/h/nestling declined with size of brood ($r=-0.73$, $P<0.001$, $n=42$). Rate of visits usually increased with age of brood till c. 8 days of age, levelled out till c. 16 days, then declined till nestlings fledged. Relative contribution by male to feeding nestlings increased over breeding season, and was greater when paired with larger female, but was not related to size, age or sex-ratio of brood (Magrath 1997; Magrath *et al.* 2002). Rate of visits usually increased with ambient temperature and decreased during periods of rainfall (Magrath 1997). Fledgelings may be fed in flight (Elliott 1934).

SOCIAL ORGANIZATION Major study of parental care, mating system, and breeding ecology, in Yarra R. Valley, 1993–95 (Magrath 1997, 1999; Magrath & Elgar 1997; Magrath *et al.* 2002). Gregarious; nest colonially, and occur in flocks throughout year (see below). Occasionally occur singly (Cooper 1941; Rix 1970; Longmore 1978), but more often recorded in flocks, either small, e.g. up to c. 20 (Littler 1910b; Hill 1911; D'Ombra 1931; Bourke & Austin 1947; Johnson & Hooper 1973; Morris 1975; Schodde 1976; Johnstone *et al.* 1977, 2000; Fletcher 1980; Johnstone 1983; Aumann 1991; Coate *et al.* 1998) or large, e.g. several hundred or occasionally thousands, especially on passage and during non-breeding season (Austin 1907; Hall & Rogers 1908; D'Ombra 1931; Lord 1943; Bravery 1970; Morris 1975; Jones 1981; Schrader 1981; Templeton 1992). Often occur in mixed-species flocks, especially with Tree Martins and Welcome Swallows (e.g. Carter 1924; Hyem 1936; Chisholm 1940; Watson 1955;

Passmore 1982; Gibson 1986; Beruldsen 1990; Hall; CSN 33; see also Food), and less often with Barn Swallows (Klapste 1977; Boekel 1980), White-throated Needletails (Learmonth 1951), Fork-tailed Swifts *Apus pacificus* (Jones 1944) or White-rumped Swiftlets *Aerodromus spodiopygius* (Hall).

Bonds Socially monogamous, but genetically promiscuous. In Yarra R. Valley, 20% of 70 broods studied contained at least one extra-pair chick, and 14% of 203 chicks overall sired by extra-pair males (Magrath 1997; Magrath & Elgar 1997). Frequency of extra-pair offspring not influenced by nesting synchrony, but tended to increase with size of colony. Previous breeding experience of genetic father of extra-pair young was greater than that of cuckolded male. Social pairs apparently form soon after arrival at colony, several weeks before nest-construction (see Sexual Behaviour). Experienced breeding birds likely to pair with each other (Magrath 1999), and choice of mate also influenced by physical attributes, as indicated by assortative pairing with respect to tarsus-length (Magrath *et al.* 2002). Pairs usually stayed together between breeding attempts within breeding season; mate-switching was more likely if previous breeding attempt unsuccessful. Females more likely to switch colonies during breeding season. No pairs known to be maintained over successive breeding seasons (Magrath 1999). **SEX-RATIOS:** In Yarra R. Valley, offspring of 135 females, 51.8% male ($n=465$; not significantly different from parity), and sex-ratio of clutches in which all eggs sexed, mean 0.50 male (0.24; 84). Sex-ratio of broods did not vary between years, between colonies, or over the breeding season. Nor was sex-ratio of broods related to brood-size or colony-size. Brood sex-ratio was negatively correlated with maternal size, i.e. mothers with larger tarsi produced more daughters (Magrath *et al.* 2002). **Parental Care** Both male and female active in all aspects of parental care (Magrath 1997; Magrath & Elgar 1997; see Breeding). Sometimes leave breeding areas while eggs or young still in nest (McGilp 1930; Ashton 1996).

Breeding Dispersion Breed colonially (e.g. Campbell 1902; Whitlock 1909; Mellor 1930; McGilp 1931; Hitchcock 1938; Lord 1943; Haines 1945a; Bell 1961; Schulz 1998; North); colonies often comprise <50 nests, e.g. 6–40 nests near Mansfield, Vic. (Bridgewater 1932), and sometimes with many more, e.g. up to 700 nests at Bedourie, sw Qld (Aust. Atlas 1); 'thousands' reported in one colony at Renmark (White 1918). Round Geelong, Vic., mean 16 active nests/colony (1–42; 15), but when inactive nests included, mean 25 nests/colony (1–147; 43) including both broken and intact nests (Hicks & Hicks 1999). Non-territorial, with members of colony claimed to help build each other's nests (McGilp 1930; Gannon 1953; Lane 1965). 'Multi-unit' nests common in colony at Broke, NSW (Lane 1965), presumably indicating that more than one pair occupied nest (see Agonistic Behaviour below). Nests usually built close together in rows or clusters, often overlapping (Magrath 1999; Campbell; North; NRS). Some colonies quite close together, e.g. 100 m apart (Heron 1970). **Roosting** Both sexes usually roost in nest during breeding season, though sometimes only one parent present, usually female, during nestling period. Sometimes crowd into nests during inclement weather (Magrath 1999). No information on roosting sites outside breeding season. **DIURNAL LOAFING:** During migration, once loafed with Welcome Swallows and Tree Martins on gravel road, low in shrubs and on wire fences; may have been on road for warmth (Semmens 1993).

SOCIAL BEHAVIOUR Poorly known; no major studies or descriptions of displays, and few published observations of behaviour. **Maintenance Behaviour** Flock observed dust-bathing in ashes and picking at charcoal near Inverell, NSW (Baldwin 1965). **Flock Behaviour** Flocks on migration heard calling in flight (Beruldsen 1990).

Agonistic Behaviour During and after construction, pairs may dispute ownership of nests, especially pairs which apparently built nests jointly. Late arrivals possibly fight incubating birds for ownership of nest (Lane 1965). **INTERSPECIFIC INTERACTIONS:** Driven from nests by House Sparrows (Anon. 1909; Hindwood 1934; Magrath 1999), Common Starlings *Sturnus vulgaris* (Hindwood 1934) and Welcome Swallows (Tarburton 1991).

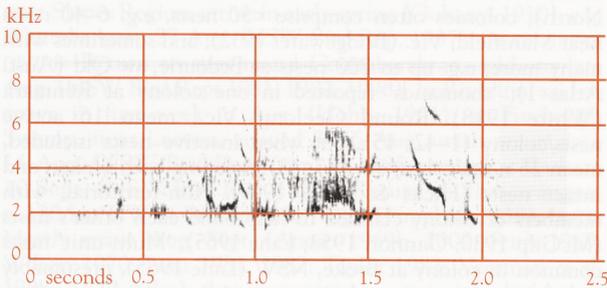
Sexual Behaviour Aerial pursuits, often involving more than two birds, observed before nest built; possibly part of courtship (Tarburton 1991; Magrath 1999). Copulation observed on ground, on fence (Magrath 1999), and, once, in nest (Tarburton 1991).

Relations within family group No information.

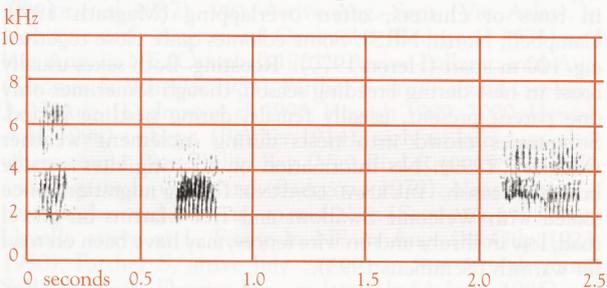
VOICE Poorly known. Usually give high-pitched twittering (e.g. Frith 1969; Morcombe 2000; Aust. RD; see below). Call in flight (Beruldsen 1990). Vocalizations higher pitched than those of Tree Martin (Pizzey 1980; Serventy & Whittell), and said to lack sweetness and variety of Welcome Swallow (Frith 1969). **DIURNAL PATTERN:** When breeding, twitter inside nests just before first light, and many call when leaving nest at first light (Lane 1965). **NON-VOCAL SOUNDS:** Noise made by wings of large flock described as rustle like far-off wind in timber (Hall & Rogers 1908).

Adult SONG: Described as sweet, feeble, high-pitched twittering (Frith 1969; Morcombe 2000; Aust. RD). See sonagram A, which includes twittering elements from more than one individual. **CONTACT CALL:** Soft, pipit-like *di*rrrr (Lindgren 1971), abrupt *dr*rr *dr*rr (Morcombe 2000), slight churring *dr*rr *dr*rr (Pizzey 1980), farting call, like a raspberry (a farting noise made with the lips) (Goodfellow 2001), and somewhat grating call (Elliot 1934), probably all describe same call. Sonagram B shows three such calls, apparently from three different individuals. **Other calls** Also give rolling *dzee* *dzee* (Pizzey 1980).

Young No information.



A R. Buckingham; Maria, SA, Sept. 1988; P48



B R. Buckingham; Maria, SA, Sept. 1988; P48

BREEDING Well known from detailed studies at Murwillumbah, NSW, July 1989–Jan. 1990, with additional observations in late Mar. 1990 (Tarburton 1991); and in

Yarra R. Valley, Vic., 1992–95 (Magrath 1997, 1999; Magrath & Elgar 1997; Magrath *et al.* 2002); 437 records in NRS to June 2004. Data from Reilly & Garrett (1973) and Ashton (1987) submitted to NRS, and included in analysis of NRS. Breed in colonies of up to 700, and, reportedly, thousands (White 1918; Aust. Atlas 1; see also Social Organization); colonies at artificial sites generally larger than those at natural sites (Magrath 1999).

Season Aust. Eggs recorded late July to early Feb. (see below). Of 218 clutches in NRS: one (0.5%) in Aug., 73 (33.5%) in Sept., 70 (32.1%) in Oct., 28 (12.8%) in Nov., 41 (18.8%) in Dec. and five (2.3%) in Jan. Little synchrony within colonies: a colony can comprise nests still being built while others contain eggs or young (Austin 1918; NRS). Unspecified breeding recorded all months, but mostly Aug.–Dec. (Aust. Atlas 2; NRS). Breeding said to follow rainfall in arid or semi-arid regions (McKeown 1923; McGill 1944, 1945; Moriarty 1972; Horton 1975; Beruldsen 1980). **QLD:** Unspecified breeding, all months (Storr 19; see below). **N. QLD:** Eggs, Aug.–Jan. (Berney 1903; Lavery *et al.* 1968). Nestlings, Oct. (NRS [n=2]). Unspecified breeding, including fledgelings, all months except Mar. (Berney 1904; Bravery 1970; Gill 1970; Horton 1975; Aust. Atlas 1, 2; NRS [n=1]). Of 72 breeding records for n. Qld in Aust. Atlas 1, 2: two (2.8%) in Apr., one (1.4%) in May, one (1.4%) in June, seven (9.7%) in July, 14 (19.4%) in Aug., 19 (26.4%) in Sept., nine (12.5%) in Oct., 11 (15.3%) in Nov., two (2.8%) in Dec., four (5.6%) in Jan., and two (2.8%) in Feb. Said to breed mainly winter in tropical coastal lowlands (Storr 19) and spring in Atherton Tableland (Nielsen 1996). **s. QLD:** Eggs, Sept. and Dec. (NRS). Of 12 clutches in NRS: one (8.3%) in Sept. and 11 (91.7%) in Dec. Nestlings, Sept.–Oct. and Dec. (NRS [n=4]). Unspecified breeding, including fledgelings, all months except Feb. and Apr. (Wheeler 1959; Aust. Atlas 1, 2). Of 183 breeding records for s. Qld in Aust. Atlas 1, 2: four (2.2%) in May, three (1.6%) in June, 24 (13.1%) in July, 41 (22.4%) in Aug., 42 (23.0%) in Sept., 31 (16.9%) in Oct., 17 (9.3%) in Nov., 15 (8.2%) in Dec., three (1.6%) in Jan. and three (1.6%) in Mar. **NSW:** Eggs, Sept.–Jan. (Austin 1918; Morris *et al.* 1981; NRS). Of 25 clutches in NRS: five (20.0%) in Sept., six (24.0%) in Oct., three (12.0%) in Nov., nine (36.0%) in Dec. and two (8.0%) in Jan. At Murwillumbah, eggs, Aug.–Feb.; nestlings, Sept.–Apr. (Bourke 1957; Tarburton 1991; NRS [n=39]). Unspecified breeding, including fledgelings, all months (Heron 1973; Baldwin 1975; Morris 1975; Gibson 1977; Wyndham 1978; Costello 1981; Gosper 1981; North; Aust. Atlas 1, 2; NRS [n=5]); of 573 breeding records in Aust. Atlas 1, 2: five (1.7%) in May, four (1.3%) in June, four (1.3%) in July, 36 (12.0%) in Aug., 115 (38.3%) in Sept., 140 (46.7%) in Oct., 104 (34.7%) in Nov., 126 (42.0%) in Dec., 28 (9.3%) in Jan., eight (2.7%) in Feb. and three (1.0%) in Mar. **VIC.:** Eggs, Sept.–Feb. (Campbell 1902; Belcher 1914; Hicks & Hicks 1999; Magrath 1999; NRS [n=1]). In Yarra R. Valley, eggs, late Sept. to early Feb. (n=305) and often includes two breeding attempts; first clutches laid late Sept. to early Dec., most by late Oct., and second clutches early Jan. to early Feb., most by late Jan; replacements for first clutches occur between first and second clutches. Most clutches were begun in Nov. (Magrath 1999). Nestlings, Oct.–Jan. (Cheney 1915; Lang 1930; McCulloch 1973; NRS [n=12]). Unspecified breeding, including fledgelings, Aug.–Apr. (Ford 1908; Bedgood 1973; Klapste & Klapste 1977; Hicks & Hicks 1999; Aust. Atlas 1, 2; NRS [n=2]). Of 191 breeding records in Aust. Atlas 1, 2: six (3.1%) in Aug., 32 (16.8%) in Sept., 44 (23.0%) in Oct., 47 (24.6%) in Nov., 38 (19.9%) in Dec., 16 (8.4%) in Jan., seven (3.7%) in Feb. and one (0.5%) in Apr. In Yarra R. Valley, timing of laying affected by various factors: (1) laying began earlier at colonies where pairs re-used nests from previous seasons,

presumably because 2-week building period avoided; (2) initiation of laying affected by flooding: some sites remained flooded till late spring, preventing breeding; and others were flooded while nests occupied, causing birds to delay nesting or relocate to alternative sites; and (3) fluctuations in supply of suitable mud appeared to influence time required to build nests (Magrath 1999). **TAS.:** No information. **SA:** Eggs, Sept.–Oct. and Dec.–Jan. (Boehm 1934; Hitchcock 1938; NRS). Of 83 clutches in NRS: 48 (57.8%) in Sept., 31 (37.3%) in Oct., two (2.4%) in Dec. and two (2.4%) in Jan. In Aldinga Scrub CP, SA, eggs, 20 Oct.–22 Jan. (Ashton 1987); at Naracoorte, eggs, 15 Sept.–22 Dec. (Attiwill 1972); nestlings, Sept.–Feb. (Cox & Pedler 1977; NRS [n=57]). Unspecified breeding, including fledgelings, all months except Feb. (Anon. 1917; Souter 1942; Jarman 1947; Badman 1981; Close & Jaensch 1984; Ashton 2001; Atlas 1, 2; SA Bird Reps 1966–67, 1977–81; NRS [n=4]); of 199 records in Aust. Atlas 1, 2: five (2.5%) in July, 18 (9.0%) in Aug., 50 (25.1%) in Sept., 61 (30.7%) in Oct., 27 (13.6%) in Nov., 21 (10.6%) in Dec., 11 (5.5%) in Jan., one (0.5%) in Mar., two (1.0%) in Apr. and three (1.5%) in May. **WA:** Most records from s. WA. **s. WA:** Eggs, Aug.–Jan. (Sedgwick 1955, 1958; Amedy 1965; NRS). Of 97 clutches in NRS: one (1.0%) in Aug., 18 (18.6%) in Sept., 33 (34.0%) in Oct., 25 (25.8%) in Nov., 19 (19.6%) in Dec. and one (1.0%) in Jan. Nestlings, Sept.–Feb. (Robinson 1933; Reid 1951; Amedy 1965; NRS [n=77]). Unspecified breeding, including fledgelings, June–Feb. (Jenkins 1931; Serventy 1948; Ford & Stone 1957; Sedgwick 1958; Amedy 1965; Masters & Milhinch 1974; Storr 21, 22, 26, 27, 28; Aust. Atlas 1, 2; NRS [n=4]). Of 73 records in Aust. Atlas 1, 2: one (1.4%) in June, one (1.4%) in July, 15 (20.5%) in Aug., 28 (38.4%) in Sept., 16 (21.9%) in Oct., eight (11.0%) in Nov., two (2.7%) in Dec. and two (2.7%) in Jan. **N. WA:** Eggs, late July (Carter 1903); nestlings Oct. (NRS [n=1]). Unspecified breeding Mar.–Jan. (Aumann 1991; Coate *et al.* 2001; Storr 11, 16; Aust. Atlas 1, 2); of 72 records in Aust. Atlas 1, 2: three (4.2%) in Mar., two (2.8%) in Apr., four (5.6%) in May, six (8.3%) in June, ten (13.9%) in July, 26 (36.1%) in Aug., nine (12.5%) in Sept., three (4.2%) in Oct., five (6.9%) in Nov. and four (5.6%) in Dec. **NT:** Eggs, Aug., Oct. and Dec.–Feb. (Le Souëf 1903; Barnard 1914; White 1924; Frith & Davies 1961; Aust. Atlas 1); nestlings, Aug. and Jan.–Feb. (Aust. Atlas 1; NRS [n=1]). Unspecified breeding June–Mar. (Crawford 1972; Storr 7; Aust. Atlas 1, 2). Of 40 breeding records in Aust. Atlas 1, 2: four (10.0%) in June, three (7.5%) in July, five (12.5%) in Aug., 11 (27.5%) in Sept., three (7.5%) in Oct., five (12.5%) in Nov., two (5.0%) in Dec., three (7.5%) in Jan., two (5.0%) in Feb. and two (5.0%) in Mar. **NZ** No information; juveniles seen in late Feb. (Bell 1984).

Site Usually on various vertical or near-vertical natural or artificial surfaces; common features of most are overhead cover and nearby water (Le Souëf 1903; Morgan 1914; White 1916; McGilp 1923; Sedgwick 1958; Mack 1970); in Yarra R. Valley, all colonies were situated above running water (Magrath 1999), and round Geelong, Vic., ten of 12 active colonies were over water (Hicks & Hicks 1999). Of 197 nest-sites in NRS: 101 (51.3%) were in culverts, 29 (14.7%) under bridges, 18 (9.1%) on cliff-faces and roadside cuttings, 16 (8.1%) on buildings and other structures, ten (5.1%) on banks (of watercourses and dams), 12 (6.1%) on trees, four (2.0%) in pipes, three (1.5%) in caves or mine shafts, two (1.0%) on water tanks, and two (1.0%) on vehicles (NRS). **NATURAL SITES:** Usually beneath overhanging rock shelves on banks, cliff-faces or breakaways, often along watercourses (e.g. Carter 1903; Whitlock 1909; MacGillivray 1910, 1914; Barnard 1914; Morgan 1914; White 1924; Serventy 1929; McGilp 1930; Lord 1956; Moriarty 1972; Gee *et al.* 1996; NRS), sometimes overhanging water (White 1914; Edwards 1921;

MacGillivray 1929; Robinson 1933; NRS). Occasionally at entrances of shallow caves (e.g. McGilp 1923; Mellor 1930; Hindwood 1934; Sedgwick 1958; Hamilton-Smith 1965; McKean 1985; Hornsby 1997; NRS), or in fissures, recesses or holes (e.g. Whitlock 1905, 1909; Sutton 1929; Cleland 1931; Sedgwick 1949; Jarman 1953; NRS). Usually favour rock surfaces (Whitlock 1905, 1909; Sutton 1929; Cleland 1931; Serventy 1948; Sedgwick 1949; Close & Jaensch 1984; Storr 21, 27; NRS), though also recorded under sand, clay and soil banks and cliffs (Gubanyi 1910; Sharland 1943; Cox & Pedler 1977; Hyett 1980; NRS). Nests also attached to trees, including undersides of leaning trunks or branches (e.g. Le Souëf 1903; Jackson 1912; Parsons 1921; Lang 1930; Costello 1981; Coate *et al.* 1998; NRS); some attached to hollow or burnt-out trees (Austin 1907; Stone 1918; McGilp 1930; Campbell; North; NRS) or beneath logs (Chenery & Morgan 1920; North). Usually in eucalypts (e.g. Carter 1903; Austin 1907; White 1917; McGilp 1930, 1931; Morgan 1930; Sullivan 1931). Of ten records of nest-plants in NRS, nine were in eucalypts (including River Red Gum, Coolibah and White Gum *Eucalyptus alba*); other, in Bracelet Honey-myrtle *Melaleuca armillaris*, possibly a damaged nest placed there by person after being dislodged from nearby drain (NRS). Other nest-plants recorded include Moreton Bay Ash (Jackson 1912) and *Melaleuca lasiandra* (Coate *et al.* 1998). One colony attached to piece of driftwood caught in branches of tea-tree (Chenery 1921). One pair used nest of Welcome Swallow (Mellor 1924). **ARTIFICIAL SITES:** Most nests in artificial sites located in concrete culverts (e.g. Lang 1927; Chaffer 1928; Jenkins 1931; Carnaby 1933; Haines 1945a; Gosper 1981; NRS). Of 291 culverts surveyed in e. Qld and ne. NSW, 116 (39.9%) contained total of 5404 nests, with mean of 46.4 nests/culvert (51.70; 1–318); another 52 culverts contained evidence of nests. Most nests were in concrete culverts (n=114), though two were made of galvanized iron (Schulz 1998). Use both round pipes and box-shaped culverts (Clarke 1967; Reilly & Garrett 1973; NRS). In e. Qld and ne. NSW, significantly more nests were in box-culverts (3396 nests in 63 culverts) than in round pipes (1990 nests in 53 culverts); and mean size of colonies also differed significantly (Schulz 1998). Nests typically attached to ceiling or top of culvert, with many nests in box-culverts placed in angle between wall and ceiling, with back of nest fixed to wall (Sedgwick 1958; Reilly & Garrett 1973; Tarburton 1991; Schulz 1998; Magrath 1999). Examination of 24 culverts near Myall Ls, NSW, and four in ne. Vic., suggested Martins selected pipes ≥ 0.6 m in diameter, with clearance above water or sand of ≥ 0.4 m (Reilly & Garrett 1973), though, elsewhere, nests in two culverts were 0.34 and 0.38 m above water (Anon. 1969a; NRS). In e. Qld and ne. NSW, number of nests per culvert positively correlated with height of culvert (Schulz 1998). Also often nest under bridges, attached to pillars or girders, to underside of bridge itself, or in angle between the two (e.g. Batey 1907; Stone 1918; Lord 1956; Hobbs 1961; Gill 1970; Griffiths & Holyoak 1993; Magrath 1999; NRS). Sometimes attached to buildings (MacGillivray 1910; Wolstenholme 1925; Bryant 1934; Souter 1942; McGill 1944; Shilling 1948; Bourke 1957; Brooker *et al.* 1979; Passmore 1982; Whitmore *et al.* 1983; Bell 1984; North; NRS), usually beneath eaves or verandas, or attached to walls (e.g. Barnard 1904; Cleland 1919; Chenery & Morgan 1920; MacGillivray 1924a; Barnard & Barnard 1925; McGilp 1930; Sullivan 1931; Hindwood 1934; Sharland 1943; Campbell; North; NRS). Nests in sheds usually built under roof or against rafters (Sharland 1943; Hindwood & McGill 1951; Campbell; NRS); one colony nested beneath door and window lintels of deserted house (McGilp 1931); and in ruins of chimney (Joseph & Black 1983). Occasionally nest under water towers (White 1918, 1946; Chenery & Morgan 1920; Jones 1981; NRS), or in empty tanks (McGilp

1931; Boss-Walker 1932; NRS); in old kilns (Serventy 1928); and under a wharf (Hopkins 1948). Sometimes nest in mines or wells (Ford 1908; MacGillivray 1910; Kersey 1919; Sedgwick 1952; BFNC 1976; NRS); also on faces of pits (gravel, clay) and quarries (Serventy 1928; Rix 1945; Sedgwick 1958; Amedy 1965; Storr 21; NRS) or on man-made sandbanks (McEvey 1965). Very occasionally nest under vehicles (Badman 1981). **RE-USE OF SITES:** Colonies, and nests within colonies, often used for several years (Sutton 1928; Lang 1930; McGilp 1930; Mellor 1930; Hindwood 1934; McGill 1944; Bedgood 1959; Ashton 1985; NRS); some nests of previous season rebuilt after damage (Magrath 1999), but even in established colonies, new nests built each season, especially for second broods (North). Individual nests may also be used for multiple attempts within a season. At Murwillumbah, of 78 nests: 13 (16.7%) produced one clutch in season, 27 (34.6%) two clutches, 33 (42.3%) three clutches and five (6.4%) four clutches. In Yarra R. Valley, 57% of nests (n=258) were re-used at least once during same season, comprising 50% by one or both members of original pair, and 7% by different pair; nests re-used after successful or unsuccessful nesting attempts (Magrath 1999). **FIDELITY TO SITE:** In Yarra R. Valley, c. 16.3% of banded adults (n=208) returned to study site in following year; of these, most (67.6%) returned to same colony, though one female moved to colony 8 km away. Males (22% of 100) more likely to return than females (11.2% of 108). Some adults changed colonies during season, usually after first breeding attempt failed, with females more likely to switch colonies during season than males. A few young (4.7%; 12 of 257) returned to study area in first year, but only three of the 12 (25.0%) returned to natal colony, with males more likely to return than females (Magrath 1999). **ASSOCIATIONS:** House Sparrows, Tree Martins and Welcome Swallows occasionally nest in Fairy Martin colonies (Conole 1981; Hicks & Hicks 2000; NRS). Several Rainbow Bee-eaters *Merops ornatus* nested near one colony. One colony shared culvert with nests of mud-wasps (NRS); and one shared church tower with hive of bees (Hindwood 1934). **MEASUREMENTS (m):** From NRS: Height of nest, 2.9 (3.92; 0.34–22.0; 90). **NATURAL SITES:** Height of nest, 4.5 (5.03; 0.4–18.3; 22) (NRS). Mean height of nests in colony on 3.5-m creek bank, 0.86 (0.32; 0.42–1.51; 22) (Klapste & Klapste 1977). For nests in cliffs and banks, depth below top of cliff or bank, 17.1 (38.69; 0.4–135.0; 12) (NRS). **ARTIFICIAL SITES:** Height of nests, 2.4 (3.39; 0.34–22.0; 68). Height of nests in culverts, 1.1 (0.42; 0.34–2.1; 45). Height of pipes or culverts, 1.2 (0.53; 0.61–3.0; 62). One nest was 5 m below ground in mine, 1.6 m above floor of mine (NRS). Near Tower Hill, WA, most nests (n=81) in disused mine shafts <1.8 m below ground (Sedgwick 1952).

Nest, Materials Bottle-, pear- or retort-shaped, with long, narrow entrance-spout and saucer-shaped depression at bottom of nest-chamber. Spouts usually horizontal or curve downward (McGilp 1930; Beruldsen 1980; North; NRS), though a few curve upward or to side (Campbell; North; NRS); nests in one culvert had spouts curved towards end of culvert (Sedgwick 1958), and in another culvert, many spouts faced inward (NRS); in another culvert, spouts were longer at end with standing water (NRS). At Murwillumbah, spouts longest in small circular culverts. Spouts totally enclosed (roofed), even when attached to ceiling (Sedgwick 1958). Made of pellets of mud or clay, and sometimes reinforced with grass, seldom with hair or other fibres; usually lined with grass, on which is placed a layer of feathers, occasionally with stems or rootlets (McGilp 1923, 1930; Lang 1930; Mellor 1930; Sedgwick 1958; Beruldsen 1980; Tarburton 1991; Magrath 1999; Campbell; North; NRS). Feathers of various species used in lining, e.g. Domestic Fowl *Gallus gallus*, Emu *Dromaius novaehollandiae*, Australian Wood Duck *Chenonetta jubata*, Pacific Black Duck *Anas superciliosa*, Cattle Egret *Ardea ibis*,

Galah *Eolophus roseicapillus* and Helmeted Guineafowl *Numida meleagris* (Sedgwick 1958; Tarburton 1991; NRS); some feathers up to 15.2 cm long (Sedgwick 1958), but mostly 2–8 cm. In Yarra R. Valley, mean of 55 (51.78; 31) feathers in lining (Magrath 1999). **ARRANGEMENT OF NESTS:** Nests sometimes in orderly rows (North); in Yarra R. Valley, usually in line along junction of vertical wall and horizontal ceiling of box-culverts; clusters typical in round culverts (Magrath 1999). One cluster of five nests, built on ceiling, formed a star, with entrances radiating outward (Hindwood 1934). Nests often share common walls (Boss-Walker 1932; Sedgwick 1958; Tarburton 1991; Magrath 1999; Campbell; NRS), and are occasionally attached only to other nests, with new nests built beneath those from earlier in season (Magrath 1999; North), though some not attached to others at all (Boss-Walker 1932; NRS). **BUILDING:** Both sexes build (Magrath 1999). Claimed that small groups of up to seven birds help to build nest (McGilp 1930; Gannon 1953; Anon. 1969a; Campbell; *contra* North). However, observations of individually marked birds indicate that some steal mud from neighbouring nests, which might explain presence of several birds at nest under construction (M.J.L. Magrath). Mud for nests is usually collected from any available source near colony (Campbell; NRS), e.g. 35 m away from colony (NRS), <90 m away (Boss-Walker 1932), within 100 m (Magrath 1999), c. 400 m away (Haines 1945a). Suggested that birds may fly further to collect mud to repair nest with eggs or young (Haines 1945b). Mud sometimes taken from several different sources, e.g. spouts of some nests in one colony comprised bands of grey, rufous and light-brown mud (NRS). Mud carried in bill (Boss-Walker 1932). Feathers collected from within c. 90 m of nest-site (Sedgwick 1958). Collection of material is communal, birds gathering material in small groups, usually of up to 20, but occasionally 50+ (Elliott 1934; Rix 1970; Aumann 1991; Hornsby 1997). On return to nest, birds alight on threshold then enter and turn round, reappearing at opening; sometimes two birds enter almost simultaneously (Boss-Walker 1932; Campbell). Sometimes one remains in nest to receive mud-pellets from others (Campbell). Mud is added to rim of nest a little at time; bill vibrated rapidly to work mud into position (Boss-Walker 1932; Hyett 1980); each pellet confined to one part of rim, and visible outside as a knob (Boss-Walker 1932). Nests usually comprise >1000 pellets (Sedgwick 1958; Anon. 1969a). Nests said to be built up in layers, with spout added last (NRS). At one colony, bouts of building lasted c. 10 min, alternating with periods of feeding (Hornsby 1997). Building recorded at all times of day, at least 7:00–14:30 (Boss-Walker 1932; NRS), though claimed that only occurs in morning and evening on hot days, possibly because mud supply dries up (Morgan 1914; McGilp 1930; Campbell). Building can be triggered by rainfall, which creates mud (McKeown 1923; McGill 1944, 1945; NRS); sometimes building activity is intermittent (Campbell; NRS), suspended due to lack of mud (Tarburton 1991; Magrath 1999), then recommences after rain (Campbell 1902), leading to variation in time taken to complete nest (Tarburton 1991, see below). Also stop building in cold weather (Anon. 1905; Barnard 1909). Once structure complete, nest lined (Tarburton 1991; Magrath 1999); some nests lined before spout added (Ashton 1987). At Murwillumbah, addition of lining usually completed within 6 days of completion of clutch, and eggs often laid several days before nest lined. Nests built in: 15.4 days (5.6; 5–36; 88) (Magrath 1999); 30 days (11; 17–64; 21) (Tarburton 1991); 18 days (n=1) (Ashton 1987); 15–20 days (no N) (North). In Yarra R. Valley, initiation of building in colonies asynchronous, commencing over 35.4 (26.7; 13) days, and laying began c. 1 week after nest-structure completed (Magrath 1999). Old nests usually repaired and relined before re-use (Barnard 1904; Cheney 1915; Lang 1930; McGilp 1930;

Mellor 1930; Campbell; North; NRS). In Yarra R. Valley, re-lining of old nests each year leads to accumulation of thick layer of decomposed grass and feathers in some (Magrath 1999). Claimed that one pair added clay to nest of Welcome Swallow to form familiar bottle-shaped structure (Mellor 1924). Quickly repair or rebuild damaged nests, e.g. 2 days after nests ruined by rain (McGilp 1930; Beruldsen 1980); damage usually patched with mud (Mellor 1930; Tarburton 1991), and after observer broke spouts off several nests to inspect contents, all were repaired by the next day (Haines 1945a). Young fledge successfully from partly repaired nests (Ashton 1987; Tarburton 1991). One colony maintained rebuilding attempts for nearly 2 weeks even though people removed new nests daily (North). Colonies said to often contain a few incomplete nests (Cheney 1915; Lang 1927), and said that more nests built than required, so some left unfinished (Lang 1927). At Murwillumbah, of 86 nests, 83 were completed and used, and three were abandoned before they extended >70 mm from wall. One bird repeatedly stole wet mud from half-built nests nearby while other birds absent (Chisholm 1965). **MEASUREMENTS** (cm): Total length: 28.7 (5.6; 12.5–42.0; 74) (Tarburton 1991); 25–25.5 (McGilp 1923, 1930; North); 16 cm (Bell 1984). Length of body of nest: 18.8 (2.6; 14.0–26.6; 76) (Tarburton 1991); 10.0 (n=1) (Bell 1984). Length of spout: 9.9 (2.8; 4.0–17.0; 75) (Tarburton 1991); mostly 5–7.5, but up to 23 (Serventy & Whittell); 12.5 (Sedgwick 1958); ≥ 15 (Beruldsen 1980); 20.5–23 (Gould); 3 (Bell 1984). Width: 16.9 (3.1; 10.0–24.0; 69) (Tarburton 1991); 14–17.1 (Sedgwick 1958; Bell 1984; North). Diameter of egg-chamber: 10–18 (McGilp 1923, 1930; Sedgwick 1958; Bell 1984; Gould; Serventy & Whittell). Depth: 7.0–10 (Bell 1984; North). Diameter of opening: 2.9 (0.5; 2.3–4.4; 77) (Tarburton 1991); 2.3–2.8 (Sedgwick 1958); 6.0 (NRS [n=1]); 2.5 (Serventy & Whittell). Minimum diameter of spout: 2.7 (0.3; 2.3–3.2; 7) (Tarburton 1991). Thickness of walls: body of nest: 1.0 (Bell 1984), 1.3–1.9 (Sedgwick 1958); spout 1.9 (Sedgwick 1958). Size varies according to position in which nest built (North). **WEIGHT** (g): Nest and lining 620–680 (Serventy & Whittell); 1250 (Sedgwick 1958 [n=1]); mud structure 603 (120.64; 33), grass lining 8.5 (5.09; 35) and feather lining 1.15 (1.22; 31) (Magrath 1999). **VOLUME**: 517 cm³ (74.68; 33) (Magrath 1999). **ATTACHMENT AREA**: One nest had attachment area of 130.6 cm² at top of nest and 101.6 cm² at rear; walls of nest widened from 1.3 to 1.9–2.5 cm towards top and rear, providing large attachment area (Sedgwick 1958).

Eggs Shape varies; usually long oval, but range from almost round to slightly pyriform or sharply pointed at one end (White 1924; McGilp 1930; Beruldsen 1980; Campbell; North). Close-grained; smooth; glossy or slightly lustrous (Beruldsen 1980; Campbell; North). White or dull white, sometimes unmarked, but usually faintly and sparsely marked, though sometimes heavily, with freckles, spots and blotches of light pink, yellowish brown, reddish brown or tan, concentrated at large end on some, forming irregular zones or distributed uniformly over shell (Le Souëf 1903; Austin 1918; White 1924; McGilp 1930; Mellor 1930; Boehm 1957; Bedggood 1959; Beruldsen 1980; Campbell; North; NRS). Shape and colour may vary in eggs of same clutch (McGilp 1930; North). At Murwillumbah, of 407 eggs: 238 (58.5%) were white, 117 (28.7%) had fine pinkish-brown speckles, 48 (11.8%) had pinkish-brown spots, three (0.7%) were off white, and one (0.2%) had fine pink-brown spots visible only in bright light; markings tended denser at large end, sometimes forming ring. Most eggs at Bungil, Vic., white with faint yellow or pink streaks, but a few pale lavender with slight smudge of purple on large end; often, single lavender egg found with three or four of usual colour (Bedggood 1959). **MEASUREMENTS**: 17.0 (0.9; 15.2–18.7; 59) \times 12.2 (0.48; 10.9–13.5) (Tarburton

1991); 17.7 (1.07; 15.7–19.6; 18) \times 12.2 (0.42; 11.4–13.0) (Le Souëf 1903; White 1924; Campbell; North); 16.7 (16.2–17.0; 13) \times 12.0 (11.6–12.3) (Serventy & Whittell); c. 17 \times 12 (Beruldsen 1980); 18 \times 12 (Boehm 1957). **WEIGHT** (g): 1.3 (0.83; 1.2–1.6; 53) (Tarburton 1991); 1.4 (no N given) (Lill & Fell 1990).

Clutch-size Usually four (Newell 1927; McGilp 1932; Storr 19); four or five (Mellor 1930; Masters & Milhinch 1974; Campbell; North); three to five (Austin 1918; Boehm 1957); three or four, rarely five (Serventy & Whittell); four to six (McGilp 1923); up to six (Stone 1912); once, seven (Storr 26). From NRS: 3.4 (0.67; 48): C/1 \times 1, C/2 \times 2, C/3 \times 24, C/4 \times 21. At Murwillumbah, 3.5 (0.62; 182): C/2 \times 10, C/3 \times 69, C/4 \times 101, C/5 \times 2. In Vic., 3.6 (n=43) (Lill & Fell 1990). In Yarra R. Valley, 3.51 (0.65; 288): C/2 \times 17, C/3 \times 114, C/4 \times 149, C/5 \times 8 (Magrath 1999). In South-Eastern Interior of WA, 3.5 (0.73; 66): C/2 \times 2, C/3 \times 35, C/4 \times 27, C/5 \times 1, C/7 \times 1 (Storr 26); elsewhere in WA, 3.3 (0.68; 34): C/2 \times 3, C/3 \times 18, C/4 \times 12, C/5 \times 1 (Storr 11, 16, 21, 22). In Yarra R. Valley, clutch-size did not differ between seasons; size of clutches laid by individual females decreased as breeding season progressed (see Magrath [1999] for monthly variation in clutch-size). Females known to have bred in previous years tended to lay larger clutches, 3.8 (0.67; 20) compared with those of unknown breeding history, 3.5 (0.70; 198) (P=0.06) (Magrath 1999). Once, apparent clutch of seven actually comprised three infertile eggs from previous breeding attempt, and four more recently laid eggs (NRS).

Laying In Yarra R. Valley, first clutches laid asynchronously within colonies over 42.2 days (23.4; n=13 colony-years). Individuals with previous breeding experience produced first clutches earlier than those without, probably related to earlier arrival of older birds. Laying asynchrony perpetuated throughout season in most colonies by laying of replacement clutches after failure, and production of second clutches by many pairs (Magrath 1999). Eggs usually laid on consecutive days (Tarburton 1991; Magrath 1999). At Murwillumbah, of 140 eggs, 115 (82.1%) were laid on consecutive days, two (1.4%) within 24-h period and 23 (16.4%) 24–48 h after previous egg. Eggs sometimes laid at longer intervals: one nest contained one egg, 30 Sept.–2 Oct., three eggs, 6–10 Oct., and four eggs, 14 Oct.; another had two eggs, 2–6 Oct. and four, 10 Oct.; a third contained three, 2–6 Oct., and four, 10 Oct. (NRS). At Murwillumbah, eggs apparently laid before 06:30. In Yarra R. Valley, usually laid in first hour after sunrise (Magrath 1999). Pairs rear up to three broods per season (Campbell 1902; Beruldsen 1980; Campbell; North; NRS). In Yarra R. Valley, many individuals (52% of 103 males, 43% of 123 females) produced at least two clutches per season, though few (28% of males, 21% of females) successfully reared two broods per season (Magrath 1999). For second or subsequent clutches, interval between young last seen in nest and next clutch, 13–28 days (n=17); interval between failure (eggs gone) and next clutch 4–36 days (n=14) (NRS). After weather-related failure, usually laid replacement clutch (Magrath 1999). See Magrath (1999) for mean seasonal productivity of individuals.

Incubation By both sexes. In Yarra R. Valley, clutches attended for mean 52.5 min/h (3.9; 40.9–56.6; 44) during daylight hours, though attendance usually declined over course of day. Females more attentive than males, with 56.0% (6.0; 44.0–68.0; 42) of attendance by female; females incubated in longer bouts than males (mean 15.1 min for females; 11.5 min males) with shorter recess periods (mean 11.4 min female; 13.1 min male). Total attendance did not vary with clutch size, but relative share of incubation by male increased with clutch size. Total attendance increased with age of clutch resulting from an increase in attendance by female, but not by male. Both sexes were more attentive on cooler days, especially in early morning and late afternoon (Magrath 1997).

Attendance by males decreased with increasing proportion of fertile females in colony (PFF), resulting from longer intervals between bouts of incubation, rather than shorter bouts; attendance of female unchanged. Thought that decline in attendance by males resulted from males spending more time seeking extra-pair matings. Males most responsive to PFF early in morning and least responsive in afternoon; and those with small clutches (2–3 eggs) more responsive than males with large clutches (4–5 eggs) (Magrath & Elgar 1997, which see for details). Attendance by male also decreased with reduced paternity (Magrath 1997; see also Young). Eggs mostly hatch asynchronously. At Murwillumbah, of 61 clutches: 18 (29.5%) hatched all eggs within 24 h, 33 (54.1%) hatched over 24–48 h, and ten (16.4%) over 48–72 h. **INCUBATION PERIOD:** From completion of clutch to hatching of each egg: 13.8 days (1.0; 302) (Tarburton 1991); 13.7 (1.0; 12–18; 187) (Magrath 1999); 15–16 days (McGilp 1930). Of 302 eggs: three (1.0%) took 11 days, 17 (5.6%) 12 days, 104 (34.4%) 13 days, 125 (41.4%) 14 days, 34 (11.3%) 15 days, 12 (4.0%) 16 days and seven (2.3%) 17 days (see Tarburton 1991 for further details). Period of incubation for whole clutches, from laying of last egg to hatching of last egg: 14.4 days (1.04; 91): of 91 clutches, two (2.2%) took 12 days, 16 (17.6%) 13 days, 35 (38.5%) 14 days, 26 (28.6%) 15 days, ten (11.0%) 16 days and two (2.2%) 17 days (see Tarburton 1991 for further details). At Murwillumbah, incubation period for individual eggs decreased as season progressed, from 14.1 days (1.09; 12–17; 160) in Aug.–Oct., to 13.5 (0.89; 11–16; 142) in Nov.–Jan. For whole clutches, incubation period decreased from 14.7 (1.00; 13–17; 43) in Aug.–Oct. to 14.0 (0.94; 12–16; 48) in Nov.–Jan. This decline probably due to increase in ambient temperature as season progressed. In Yarra R. Valley, incubation period also decreased slightly over season. Females with previous breeding experience tended to be more attentive to eggs (Magrath 1999). In Yarra R. Valley, incubation period was longer at nests where male less attentive to clutch; duration of incubation period positively correlated with mean PFF (Magrath & Elgar 1997). Eggshells removed from nest (NRS). Unhatched or infertile eggs are left in nests; a second clutch of four eggs was laid in one nest containing three unhatched eggs from previous clutch (NRS).

Young Altricial, nidicolous. Hatch naked (NRS) or with a little straw-coloured down (Tarburton 1991). **DEVELOPMENT OF NESTLINGS:** At Murwillumbah, pins of primaries and secondaries appeared first, erupting from skin in 5.8 (0.71; 8) days and bursting at 9.6 (1.27; 56) days; at least once, bursting of wing-feathers preceded by opening of body-contour pins, but these usually tend to open at 12–14 days, by which time nestlings usually well feathered. Feathering on crown developed at 14–16 days. Elsewhere, nestlings develop pins after c. 6 days, are feathered after 10–11 days, and well feathered by 15 days (NRS). At Murwillumbah, weight of nestlings on day of hatching 1.20–1.78 g ($n=5$) (see Tarburton 1991 for wing-growth curves and weight gain over fledging period). In Yarra R. Valley, weight of nestlings increased after hatching, reaching maximum of c. 13.5 g, or 125% of mean adult body-mass, 9–14 days after hatching; weight then declined before fledging. Weight of nestlings tended to be greater in middle of breeding season, though no significant difference between months ($P=0.1$). Juveniles (1–2 weeks after fledging) weighed 9.9 g (0.86; 23) (Magrath 1999). Within mixed-sex broods, male and female nestlings did not significantly differ in weight ($n=104$ broods; 11–17 days old). **PARENTAL CARE:** In Yarra R. Valley, both parents fed and brooded nestlings from hatching age (Magrath 1997; Magrath *et al.* 2002). Near L. Frome, SA, claimed that for c. 1 week after hatching, one parent, presumably female, broods and takes food from other parent to feed to nestlings; thereafter, fed by both parents (McGilp 1923, 1930). Claimed that nestlings came to nest-entrance to be fed

(NRS). Time spent brooding decreased steadily till c. 8 days old (Magrath 1997; Magrath *et al.* 2002). Adults remove faecal sacs from nest (NRS).

Fledging to independence **FLEDGING PERIOD:** From hatching to day first recorded absent from nest: 22.5 days (3.5; 14–30; 91) (Tarburton 1991) and 22.1 (2.4; 17–32; 148 broods) (Magrath 1999); from hatching of last nestling to fledging of same: 18 ± 1 days (no N) (Ashton 1987); 18–19 days (McGilp 1930). In Yarra R. Valley, fledging period increased with brood-size ($n=143$) but did not vary throughout season ($n=143$). Disturbance of nestlings >16 days old can lead to premature fledging (Magrath 1999). At Murwillumbah, individual broods usually fledged over 1–4 days, though one brood fledged over 8 days, and another over 10 days. Some fledgelings fly strongly when leaving nest, and others have weak flight, unable to fly >6 m at a time (NRS). Some fed in flight (Elliott 1934). In Yarra R. Valley, young roosted in nest for several weeks after fledging (Magrath 1999).

Success For ten nests where clutch-size, number hatched and fledging known: of 31 eggs, none hatched. For 17 nests where clutch-size and number hatched known, but fledging outcome unknown: of 52 eggs, 21 (40.4%) hatched; of 46 nests where outcome known, 17 (37.0%) successfully fledged at least one young, and 29 (63.0%) failed; at another 34 nests where outcome unknown, young were considered capable of leaving nest when last seen, i.e. of 80 nests, 51 (63.7%) possibly fledged at least one young (NRS). At Murwillumbah, of 642 eggs in 182 clutches, 597 (93.0%) hatched, and 417 (65%) fledged; equivalent to 2.27 fledgelings per clutch (Tarburton 1991; M.K. Tarburton). Success decreased with clutch-size: in clutches of two, 90.0% of eggs ($n=20$) resulted in fledged young, 84.9% ($n=219$) in clutches of three, 76.0% ($n=408$) in clutches of four and 60.0% fledged from single clutch of five. Hatching and fledging success both decreased as season progressed. Hatching success declined significantly from 3.3 (0.9; 94) hatched per clutch before 1 Nov. to 3.0 (0.7; 89) from Nov. onward; before 1 Nov., 3.55 (2.33) young fledged per brood, declining significantly to 2.66 (0.99) on or after 1 Nov. (Tarburton 1991). In Yarra R. Valley, of 1013 eggs in 289 completed clutches, 645 (63.7%) hatched and 533 (52.6%) fledged young, equivalent to 1.84 fledgelings per clutch; 174 (60.2%) clutches successfully fledged at least one young; fledging success lowest in Oct. and greatest in Nov. Of 350 clutches (includes incomplete clutches), 206 (58.9%) successfully fledged at least one young, and 144 (41.1%) failed; 80% of failures occurred before hatching (Magrath 1999). **CAUSES OF FAILURE:** Most nests fail due to inclement weather, falling or being washed away during heavy rain or flooding (Lang 1930; McGilp 1930; Reese 1931; Robinson 1933; Tarburton 1991; Schulz 1998; Campbell; NRS); and sometimes adults and fledgelings die in nests due to cold snaps (Morgan 1916; Magrath 1999). Nests often fail due to human interference. Many, sometimes entire colonies, are destroyed by children, vandals or egg-collectors (Sutton 1921; Mellor 1930; Amedy 1965; Ashton 1987; NRS); and nests sometimes removed from public buildings (Chenery & Morgan 1920; NRS). All 175 nests in one colony in iron shed (with eggs and young) were destroyed when shed torn down (NRS). House Sparrows and occasionally Starlings harass Martins and usurp their nests (Campbell 1902; Anon. 1909; Hindwood 1934; Roberts 1955; North). One half-built nest was usurped by Welcome Swallows; after Swallows had reared young, Martins reclaimed nest and fledged their own young (Tarburton 1991). Nests that are active late in season sometimes fail when adults leave before eggs hatched or young fledged (McGilp 1930; Ashton 1996). Nests under bridges and culverts occasionally dislodged by vibration of passing trains or vehicles (Camaby 1933; Masters & Milhinch 1974; NRS). Nests sometimes deserted during building stage when mud source dries up; one

colony was apparently deserted when nearby pool dried out, despite presence of dam a few hundred metres away (McGill 1945). At one site, nests built two or three deep fell under their own weight (Mellor 1930). One nest had dead adult stuck in spout, with four dead nestlings inside (Ashton 1987). One fledgeling found dead on road was killed by vehicle (Tarburton 1991). In Yarra R. Valley, of 350 nesting attempts, 39% failed when clutch or brood was deserted during bouts of cold, wet weather, mostly early in season; 17% failed when nests fell from substrates; 10% were washed away by floods (10%); 4% were usurped by House Sparrows during final stages of nest building; 24% were abandoned from unknown causes; and in 6% clutch or brood disappeared from nest, of which two cases may have resulted from predation. Of 182 clutches that hatched at least one young, 33% contained at least one unhatched egg; and 12% of eggs failed to hatch, due to either infertility or embryonic mortality. Of 158 nests that produced at least one fledgeling, 11% lost at least one chick, but only 4% of chicks died. There was no seasonal pattern of egg-failure or partial brood-loss (Magrath 1999). **PREDATORS:** Contents of nests preyed on by snakes, such as Carpet Snakes *Morelia spilota* (Anon. 1901; Carter 1903), and once, Tiger Snake *Notechis scutatus* found in nest in deserted colony (Bridgewater 1932). Pair of Red-backed Kingfishers *Todiramphus pyrrhopygia* seen taking turns at breaking open nest and devouring contents, returning each day for several weeks to repeat process. Once, raven *Corvus* thought to have broken nests and eaten young, though Red-backed Kingfisher seen nearby (North). Entire colonies sometimes invaded by ants, killing nestlings and causing desertion (Batey 1907; NRS). Suggested that Foxes sometimes destroy nests and eat young (Caldwell 1918; NRS).

PLUMAGES Prepared by J.S. Matthew. Hatch naked (NRS) or with sparse natal down (Tarburton 1991); see Breeding for development of feathers in nestlings. Fledge in juvenile plumage. Partial post-juvenile (first pre-basic) moult to adult (first basic) plumage. Thereafter, complete post-breeding (pre-basic) moult each cycle produces successive adult non-breeding (basic) plumages. Sexes similar. Plumages described below based on descriptions of skins of nine adults and seven juveniles (HLW, MV).

Adult (Definitive basic). **HEAD AND NECK:** Forehead, crown, nape and upper hindneck, bright rufous-brown (136) with fine dark-brown (121) streaking which is less prominent or absent on nape and hindneck; feathers, rufous-brown (136) with V-shaped dark-brown (121) marking across centre, apex of V extending to tip and visible as narrow dark streak; most birds have cream (54) tips to feathers of lower forehead, combining to form diffuse pale patch above base of bill. Lower hindneck, sides of neck and lower ear-coverts, rufous-brown (c38), paler than top of head, with dark-brown (121) or blackish-brown (119) streaking or mottling formed by shaft-streaks to feathers; lower hindneck sharply demarcated from uniform bright rufous-brown upper hindneck. Upper lores and front half of eye-ring, black-brown (119) or blackish (c89); rest of eye-ring and upper ear-coverts, dark brown (121); all feathers combine to form narrow dark eye-stripe which blackish (c89) in front of eye and dark brown (121) behind eye. Lower lores, off-white (ne) with faint rufous-brown (c38) tinge; usually form small off-white (ne) loreal patch. Malar area, chin and throat, off-white (ne) with faint buff (124) tinge and dark-brown (121, 119A) streaking formed by shaft-streaks to feathers, more prominent on chin. Several very short and fine black (89) bristles arise from lower lores. **UPPERPARTS:** Mantle, scapulars and back, glossy blue-black (glossy 90); most feathers glossy blue-black (glossy 90) at tips with concealed or partly visible broad white band across centres and concealed grey (87) bases; outer scapulars, dark brown across centres (lacking

white). Feathers of rump and most uppertail-coverts, white with pale-buff (123D) or pale orange-buff (pale 118) tinge and indistinct dark-brown (121) shafts; feathers combine to form prominent broad whitish or buff-white (ne) rump-patch, very finely and indistinctly streaked dark brown (121). Longest uppertail-coverts, brown (28) or dark brown (121) with dark-brown (121) shafts and narrow off-white (ne) fringes. **UNDERPARTS:** Most of underparts, off-white (ne) or cream (c54), often whiter on vent and undertail-coverts, with varying light-brown (c39) or pale orange-buff (pale 118) wash on breast and flanks, especially on sides of upper breast; most birds have indistinct and fine dark-brown (121) streaks on upper breast formed by shaft-streaks to feathers. Axillaries, orange-buff (118) or light brown (c39). **UPPERTAIL:** Rectrices, blackish brown (dark 121) with faint dark-bluish (ne) or greenish-blue (c164) gloss, indistinct light grey-brown (119D) outer edges and concealed off-white (ne) inner edges which are broader on outer rectrices. **UNDERTAIL:** Rectrices, dark brown (121) with narrow white inner edges which are visible on outer rectrices. **UPPERWING:** Marginal and median secondary coverts, dark brown (121) or black-brown (119) with glossy blue-black (glossy 90) wash near tips and narrow light-brown (223D) fringes at tips when fresh; outermost marginal coverts with mostly light grey-brown (119D) outer webs and off-white (ne) tips, feathers combining to form small area of pale mottling on otherwise dark bend of wing. Greater secondary coverts, dark brown (121) with narrow off-white (ne) or buff-white (ne) fringes at tips; inner 2–3 coverts with pale-greyish (c86) or off-white (ne) inner webs or broad inner edges and buff-white (ne) or buff (124) fringes at tips, these coverts usually concealed by overlying scapulars. Marginal and median primary coverts, dark brown (121) with buff (c124) or light-brown (223D) tips. Greater primary coverts and alula, dark brown (121) with very narrow light-brown (223D) fringes to tips of primary coverts; two shortest feathers of alula with very narrow off-white (ne) fringes at tips. Tertiaries, black-brown (119), grading to dark brown (121) with wear, with faint dark-blue (ne) gloss near tips and narrow off-white (ne) fringes to tips when fresh; fringes lost with wear, leaving small notch at tip of feather. Secondaries and primaries, dark brown (121) with faint dark-blue (ne) gloss near tips, narrow off-white (ne) fringes at tips when fresh and concealed broad light grey-brown (119D) submargins to inner webs, bordered by narrow white margin. **UNDERWING:** All marginal coverts, brown (28) with broad off-white (ne) or pale-buff (123D) tips; on primary coverts, brown extends as narrow shaft-streak to tip. All median coverts and greater secondary coverts, light grey-brown (119D) with orange-buff (118) fringes. Greater primary coverts, greyish (c85) with narrow orange-buff (118) fringes. Remiges, brownish grey (c79) with narrow white margins to inner webs.

Nestlings Natal down described as straw-coloured (Tarburton 1991).

Juvenile Differs from adult by: **HEAD AND NECK:** Forehead, crown, nape and upper hindneck, dull rufous-brown (c340) with fairly bold black-brown (119) or dark-brown (121) streaking or mottling formed by broad shaft-streaks or centres to feathers; streaking or mottling less distinct on hindneck; some birds have narrow cream (54) tips to feathers of lower forehead, as in adults. Lower hindneck and sides of neck, paler rufous-brown (pale 38) with faint dark-brown (121) mottling. Eye-stripe similar to adult but slightly paler and more diffuse in front of eye. Malar area, chin and throat, off-white (ne) with rather indistinct and diffuse brown (28) streaking, more prominent on chin. **UPPERPARTS:** Mantle, scapulars and back, black-brown (119) with, at most, faint greenish-blue (ne) gloss and with fine light-brown (223D) scalloping formed by narrow fringes to tips of feathers. Rump and uppertail-coverts, as adult, but fringes to longest uppertail-

coverts slightly broader and light brown (223D) or pale buff (123D) (cf. off-white in adult). Feathers, especially those of mantle, softer and more loosely textured than in adult. **UNDERPARTS:** As adult, but upper breast more uniformly light brown (c39) and, at most, only faintly and diffusely streaked brown (28). **TAIL:** As adult, but uppertail lacks gloss; rectrices with narrow off-white (ne) edges near tips of outer webs, grading to light grey-brown (119D) basally (cf. entirely light grey-brown in adult). **UPPERWING:** All marginal and median coverts, blackish brown (c119) or dark brown (121) with light-brown (39) tips or fringes at tips. Greater secondary coverts, black-brown (119) or dark brown (121) with narrow light-brown (39) fringes at tips which combine to form narrow light-brown (39) wing. Greater primary coverts and alula as adult, but two shortest feathers of alula have narrow light-brown (39, 223D) fringes at tips. Tertiaries, dark brown (121) with light-brown (39) tips which are broader on outer webs. Primaries and secondaries, dark brown (121), lacking gloss, with narrow light-brown (39) fringes at tips of secondaries and primaries, fringes merging with inner margins, which are as adult. **UNDERWING:** As adult.

BARE PARTS Based on photos (unpubl.: D.W. Eades; L.N. Robinson; and standard sources), museum labels (MV) and other information as cited. **Adult** Bill and gape, black (89). Iris described as dark brown (MV). Orbital ring, dark grey (83). Legs and feet described as black or greyish (MV). **Nestlings** No information. **Juvenile** Differs from adult by: Bill, grey-black (82) with flesh-yellow (ne) base to lower mandible; also buff with dark tip or dull yellow with dark tip (MV). Gape, dull yellow (c55). Palate described as yellow (Rogers *et al.* 1986). Legs and feet, dark grey (83) with pinkish (c4) tinge; also yellowish brown or dull flesh (MV).

MOULTS Based on examination of skins of 13 adults and six juveniles (HLW, MV, SAM). **Adult post-breeding** (Probably second and subsequent pre-basic). Little known. Probably complete. From skins collected Sept.–Jan. (n=12) and May (n=1): none had active moult of any feather-tract; those from Sept.–Jan. had all primaries worn; one from sw. Qld in May had all primaries new. In Kimberley Div., WA, one bird finished and another nearly finished moult of primaries and rectrices in May; at Tully, se. Qld, five birds had moult of crown and secondaries in late July; at Monkira, sw. Qld, one bird had fresh plumage in June (Hall). Rogers *et al.* (1986) captured one in Vic. in Mar.; this bird had no active moult. **Post-juvenile** (First pre-basic). Little known. Probably complete as in Tree Martin, but data needed to confirm this. Six skins, collected Nov.–Jan. had no active moult.

MEASUREMENTS (1) Qld, NSW, Vic. and SA, skins (HLW, MV, SAM): (1) Adults; (2) Juveniles. (3) Yarra R. Valley, Vic., breeding adults, live, sexed by presence (females) or absence (males) of brood-patch (Magrath 1999).

	MALES	FEMALES	
WING	(1) 92.6 (2.40; 89–98; 10)	92.0 (2.35; 90–95; 4)	ns
	(2) 92, 98	90, 92	
	(3) 91.5 (1.79; 87–95; 136)	90.7 (2.03; 86–96; 152)	**
TAIL	(1) 46.2 (2.53; 41–51; 10)	47.9 (1.49; 46–50; 4)	ns
	(2) 42, 43, 51	42, 42, 45	
	(3) 47.7 (1.69; 43.5–53.0; 155)	47.1 (1.96; 40.0–51.7; 173)	**
TAIL FORK	(1) 6.8 (1.40; 5.4–8.7; 5)	8.0, 8.2, 9.1	
	(2) 4.9, 5.3, 5.8	6.2, 6.4	
THL	(3) 24.1 (0.55; 21.5–25.4; 92)	23.9 (0.53; 22.5–24.9; 95)	**
BILL S	(1) 8.6 (0.80; 7.2–9.5; 9)	8.9 (0.54; 8.4–9.6; 4)	ns
	(2) 8.6, 9.6, 10.1	7.0, 8.5, 9.9	
TARSUS	(1) 10.3 (1.05; 9.0–11.8; 9)	9.2, 9.7	
	(2) 8.7, 9.3, 9.3	9.3, 9.6	
	(3) 10.8 (0.39; 9.7–11.7; 90)	10.8 (0.33; 10.0–11.9; 93)	ns

(4) Qld, live adults, unsexed (Rogers *et al.* 1990).

UNSEXED	
WING	(4) 90.0 (3.00; 80–93; 57)
TAIL	(4) 45.9 (3.14; 37–52; 57)
THL	(4) 23.8 (0.59; 22.8–24.6; 56)

Rogers *et al.* (1986) record following for single 'immature' (probably referring to juvenile, judging by accompanying plumage and bare part descriptions): Wing 90; Tail 40; THL 24.6.

WEIGHTS (1–2) Qld, Vic. and WA, from museum labels (MV) and Hall: (1) Adults; (2) Juveniles. (3) Yarra Valley, Vic., breeding adults, live, sexed by presence (females) or absence (males) of brood-patch (Magrath 1999).

	MALES	FEMALES	
(1)	10.2 (0.40; 9.8–10.5; 4)	9.9, 10.5	
(2)	10.5, 10.9	–	
(3)	10.7 (0.64; 9.1–13.0; 193)	11.0 (0.84; 9.1–14.1; 202)	**

Rogers *et al.* (1990) recorded mean weight of 10.7 g (1.59; 8.5–14.0; 54) for adults captured in Qld. Rogers *et al.* (1986) recorded weight of one immature (probably referring to juvenile) captured in Vic. as 11.2 g. Magrath (1999) found that weight of adults was highest during laying stage of breeding cycle, and lowest during nestling and post-fledging stages; see Figure 1 in that reference.

STRUCTURE Wing long, narrow and pointed at tip. Ten primaries: p9 longest, p8 sometimes =; p10 vestigial; p8 0–1 mm shorter, p7 5–9, p6 12–18, p5 17–22, p4 24–28, p3 30–34, p2 35–39, p1 40–44. Primaries not emarginated. Nine secondaries including three tertials; tips of longest tertials fall shorter than tips of secondaries on folded wing. Secondaries with distinct notch in centre of tips. Tail rather short with fairly distinct fork (see Measurements); 12 rectrices; t6 longest, t1 5–9 mm shorter than t6 (see Measurements). Bill short and flattened, broad at base, pointed at tip. Tarsus short and slender, compressed laterally; scaling laminipantar with ridged plantar surface. Tibia fully feathered. Middle toe with claw c. 12.5 mm; outer and inner toes 65–80% of middle, hindtoe 60–80%.

GEOGRAPHICAL VARIATION None known (Turner & Rose 1989; Peters; DAB; this study). Sometimes considered conspecific with very similar Indian Cliff Swallow *H. fluvicola* (Vaurie 1951), but latter species has brownish rump and uppertail-coverts and bolder streaking to underbody which also extends to face (Turner & Rose 1989; DAB).

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Volume 7 (Part B), Plate 44

White-backed Swallow *Cheramoeca leucosternus* (page 1499)
1 Adult; 2 Juvenile

Barn Swallow *Hirundo rustica* (page 1508)
SUBSPECIES *GUTTURALIS*: 3 Adult male; 4 Juvenile

Welcome Swallow *Hirundo neoxena* (page 1517)
NOMINATE *NEOXENA*: 5 Adult male (fresh plumage); 6 Adult male (worn plumage); 7 Juvenile

Red-rumped Swallow *Hirundo daurica* (page 1549)
SUBSPECIES *JAPONICA*: 8 Adult male; 9 Juvenile

Tree Martin *Hirundo nigricans* (page 1553)
10 Adult; 11 Juvenile

Fairy Martin *Hirundo ariel* (page 1568)
12 Adult; 13 Juvenile

Asian House Martin *Delichon dasypus* (page 1583)
NOMINATE *DASYPUS*: 14 Adult



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Volume 7 (Part B), Plate 45

White-backed Swallow *Cheramoeca leucosternus* (page 1499)
1, 2 Adult

Barn Swallow *Hirundo rustica* (page 1508)
 SUBSPECIES *GUTTURALIS*: **3, 4** Adult male

Welcome Swallow *Hirundo neoxena* (page 1517)
 NOMINATE *NEOXENA*: **5, 6** Adult male

Red-rumped Swallow *Hirundo daurica* (page 1549)
 SUBSPECIES *JAPONICA*: **7, 8** Adult male

Tree Martin *Hirundo nigricans* (page 1553)
9, 10 Adult

Fairy Martin *Hirundo ariel* (page 1568)
11, 12 Adult

Asian House Martin *Delichon dasypus* (page 1583)
 NOMINATE *DASYPUS*: **13, 14** Adult