

Order APODIFORMES

A superficially heterogeneous order of three families of rather small to tiny land birds: (1) APODIDAE: cosmopolitan, almost wholly aerial and insectivorous swifts; (2) HEMIPROCINIDAE: e. Palaeotropical tree-swifts; and (3) TROCHILIDAE: nectarivorous New World hummingbirds. Apodiformes stand apart from other non-passerine land birds in sharing, in combination: Holorhinal and impervious nares. No basipterygoid processes; un-notched, posteriorly broadened sternum, with fused spina 'communis'; stout U-shaped furcula, with well-developed but short hypocleidium. Tiny feet, with simple single-furrowed hypotarsus yet well-developed claws for clinging and grasping; type 5 flexor tendons. Pelvic muscle formula of A. Single left carotid artery (except Cypseloidinae, which have two). Usually no caeca. Aftershafts usually present in contour plumage; very short and thick humerus and ulna, with 6–11 short secondaries, but prolonged carpus, with ten primaries (outermost longest), adapted for rapid flight; ten rectrices. Plain white eggs; young, altricial, nidicolous.

Historically, swifts and hummingbirds often thought unrelated, the swifts having supposed affinity with passerine swallows (e.g. Shufeldt 1885). Both morphological (Garrod 1874; Stejneger 1885; Beddard 1898; Burton 1971; Cracraft 1981, 1988; Olson 1985) and molecular (Sibley & Ahlquist 1990) evidence now indicate that they are one another's closest relatives, with further links to Caprimulgiformes still in dispute. Recent convention includes the swifts and hummingbirds in one order, usually as suborders (e.g. Stresemann 1934; Wetmore 1960; Peters; BWP). Wolters (1976), Sibley & Ahlquist (1990) and Sibley & Monroe (1990) separated them as orders, the latter within the superorder Apodimorphae, leaving the issue of status open. Hummingbirds differ from swifts and tree-swifts, *inter alia*, in: long slender bills and extendable tongues adapted to nectarivory; metallic plumage; much shorter wings, adapted for hovering; schizognathous palate; only 6–7 secondaries; vestigial aftershafts; no gall bladder; distinctly bilobed uropygial gland; and syrinx with two pairs of special extrinsic syringeal muscles and no sterno-tracheal muscles. Tree-swifts differ from other swifts in: tree-perching habit; heads ornamented with plumes; patch of downy or silky feathers on the flanks; lack of a claw on the carpus; anisodactylous feet, with hind-claw directed irreversibly backwards for tree-perching; tiny saucer-like arboreal nest; and mottled plumage of nestlings and fledgelings.

Wholly extralimital Hemiprocinae and Trochilidae not considered further here. The comparative features of swifts (Apodidae) are discussed below.

REFERENCES

- Beddard, F.E. 1898. *The Structure and Classification of Birds*. Longmans Green, Lond.
- Benton, M.J. (Ed.) 1988. *The Phylogeny and Classification of the Tetrapods*. 1. OUP, Oxford.
- Burton, P.J.K. 1971. *Ibis* 113: 19–28.
- Cassino, S.E. (Ed.) 1885. *J.S. Kingsley, The Standard Natural History*. 4. Boston.
- Cracraft, J. 1981. *Auk* 98: 681–714.
- 1988. Pp 339–61 In: Benton 1988.
- Farner, D.S., et al. (Eds) 1985. *Avian Biology*. 8. Academic Press, New York.
- Garrod, A.H. 1874. *Proc. Zool. Soc. Lond.* 1874: 111–24.
- Kükenthal, W., & T. Krumbach (Eds) 1934. *Handbuch der Zoologie*. 7(2). W. de Gruyter, Berlin.
- Olson, S.L. 1985. Pp 79–238 In: Farner et al. 1985.
- Shufeldt, R.W. 1885. *Proc. Zool. Soc. Lond.* 1885: 886–915.
- Sibley, C.G., & J.E. Ahlquist. 1990. *Phylogeny and Classification of Birds*. Yale Univ. Press, New Haven.
- , & B.L. Monroe Jr. 1990. *Distribution and Taxonomy of Birds of the World*. Yale Univ. Press, New Haven.
- Stejneger, L. 1885. *Birds* In: Cassino 1885.
- Stresemann, E. 1934. *Aves* In: Kükenthal & Krumbach 1934.
- Wetmore, A. 1960. *Smithson. Misc. Coll.* 139(11): 1–37.
- Wolters, H.E. 1976. *Die Vogelarten der Erde*. 2. Paul Parey, Hamburg.

Family APODIDAE swifts

Small to medium-sized, ranging in size from Indo-Papuan swiftlets of *Collocalia sensu stricto* (9–10 cm, 5–7 g) to the se. Asian *Hirundapus giganteus* group (22–25 cm, c. 180 g). Nearly 100 species in 14–20, and probably 17–20, genera (Wolters 1976; Campbell & Lack 1985; Sibley & Monroe 1990; Chantler & Driessens 1995; Peters). Most diverse in warmer parts of world, with centres in S. America, Africa, se. Asia and adjacent archipelagos. Principal genera include: *Aerodramus* (roughly 22–27 species of dull-plumaged, e. Palaeotropical swiftlets); *Apus* (roughly 14–17 species of Afro-Eurasian fork-tailed swifts); *Chaetura* (about nine species of New World needle-tailed swifts); and *Cypseloides* (about 9–10 species of dusky, diastataxic New World swifts, which build nests without binding saliva). Often broken up into three subfamilies (Lack & Campbell 1985; BWP): New World Cypseloidinae, cosmopolitan Chaeturinae, and prevailingly Old World Apodinae (the latter with toes 1 and 2 opposed to 2 and 4 for grasping laterally inward and

seemingly pamprodactyl at rest). DNA–DNA hybridization and mtDNA sequences (Sibley & Monroe 1990; Lee *et al.* 1996) nevertheless support Brooke's (1970) morphological case for two: CYPSELOIDINAE: About 12 species, occurring from S. to N. America; wing diastataxic; carotid arteries paired; trans-palatine processes vestigial; *Musculus splenius capitis* simple; feet anisodactylous; some sexual dimorphism in plumage; nestlings covered in down-like semi-plumes; and no cementing saliva used in nests. APODINAE: About 85 species; cosmopolitan; wing eutaxic; carotid arteries single; trans-palatine processes usually well developed; *Musculus splenius capitis* complex; feet anisodactylous or pseudo-pamprodactylous; no sexual dimorphism in plumage; nestlings naked (except *Cypsiurus*); cementing saliva used in nearly all nests (except *Hirundapus* and some others).

Circumscription of tribes in Apodinae unsettled. Usually three recognized: swiftlets (Collocaliini), needle-tailed swifts (Chaeturini), and pseudo-pamprodactyl Apodini (e.g. Brooke 1970; Chantler & Driessens 1995; Schodde & Mason 1997). MtDNA sequences (Lee *et al.* 1996), however, indicate that Collocaliini are polyphyletic, split by members of both Chaeturini and Apodini. Representation of family in HANZAB region poor, with only two species of swiftlets (Collocaliini) resident breeders, and one of Chaeturini (*Hirundapus*) and one of Apodini (*Apus*) regularly non-breeding migrants.

Skull broad and flat. Palate aegithognathous, with truncated vomer bifid at level of departure of palatine processes from maxillary; premaxilla unossified; maxillary processes unexpanded; palatine shelf unexpanded, with narrow posterior processes; lacrymals vestigial; and nasals and maxillary fused in a bar anteriorly to inarticulate naso-frontal hinge. Nasal septum extensively perforate. Thirteen to 14 cervical vertebrae; 6–7 ribs per side. Syrinx tracheo-bronchial, with single pairs of extrinsic and intrinsic muscles. *Musculus tensor patagium brevis* strong and extensively fleshed, but *M. expansor secundariorum*, *M. sternocoracoideus* and biceps slip absent; no *M. ambiens*; and deep plantar tendons Type V, usually fully fused. No crop in adults or nestling; right lobe of liver larger than left and gall bladder present; no caeca. Naked oil gland indistinctly bilobed. Diploid karyotype of 64–76 chromosomes, with five pairs of macrochromosomes (Christidis 1990).

Adaptation to aerial life and insectivory reflected in aerodynamic form and internal structure. Body bullet-shaped, with short neck, and long-tapered and bow-shaped wings. Bill very short, wide and without bristles, with broadened gape extending back below eyes to increase sweep; bills dusky, or lower mandible flesh-toned; nostrils inoperculate oblique holes opening vertically at base of maxilla. Tongue short, triangular, bifid at tip and not extendable. Wide-gaped mouth able to accumulate insects in a saliva-cemented wad or bolus, which is carried in a pouch under the tongue when feeding young. Large salivary glands present, which swell during reproductive period to produce saliva for cementing nest. Eyes, large, with dark irises. Feet have feeble, often feathered, tarsi, and four strong and well-clawed heterodactyl (Apodini; Collins 1963) or anisodactyl (all other swifts) toes, the hallux reversible, used for clinging to vertical surfaces when at rest or nest. Swifts can barely more than shuffle at a perch and launch themselves into flight directly from resting place. Feathering sleek, in well-defined tracts: throat wholly feathered, so that paired ventral tracts begin on neck and widen without branching over breast; dorsal tract has narrow central apterium; and femoral tracts well marked; aftershafts long and downy, and apteria have dense under-down. Colouring usually dull, blackish greys and browns; infrequently glossy, with little patterning except for contrastingly pale throats and rumps. Sexual dimorphism none or slight (Cypseloidinae). Wings narrow, back-swept and down-swept, with shallow camber; adapted for high-speed, rather than manoeuvrable, flight, the long primaries and short secondaries producing a strong downward force and forward propulsion; swifts sweep through the air, with flickering wing-beats and protracted scything glides. Wing-shape varies between genera, from slender and arced (many Apodini) to broader and rounded (many Chaeturini), conferring different flight-characteristics. Carpus clawed, with 2–3 alula feathers; primaries moult outwards, and the 8–11 secondaries inward, but timing varies between taxa with season and age, and moult sometimes interrupted or much protracted (swiftlets); wave-moult occurs in some species of *Apus*. Tail from short and square-tipped to rather long and deeply forked; shafts of rectrices in many squarish tailed genera (Chaeturini, *Streptoprocne* in Cypseloidinae) projecting as short spines beyond tips of vanes, for bracing at perch; moult centripetal. Young fledge in adult-like, but duller, plumage; full adult plumage attained in a post-juvenile (first pre-basic) moult several months after hatching, commonly on arrival at wintering quarters in migratory species; this moult is usually complete except for remiges and, sometimes, wing-coverts.

Swifts are the most aerial of all birds, feeding, drinking, bathing, resting and even sleeping and copulating on the wing as well as in nest. Habitat is mainly the sky, from sea-level to 4000 m asl, sometimes more; mostly feed within 200 m of ground because abundance of prey declines significantly above this height. Occur over most types of habitat. When not nesting, swifts remain on the wing throughout day, but at night many (Cypseloidinae, Chaeturini, all swiftlets) congregate to roost at regularly used sites, such as crevices in cliffs, caves, buildings and dense crowns of trees, where cling and sleep in vertical position; Apodini, and possibly other swifts, thought to sleep on wing, particularly on migration. Migratory species in HANZAB region (i.e. Fork-tailed Swift, White-throated Needletail) sometimes incorrectly said to remain exclusively in air while in region, and, indeed, for Fork-tailed Swifts, most roosting probably aerial, but Needletails recorded roosting among foliage and in hollow branches, though number of references in literature probably overemphasize such occurrences.

Worldwide, eight species are threatened: some adversely affected by loss of habitat, others by disturbance by tourists or the introduction of potential predators, such as the Common Myna *Acridotheres tristis*; colonies of one species, the Volcano Swiftlet *Collocalia vulcanorum* of Indonesia, are susceptible to periodic extirpation by volcanic activity (Collar *et al.* 1994).

Sedentary, resident and migratory. Tropical species, including all swiftlets, rather sedentary or resident; species breeding in temperate latitudes migratory to varying extent. Those breeding in n. hemisphere commonly winter from tropical to temperate latitudes in s. hemisphere, including Aust., e.g. White-throated Needletail and Fork-tailed Swift abundant trans-equatorial migrants to HANZAB region from breeding grounds in n. hemisphere. Many larger species are highly mobile, foraging over vast distances in non-breeding periods, e.g. White-throated Needletail and Fork-tailed Swift in Aust. Several species recorded as vagrants have main distributions that abut HANZAB region.

Most aerial of all birds; feeding solely on aerial insects and some drifting spiders. Usually gather food well above ground, from one to several hundred metres. Feeding flight characterized by much circling, particularly through prey-rich sites; most species in Aust. search for prey along edges of low-pressure systems. Forage in small to very large groups above forests and open agricultural land; some (e.g. Glossy Swiftlet *Collocalia esculenta*) forage at low elevations in cultivated areas, over open water, or over fig trees at times when fig-wasps swarming (Hymenoptera: Agaonidae). Mostly diurnal, but some subspecies of White-rumped Swiftlets in Indonesia feed at twilight. Bill short and broad with wide gape that usually occupies full width of broad skull. No crop; no caeca; salivary gland large, and enlarged further in breeding season, when used in construction of nests. Food collected for young is formed into bolus in mouth.

Commonly gregarious. Swifts pair monogamously to nest, usually in loosely to densely packed colonies; in migratory species, re-pairing takes place at nesting site of previous season, which is commonly re-used. Nesting sites, especially holes, defended by threat display (screaming, attacking flight with raised wings), followed by aerial fighting if pressed; will also grapple with feet, and, to lesser extent, bills. Aerial copulation, often at high altitude, preceded by display flight initiated by female: female flies in front of male, dipping down with wings held vertically above back, the male in pursuit; she then flattens out on quivering wings, the signal for the male to mount, his wings held high over his back while hers are horizontal. Flight-path then becomes a shallow descending glide, as both partners manipulate their tails frantically to effect coitus while one or other flaps its wings. This sequence the norm for Common Swift *Apus apus* (Lack 1956), but is similar in other swifts (Chantler & Driessens 1995). Many species also copulate in nest, swiftlets apparently exclusively so.

Calls range from insect-like to parrot-like chattering, twitters, wheezes and buzzes, rapid chippings, and drawn-out buzzy screams or screeches. *Aerodramus* swiftlets utter unique metallic clicks which function as sonar and allow them to echolocate and find their nests in the darkness of deep roosting and nesting caves (Medway & Pye 1977; see White-rumped Swiftlet); the glossy swiftlets and waterfall swiftlet (*Collocalia, Hydrochous*) do not echolocate. Noisy at breeding sites, and when arriving at and leaving roosts (which are often same as breeding sites).

Timing of breeding correlated with seasonal conditions that increase populations of prey, e.g. wet monsoon in Tropics. Nests small and usually shallow; bowl- or bracket-shaped; of finely interwoven plant material (commonly bryophytes) and feathers, usually gathered on wing, and bound with cementing saliva produced by enlarged salivary glands in mouth (except Cypseloidinae); proportions of material and saliva vary, particularly in swiftlets, where composition species-specific (Medway 1966); nests of se. Asian species building nests prevailingly of saliva are harvested commercially for culinary purposes, especially bird's-nest soup. Some species (e.g. *Panyptila*) build hanging sleeve-like nests with nest-chamber at top, and others semi-suspended hemispherical bags (*Tachornis*, Little Swift *Apus affinis*); still others (e.g. *Hirundapus*) nest on a scrape in tree-hollows. Nest built by both sexes; most nests are placed on rock ledges, where supported at base (Cypseloidinae, some Apodini), or on vertical or overhanging walls in rock and tree holes, caves, rock crevices and chimneys, where glued on at side by saliva (many Chaeturini, swiftlets); side-glued nests may also be fastened to underside of large leaves (e.g. palm fronds), and the eggs glued to the nest-lining as well, to prevent their rolling out (Afro-Asian palm swifts, *Cypsiurus*). Eggs elliptical, white and lustreless. Clutches usually 2–3, occasionally 1 or 4. Eggs laid normally at intervals of 2 days, and incubated by both sexes in turn at intervals of roughly 1–3 h by day (Fry *et al.* 1988; BWP). Incubation and nestling periods long for size of birds: incubation period mostly 20–30 days; fledging period 35–60 days. Nestlings hatch naked or, in Cypseloidinae and apodine *Cypsiurus*, covered with dense dark-grey protoptile down (Collins 1963, 1965). Both parents brood and feed nestlings; brooding continuous for c. 1 week, then mainly at night. Feeding by bill-to-bill deposition of whole food bolus into large gapes of nestlings. Nestlings beg with sibilant screaming and waving of upthrust open bill; initiated by appearance of arriving parent and accompanying sounds. Susceptible to snakes, rats and other predators at nests, and to adverse weather conditions, which can cause starvation (Chantler & Driessens 1995). Mortality rates low, commonly <20% per year across species.

Because of aerial lifestyle and speed of flight, swifts have few predators except some falcons. Swifts carry an array of ectoparasites and endoparasites, including cestodes, cimicid bugs, hippoboscids, ticks, feather mites and feather

lice (Acarina, Mallophaga); some are represented by endemic families. Two particular genera of feather lice, *Eureum* and *Dennyus*, also endemic on swifts; the distribution of their species-groups carries information on phylogenetic affinities of their hosts (e.g. Ledger 1970).

REFERENCES

- Brooke, R.K. 1970. *Durban Mus. Novit.* 9: 13–24.
- Campbell, B., & E. Lack. 1985. *A Dictionary of Birds*. T. & A.D. Poyser, Calton, England.
- Chantler, P., & G. Driessens. 1995. *Swifts*. Pica, Robertsbridge, England.
- Collar, N.J., et al. 1994. *Birdlife Cons. Ser.* 4.
- Collins, C.T. 1963. *Condor* 65: 324–8.
- 1965. *Ostrich* 20: 201–2.
- Christidis, L. 1990. *Animal Cytogenetics*. 4. Borntraeger, Berlin.
- Fry, C.H., et al. 1988. *The Birds of Africa*. 3. Academic Press, Lond.
- Lack, D. 1956. *Swifts in a Tower*. Chapman & Hall, Lond.
- Ledger, J.A. 1970. *J. Ent. Soc. S. Africa* 33: 239–60.
- Lee, P.L.M., et al. 1996. *Proc. Natl. Acad. Sci. USA* 93: 7091–6.
- Medway, Lord, & J.D. Pye. 1977. Pp 225–38 *In*: Stonehouse & Perrins 1977.
- Schodde, R., & I.J. Mason. 1997. *Zoological Catalogue of Australia*. 37.2. *Aves*. CSIRO Publ., Melbourne.
- Sibley, C.G., & B.L. Monroe Jr. 1990. *Distribution and Taxonomy of Birds of the World*. Yale Univ. Press, New Haven.
- Stonehouse, B., & C. Perrins (Eds) 1977. *Evolutionary Ecology*. Macmillan, Lond.
- Wolters, H.E. 1976. *Die Vogelarten der Erde*. 2. Paul Parey, Hamburg.

Hirundapus caudacutus **White-throated Needletail**

COLOUR PLATE FACING PAGE 1057

Hirundo caudacuta Latham, 1802 (1801), *Index Orn. Suppl.*: 57 — Nova Hollandia = New South Wales, probably near Port Jackson.

The generic name combines the genera *Hirundo*, swallow, and *Apus*, swift. Hodgson (1837, *J. Asiat. Soc. Bengal* 5: 780) wrote: 'This singular species, by the structure of its feet, opens a passage from *Hirundo* to *Cypselus*' (*Cypselus* was formerly widely used for the swifts *Apus*). The specific epithet reflects the substantive name, both referring to the rigid shafts of the rectrices, which protrude beyond the tip of the feather (Latin *cauda*, tail, and *acutus*, sharpened).

OTHER ENGLISH NAMES Needletailed, Spine-tailed or White-throated Swift; Needletail or Northern Needletail; Needle-tailed, Pin-tailed or Prickly Swallow; Prickly Tail or Prickly Swift; Storm Bird.

POLYTYPIC Nominate *caudacutus*, central and e. Siberia, through n. Mongolia, n. China and North Korea to Sakhalin and Japan; migrates to A'asia in non-breeding season. Extralimitally, subspecies *nudipes* (Hodgson, 1837), Himalayas from n. Pakistan to sw. China and Assam.

FIELD IDENTIFICATION Length 20 cm; wingspan 49 cm; weight 115–120 g. Largest swift in HANZAB region. Distinctive, powerful swift with rather thicketed cigar-shaped body; short, slightly rounded tail; and long pointed wings, which, with fast powerful flight, give highly distinctive jizz characteristic of genus. Much bigger and bulkier than Fork-tailed Swift *Apus pacificus*, with broader, less pointed wings and without forked tail. Dark swift, with distinctive white patch on chin and throat, diagnostic large U-shaped white mark round vent, and contrasting pale saddle. Sexes alike. No seasonal variation. Juvenile separable in close view. **Adult** Most of head, neck and body, dark olive-brown, with: greenish-blue gloss on crown; prominent narrow white band across forehead and lores (sometimes broken in middle of forehead); prominent and contrasting pale mantle and back (which becomes even paler when worn); distinctive large clear-cut white patch on chin and throat; and white U-shaped band extending across rear-flanks, vent and undertail-coverts. Tail, above and below, black with greenish gloss as upperwings; distinctive short spines project beyond webs of rectrices and sometimes visible in exceptional views. Upperwings appear blackish in most views but can show strong green gloss when plumage fresh; gloss becomes purplish with wear and eventually lost; also have small but prominent white patch at base of trailing edge of upperwing. Underwing: leading coverts, black-brown, contrastingly darker than glossy grey-brown remiges and greater coverts, which can appear silvery grey-brown in some lights. Bare parts appear blackish. **Juvenile** Duller than adults and differ by: little green gloss to crown, upperwings or tail; pale saddle somewhat duller and less contrasting (though difference may not be marked in HANZAB region); white patch on trailing edge smaller and less obvious; forehead and lores duller grey-brown and much less prominent; and white U-shaped patch below scaled black, though this visible only in close views (but also most reliable distinction from adult). Sometimes, when worn, underbody appears mottled white.

Similar species Fork-tailed Swift smaller and slimmer, with finer, more rakish wings and deeply forked tail; uniformly dark upperparts except for obvious narrow white band over rump; and much less clear-cut or prominent pale patch on throat. **House Swift** *Apus affinis* is much smaller and more

compact, with obviously forked tail and uniformly dark upperparts except for prominent white patch on rump (like that of Fork-tailed Swift).

Gregarious and aerial in HANZAB region. Seen over most habitats in coastal and inland n. and e. Aust., but most often in large feeding flocks over timbered hills and ranges. Typically seen passing high overhead and moving consistently in one direction, with some birds stopping to soar; or in large flocks feeding while soaring in rising air from near ground level to more than 1000 m. Often seen ahead of weather fronts and sometimes attracted to bushfires. Feed on wing at any altitude, from near ground-level to high in sky; drink by skimming low over water. In HANZAB region, only rarely seen to settle, briefly, on trunks of dead trees or in foliage or, very occasionally, on ground. Flight graceful and powerful, with slow purposeful turns and much gliding and soaring. Often seen in wide circling flight. Also capable of sustained high-speed flight, alternating bursts of powerful but surprisingly shallow wing-beats with fast glides. Flight-silhouette distinctive: body noticeably broad-beamed and rather cigar-shaped, tapering to short square-ended tail that appears rather pointed when tightly closed (e.g. in fast direct flight) but gently rounded at tip when well spread (e.g. when soaring or banking). Wings long and pointed, with often noticeably curved or bulging trailing edge to primaries, especially inner ones; this, and fact that secondaries often appear markedly narrower than primaries (causing noticeable kink or pinched-in effect on trailing edge near base of wing), gives overall wing-shape like Gurkha knives when bird in fast direct glide. Wings held straighter in soaring flight, though still with same distinctive bulging leading and trailing edges to primaries and pronounced pinched-in effect near base of wing characteristic of genus. Utter variety of calls in flight, including *churr* and twittering notes; call less often than Fork-tailed Swifts (M.K. Tarburton).

HABITAT Almost exclusively aerial in HANZAB region; from heights of <1 m up to >1000 m asl (Watson 1955; Coventry 1989); often seen flying between trees, below canopy (Dove 1905; Ashby 1920; MacGillivray 1928; Learmonth 1950). Occur over most types of habitat, but probably more often over wooded areas, including open forest and rainforest,

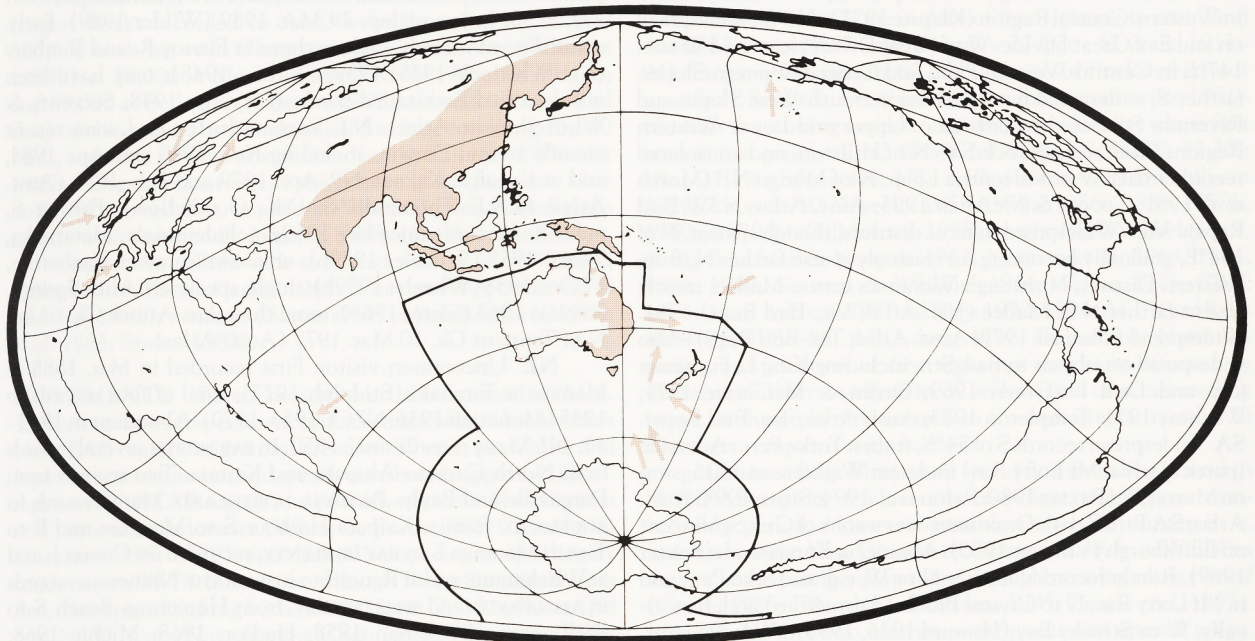
though less commonly over woodland (Blackburn 1970; Miller 1980; Smith 1984; Morris 1989; Templeton 1991; Slater 1995); also in clearings within forest (McDonald 1938; Warham 1961). Often above heathland (Learmonth 1951; Cooper 1971; Pyke 1985; Morris 1986, 1989; McFarland 1988; Mitchell *et al.* 1996). Less often above treeless areas such as grassland, swamps or farmland (McCaskill 1943; Lawrence 1945; Learmonth 1951; Hudson 1968; Cooper 1971; Longmore 1978; Gosper 1981); in farmland, more often over partly cleared pasture, plantations or remnant vegetation at edge of paddocks (Michie 1968; Bravery 1971; Emison & Porter 1978; Friend 1982; Tarburton 1993). Also in orchards or vineyards, sometimes flying between rows of fruit trees (Althofer 1937; Fielding 1979; Backhouse 1985). Sometimes over sandy beaches or mudflats (Compton 1936; Davis 1965; Cooper 1971; Longmore 1978) and often around coastal cliffs and other areas with prominent updraughts, such as ridges, volcanic craters and sand-dunes (Buchanan 1958; Cooper 1971; Loyn 1980, 1985; Smith 1984; Dawson *et al.* 1991; Guest 1992; Schulz & Kristensen 1994; Mitchell *et al.* 1996). Sometimes recorded above islands or well out to sea (Warham 1957; Bell 1959; Brandis *et al.* 1992; Guest 1992; CSN); once seen flying low over water of harbour (Bielewicz & Bielewicz 1996).

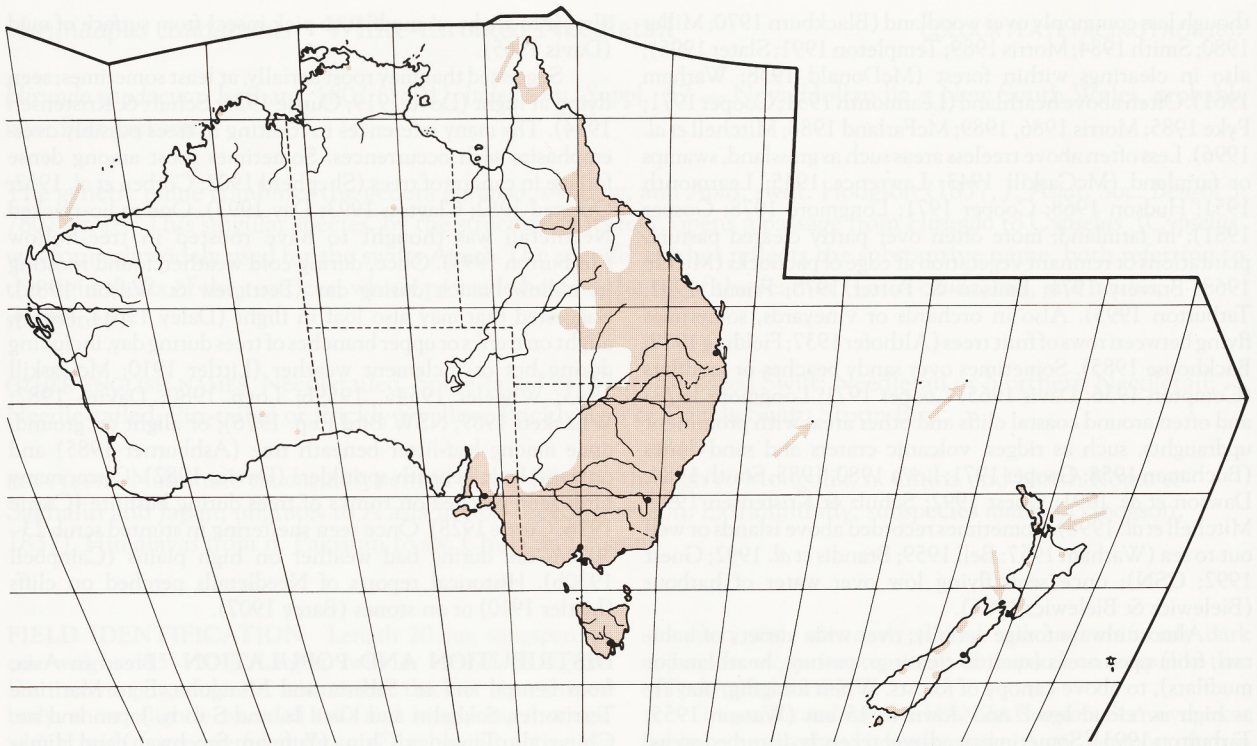
Almost always forage aerially; over wide variety of habitats, from open areas (such as clearings, pasture, heathland or mudflats), to above canopy of forests. When foraging, may fly as high as 'cloud level' and down to 15 cm (Watson 1955; Tarburton 1993). Sometimes feed over recently disturbed areas, such as forest that has recently been cleared or burnt, or above paddocks as they are being ploughed (Cameron 1968; Loyn 1980; Reilly 1991). Often forage in areas of updraughts, such as ridges, cliffs or sand-dunes (Legge 1927; Loyn 1985; Mitchell *et al.* 1996), in smoke of bushfires, or in 'severe whirlwind' (Campbell 1902; McCulloch 1966). Once seen to hang onto branches of tree, then launch after flying insects (McCaskill 1943). Once seen to land on vertical trunk of tree and pick food from it (Quested 1980); and once seen feeding on insects and spiders on window (McCaskill 1943). Rarely, alight on ground to feed on emerging termites (Carlyle 1982), and once seen

almost to alight on mudflat to pick insect from surface of mud (Davis 1965).

Suggested that may roost aerially, at least sometimes; seen flying at night (Dove 1919; Currie 1928; Schulz & Kristensen 1994). The many references to roosting in trees possibly over-emphasize such occurrences. Sometimes roost among dense foliage in canopy of trees (Shepherd 1902; Corben *et al.* 1982; Quested 1982; Clayton 1993; Day 1993). One radio-tracked Needletail was thought to have roosted in tree-hollow (Tarburton 1993). Once, during cold weather, found roosting in hollow branch during day (Pettigrew & Wilson 1985). Suggested that may also loaf in flight (Daley 1961). Rarely, alight on trunks or upper branches of trees during day, including during hot or inclement weather (Littler 1910; McCaskill 1943; Wheeler 1954a, 1959b; Loyn 1980; Davies 1982; Whackett 1989; NSW Bird Rep. 1976); or alight on ground, once among leaf-litter beneath tree (Ashburner 1985) and once on lawn beneath sprinklers (Davies 1982). Once, many birds seen perched on trunks of trees during bushfire (Currie 1916; Currie 1928). Once seen sheltering in stunted scrub 23–30 cm tall during bad weather on high plains (Campbell 1930b). Historical reports of Needletails perched on cliffs (Littler 1910) or on stones (Batey 1907).

DISTRIBUTION AND POPULATION Breed in Asia, from central and se. Siberia and Mongolia, E to Maritime Territories, Sakhalin and Kuril Is, and S to n. Japan and ne. China; also Taiwan, s. China (Yunnan, Szechwan) and Himalayas in n. India and Pakistan (Orn. Soc. Japan 1974; de Schauensee 1984; Flint *et al.* 1984; Sibley & Monroe 1990; Roberts 1991). Recorded on passage in Himalayas, Korean Pen., Indochina, Malay Pen., Melanesia and Indonesia to e. New Guinea (once on Aru Is); spend non-breeding season in A'asia, mostly in Aust., and occasionally, NZ (Gore & Won 1971; King & Dickinson 1975; Medway & Wells 1976; Coates 1985; Inskipp & Inskipp 1985; Beehler *et al.* 1986; White & Bruce 1986; Pratt *et al.* 1987; Sibley & Monroe 1990; Diamond & Bishop 1994). Vagrants recorded farther E: in Fiji and Aleutian Is (Brown & Child 1975; White & Baird 1977;





Watling 1982); and farther W, including w. Europe and Madagascar (Dymond 1990; BWP).

Aust. Widespread in E and SE. **Qld** Scattered records on islands in Torres Str. and C. York Pen.; scarcity of records probably result of lack of observers during wet season (Aust. Atlas; see Movements). Farther S in North-Eastern and ne. Mid-Eastern Regions, mostly E of Great Divide, though sometimes farther W at Richmond, Hughenden and Toomba L. Widespread S of 22°S, ranging from coastal regions inland to Kyong, Barcardine, Adavale, W of Charleville and Dirranbandi (Storr 19; Aust. Atlas; Qld Bird Reps). Reported near Julia Ck in Western-Central Region (Klapste 1977). **NSW** Widespread on and E of Great Divide. W of Great Divide, scattered W to c. 147°E in Central-Western Plain and Central-Western Slopes; farther S, widespread but scattered in South-West Slopes and Riverina. Scattered records in e. Upper and Lower Western Regions, from near Byrock S to N of Hillston, and an isolated record farther W at Kaleentha Loop, N of Mungo NP (Morris *et al.* 1981; Cooper & McAllan 1995; Aust. Atlas; NSW Bird Reps). **Vic.** Widespread in most districts, though sparser W of 144°E, gradually becoming increasingly sparse farther N, from Western District, N through Wimmera into s. Mallee; mostly absent farther N in Mallee (Vic. Atlas; Vic. Bird Reps). **Tas.** Widespread (Thomas 1979; Aust. Atlas; Tas. Bird Reps). Also widespread on islands in Bass Str., including King I., Furneaux Grp and Deal I. (Green 1969; Green & McGarvie 1971; Whinray 1971; Templeton 1973; Aust. Atlas; Tas. Bird Reps). **SA** Widespread records S of 34°S, from s. Yorke Pen., Adelaide (particularly s. Mt Lofty Ras) and near Waikerie and Kingston on Murray R. (Baxter 1980; Paton *et al.* 1994; Stove 1994; Aust. Atlas; SA Bird Reps). Once seen over waters of Gulf St Vincent off Edithburgh (Vincent 1980). Also occur Kangaroo I. (Baxter 1989). Rarely recorded farther N or W, e.g. n. Yorke Pen. and n. Mt Lofty Ras, N to Crystal Brook (Aust. Atlas) and, historically, W to Streaky Bay (Howard 1936, 1938). **WA** Vagrant.

Several, Napier Broome Bay, 20 Feb., 10–12 Mar. 1910 (Hill 1911; Storr 11); flock of unknown size, Bickley, 23 Mar. 1944 (Serventy 1948); single, Eclipse I., 7 Feb. 1956 (Warham 1957); six, Yellowtail, 60 km NNE of Rawlinna, 4 May 1969 (Brooker *et al.* 1979; Storr 27); 42, Mitchell Plateau, 22 Dec. 1972 (Storr 11); unknown number, Barrow I., <1976 (Sedgwick 1978); 30, Mitchell Plateau, 28 Sept. 1978 (Aust. Atlas); 3–10, Mitchell Plateau, 1–5 Oct. 1978 (Aust. Atlas); c. 12, near Augusta, 16 May 1980 (Aust. Atlas); 10–12, Pelsaert I., Houtman Abrolhos, 9 Feb. 1984 (Storr 24); singles, Mundrabilla Stn and nearby Roe Plains, 18–19 Jan. 1985 (Anon. 1985; Storr 27); c. 50, L. Joondalup, 29 Mar. 1989 (Wilder 1989). Early, unconfirmed records, such as those at Fitzroy R. and Bunbury (e.g. Whitlock 1925, 1939; Shilling 1948), may have been misidentified Fork-tailed Swifts (Serventy 1948; Serventy & Whittell; Aust. Atlas). **NT** Vagrant. In Top End, some recent records around Darwin, including Nov. 1980 and Apr. 1985, and at Kapalga, Kakadu NP, Apr. 1979 and Feb. 1981 (Aust. Atlas; H.A.F. Thompson & D.K. Goodfellow). Farther S, published records since late 1950s include: single, Mataranka, 9 Oct. 1958 (Wheeler 1959b); unknown number, Katherine, 17 Oct. 1958 (Wheeler 1959b); single, specimen, Alice Springs, 26 Nov. 1963 (Slater 1964); more than one, Attack Ck, 64 km N of Tennant Ck, 10 Mar. 1977 (Aust. Atlas).

NZ Uncommon visitor. First recorded in Mar. 1888 at Manaia in Taranaki (Stidolph 1927); total of four records to 1935 (Moncrieff 1936; NZCL 1953, 1970). Abundant in 1942–43. **NI** Many records since 1950. In **FAR NORTH** several records from North Cape to Ahipara and Kaitaia. Two records from Dargaville and Baylys Beach in **NORTHLAND**. Many records in **AUCKLAND**, from s. Kaipara Harbour S to Mangere and E to Tiritiri Matanga I. In **BAY OF PLENTY**, recorded on Cuvier I. and at Whakatane, and at Rangitoto in **WAIKATO**. Numerous records in **MANAWATU** and **WELLINGTON**, from Himatangi Beach S to Wellington (Buchanan 1958; Hudson 1968; Michie 1968;

Edgar 1971; Onley 1989; Guest 1992; CSN). **SI** Since 1950, recorded in most regions. Single record in MARLBOROUGH, at Stephens I. Few records along e. coast, in CANTERBURY and NE. OTAGO, at Gore Bay, Timaru and Hampden. In SOUTHLAND, several records between Tautuku and Bluff, and inland to Hokonui Hills; also on Stewart I. Many records in WEST COAST, from Haast R. N to Karamea (Bell 1959; Wright & McKenzie 1966; Dorizac 1968; Imber & Crockett 1970; Miller 1980; NZCL 1970; CSN).

Lord Howe I. Single, Nov. 1942 (Hindwood & Cunningham 1950); many, Jan. 1943 (Hindwood & Cunningham 1950); single (?), 25 Nov. 1971 (NSW Bird Rep. 1971). Also said to have been observed more recently (Hutton 1991). Unconfirmed historical records of 'swifts', probably this species, in Nov. 1935; and 'swallows' visiting in about Dec. 1852 may also have been this species (Hindwood 1940).

Norfolk I. Up to 12, from 16 Nov. to some time in Dec. 1968 (Smithers & Disney 1969;); many, Nov. 1976 (Hermes *et al.* 1986); four or five, 7–8 Dec. 1978 (Schodde *et al.* 1983); eight, 18 Dec. 1979 (M.K. Tarburton); single (remains), 17 Dec. 1992; single, 26 Dec. 1992 (Davidson 1993).

Cocos-Keeling Is Flock of 32 unidentified swifts, 14 Jan. 1982, probably this species (Stokes *et al.* 1984).

Macquarie I. First record: single specimen, 11 Jan. 1960 (Warham 1961). Several subsequent unpublished records, especially during summer 1970–71 (Green 1989).

Snares Is Said to have been recorded (NZCL).

Campbell I. Singles: 9–10 May, 16 Aug. 1942 (Bailey & Sorenson 1962).

Irruptions In NZ, major irruption recorded between Nov. 1942 and early Mar. 1943 (McCaskill 1943). On NI, isolated record on Whangaparoa Pen., but more widespread from Hamilton S to Mt Egmont and inland to w. L. Taupo. Also isolated record at Paraparaumu. In SI, recorded at Pakawau and Stoke in Nelson. Many records on e. and w. coasts, from Christchurch S to Waimate and from Greymouth S to Fergusons, respectively. Also recorded at Horseshoe Bay on Stewart I. (McCaskill 1943; Moncrieff 1943; see map). This coincided with large numbers in Tas. (Napier 1969).

Populations No measures of abundance (Aust. Atlas). Largest flocks recorded in Aust. were: between 50,000 and 100,000 birds between Glengarry and Cowarr, Vic. (Wheeler 1959b); c. 20,000 at Murwillumbah, NSW (Wheeler 1960a); and 10,000 at Bell, Qld (Wheeler 1960a). In addition, a mixed flock of this species and Fork-tailed Swifts, containing 15,000 birds, recorded in foothills of Dandenong Ra., Vic. (Wheeler 1960a). Organized surveys of swifts in se. Aust. between 1951 and 1967 showed that, in general, White-throated Needletails greatly outnumbered Fork-tailed Swifts (see that text).

Sometimes collide with overhead wires (Le Souéf 1917; Campbell 1930a; McCaskill 1943; Wheeler 1965; Cameron & Hinchey 1981), windows (Slater 1964) or lighthouses (Druffan *et al.* 1983; Stokes 1983).

MOVEMENTS Based mostly on contribution by M.K. Tarburton. Two subspecies: nominate *caudacutus*, which occurs HANZAB region, migratory; breeds e. Siberia, ne. China and Japan in boreal summer and spends non-breeding period (Oct.–Apr.) in HANZAB region and possibly also in s. New Guinea and parts of e. Indonesia (White & Bruce 1986; Chantler & Driessens 1995; BWP); extralimital subspecies *nudipes* largely resident (see BWP). Enter Aust. through Torres Str. and Arafura Sea, then spread S along both sides of Great Dividing Ra. in Qld and NSW, Oct.–Nov. (*contra* Chantler & Driessens 1995),

some reaching W of Melbourne and Tas. before Dec., but greater numbers in e. Vic. and se. NSW in Dec. By Feb.–Mar., while reporting rates peak in Vic. and Tas., still numerous in NSW and Qld (Aust. Atlas; M.K. Tarburton). Said to be nomadic after arrival in Aust. (Vic. Atlas). Vagrants to NT and WA may arrive directly from Timor or Arafura Seas, though record from Mundrabilla, se. WA, 19 Jan. (Anon. 1985) suggests some may cross Nullarbor Plain from E, possibly with Fork-tailed Swifts. In NZ, annual visitor in small numbers, reaching Campbell and Snares Is. Movements said to be affected by weather systems, e.g. fly lower during humid or sultry conditions, but details poorly understood.

Departure Leave breeding grounds in Siberia, singly or in scattered low-flying flocks, from Aug., departure continuing through Sept. and Oct. (Dement'ev & Gladkov 1951); departure from Sakhalin similar, leaving early Sept.–Oct. (Lobko-Lobanovski 1956). Thousands recorded migrating on some days (Lyuleeva 1991). Pass through China and Japan, Aug.–Nov. (Dement'ev & Gladkov 1951; La Touche 1931–34); Korea, Sept.–Oct. (Gore & Won 1971); small numbers pass S through Malay Pen., 20 Sept. – 30 Nov. (Medway & Wells 1976); Sulawesi and nearby islands, Oct. to early Apr.; Buru in Nov.; Flores and Timor in late Sept.–Oct.; appear transient in e. Indonesia, but may winter as small numbers recorded Jan.–Feb. (White & Bruce 1986; Coates *et al.* 1997). In PNG, recorded 27 Sept. – 21 Apr., most records Sept.–Nov., which may be birds on s. passage (Rand 1942b; Vaurie 1965; Rand & Gilliard 1967; Bell 1969, 1970; Hicks 1990, 1991; Eastwood & Gregory 1994, 1995; Gregory 1995; Richards & Rowland 1995; Richardson 1997).

AUST.: Arrive from N. Recorded crossing Torres Str. during Sept. and Oct., probably on broad front (Druffan *et al.* 1983; Aust. Atlas); some arrive as early as Sept. (Wheeler 1960a; Clark 1976) and s. migration recorded over Arafura Sea and Torres Str. in first week of Nov. (Warham 1962). In 1950s, birds passed near Atherton, n. Qld, flying fast to S between 07:00 and 08:00 for c. 12 days in Oct. (Wheeler 1960a); may have been birds on passage. Based on review of published information and Aust. Atlas and ABC data of first sightings of Needletails in Aust. and considering all records May–Aug. as wintering records (see Breeding below): mean date of first sighting in mainland Aust., 22 Oct. (27.62 days; 1 Sept. – 27 Dec.; 42 years, 1911–94), in groups of one to 60 (though size of flocks often not specified). Records in years of organized surveys of swifts, 1951–67, show that timing varies from year to year; locality where first seen varies greatly: Qld, 40.5% (of 42 years); NSW, 33.3%; Vic., 21.4%; SA, 2.4%; NT, 2.4% (Barnard 1926; Sullivan 1929; Anon. 1930; Wheeler 1953, 1954a, 1956a, 1958, 1959b, 1960a, 1970; McGill & Lane 1955; Knight 1961; Wheeler *et al.* 1961; Bouchier & Noonan 1962; Noonan *et al.* 1963, 1964, 1966, 1967; Noonan & Wheeler 1965; Glover 1975; Clark 1976; Aust. Atlas; NSW Bird Reps 1992, 1994; ACT Bird Reps 1984–85, 1985–86; ABC data; M.K. Tarburton). However, timing and location of first sightings no doubt affected by differential observer effort in n. and s. parts of non-breeding range, as shown by first records in S where greater number of observers compared with n. Aust.

Non-breeding Most or all spend non-breeding period in HANZAB region; few records elsewhere throughout non-breeding period. However, possible that birds winter in e. Indonesia and s. New Guinea; records in Jan.–Feb. in Wallacea suggest some possibly stay there through non-breeding period (Coates 1985; Chantler & Driessens 1995; Coates *et al.* 1997).

Movements into southernmost portion of normal range,

Tas., begin increasing in Jan., becoming common in Feb. with most sightings occurring in Mar., before declining in Apr. Numbers crossing Bass Str. to Tas. vary annually; in some years many cross both N and S during Mar. (Templeton 1973), e.g. large numbers seen moving S from Tas. n. coast on 31 Mar. and 8 Apr. (Dove 1909); such movement possibly retro-migration, or, alternatively, birds continue to seek high-quality prey to put on weight before returning to breeding grounds (M.K. Tarburton); suggested may visit Tas. late in season to take advantage of newly airborne swarms of ants and termites (Dove 1905). Still many in NSW and Qld during Feb.–Mar., e.g. in 1965 while thousands of birds were seen in various parts of Tas., Needleetails were seen at Murwillumbah, n. NSW, on 31 days in Jan., 25 in Feb., 29 in Mar. and 12 in Apr. (Noonan & Wheeler 1965). During organized survey of swifts, 1951–67, a sudden increase in sightings in Vic. during Jan. recorded in some years (Noonan *et al.* 1964); this would serve to feed influx to Tas. in Feb.

Many observations of Needleetails preceding, or arriving with or soon after a frontal weather change or other atmospheric disturbance (e.g. Dove 1902, 1918, 1920, 1941; Littler 1910; Campbell & Barnard 1917; Bridgewater 1934; Marshall 1935; Crompton 1936; Cameron 1952; Mackay 1970; Vincent 1980) and some claim, based on long-term observations, that sudden appearance of Needleetails is harbinger of rain (e.g. Dove 1920, 1941; D'Ombain 1934); also suggested that appearance always coincides with falling barometric pressure (e.g. Johnson 1947). Needleetails are attracted to such disturbances and benefit from sailing into or against accompanying winds, and by abundance of invertebrates, which are often stimulated to swarm by such conditions and that, along with other species, are lifted into the air (M.K. Tarburton). However, also often seen flying in clear skies, with no rain or sultry weather on preceding or subsequent days (Learmonth 1950; Wheeler 1956a,b, 1957), and reliability of appearance in predicting rain cannot be accepted. In some districts, correlation so poor that it has been thought that arrival of Needleetails heralded fine weather, though larger samples over several years refute this too (Edwards 1948). Appearance also reported to be almost always a prelude to a period of drought, with higher flight signalling a longer dry spell (McNamara 1948). One observer summarized his own 125 observations by stating that rain fell within 24 h of these observations on only 48 occasions (Wheeler 1950). Appear to avoid hailstorms (Wheeler 1958).

Some patterns to local movements, and movements through specific localities. Round Beeac, Colac and Geelong, Vic., regularly fly toward coastal cliffs just before sunset (Wheeler 1960b). Single bird radio tracked for 4 days near Gin Gin, Qld, while going to and on leaving roost: at dusk, flew low inland of Gongiberoo Ra., before roosting in tree-hollow; left roosting tree before sunrise and foraged to E of roosting site each day, returning to roost after sunset (Tarburton 1993).

Return Some leave Aust. in Feb., most from mid-Mar. to Apr. (e.g. Aust. Atlas). Based on review of published information and Aust. Atlas and ABC data of last sightings of Needleetails in Aust. and considering all records May–Aug. as wintering records (see Breeding below): mean date of last sighting in Aust., 13 Apr. (11.79 days; 7 Mar. – 30 Apr.; 42 years, 1902–95), in groups ranging in size from one to 50 (though size of flocks often not specified). Much variation between years in locality of last sighting; state by state: Qld, 7.1% (of 42 years); NSW, 38.1%; Vic., 40.5%; Tas., 14.3% (Dove 1902; Bridgewater 1934; Wheeler 1952, 1953, 1954a, 1956a, 1957, 1958, 1959b, 1960b; Wheeler *et al.* 1961; Bouchier & Noonan 1962; Noonan

et al. 1963, 1964, 1966, 1967; Noonan & Wheeler 1965; Clark 1976; Mathews; Aust. Atlas; ABC data; M.K. Tarburton). Birds may leave Aust. without being detected (M.K. Tarburton). At least some, and probably most, fly N across Torres Str.; casualties recorded at Booby I. lighthouse on passage (e.g. Stokes 1983). Extraliminally, thought to travel E of Borneo, where first recorded (three birds) 19 Apr. in 1957 (Smythies 1957, 1981); small numbers recorded Malay Pen., 24 Apr. – 15 May (Medway & Wells 1976); Lombok, early Apr.; and Sulawesi, Mar.–Apr (White & Bruce 1986; Coates *et al.* 1997). Recorded passing through Hong Kong, 17 Mar. – 18 May (Chantler & Driessens 1995); and China, 6–31 May (La Touche 1931–34). Usually first arrive over broad area of Siberia in mid-May, though timing varies (Dement'ev & Gladkov 1951; Chantler & Driessens 1995).

Breeding A few appear to remain in HANZAB region when most of population in n. hemisphere breeding grounds. Records between May and Aug. considered to be wintering, but possible some or all represent extremes of migration (see Table 1).

Table 1. Possible wintering records in HANZAB region.

NUMBER	DATE	LOCATION	STATE	REFERENCE
	27 Aug. 1943	Atherton	Qld	1
3	6 May 1951	Laverton	Vic.	2
	1 May 1958	Mystic Park	Vic.	3
	8 May 1960	Blackburn	Vic.	4
1	25 May 1963	Carlton	Vic.	5
5	19 July 1970	Iron Ra.	Qld	6
	27 July 1974	37°00'S, 148°20'E	Vic.	7
	9 May 1977	38°15'S, 145°15'E	Vic.	7
	27 May 1977	37°50'S, 141°45'E	Vic.	7
	15 June 1977	12°30'S, 143°30'E	Qld	7
1	23 July 1977	26°15'S, 152°25'E	Qld	7
1	31 July 1977	12°30'S, 143°30'E	Qld	7
	1 May 1978	35°25'S, 148°55'E	NSW	7
	25 Aug. 1978	23°35'S, 150°35'E	Qld	7
	16 May 1980	34°15'S, 115°05'E	WA	7
	27 July 1980	16°55'S, 145°45'E	Qld	7
	19 Aug. 1980	12°45'S, 143°15'E	Qld	7
	27 Aug. 1980	12°45'S, 151°05'E	Qld	7
	10 June 1981	37°55'S, 145°25'E	Vic.	7
	29 Aug. 1981	12°45'S, 143°15'E	Qld	7
1	25 May 1983	Woorail	Vic.	8
2	24 Aug. 1986	Woorail	Vic.	8
2	29 Aug. 1986	Woorail	Vic.	8
35	7 May 1991	Mt Evernden	NSW	8
4	17 Aug. 1991	Kuranda	Qld	8
1	1 June 1992	Waterfall	NSW	9
11	17 June 1992	Bundaberg	Qld	8
20	17 Aug. 1992	Potato Pt	NSW	9
1	6 June 1994	Greenwich	NSW	8

REFERENCES: ¹ Bourke & Austin 1947; ² Watson 1955; ³ Wheeler 1958; ⁴ Wheeler 1960b; ⁵ Noonan *et al.* 1963; ⁶ Blackburn 1970; ⁷ Aust. Atlas data; ⁸ ABC data; ⁹ NSW Bird Rep. 1992.

FOOD Insectivorous, taking a wide variety of insects and spiders. **Behaviour** Aerial. Forage from within 1 m of ground to at least c. 1800 m asl; over wide range of habitats (Wheeler 1960a; Cooper 1971; Coventry 1989; see Habitat). Mostly forage in small groups, of up to ten or hundreds (Learmonth 1950, 1951; Watson 1955; Wheeler 1958, 1959a; Cameron 1968; Loyn 1985; Coventry 1989), though feeding groups of

many thousands sometimes seen (McMicking 1925; Wheeler 1960a). Feed in mixed flocks with other aerial foragers, particularly Fork-tailed Swifts (Learmonth 1951; Wheeler 1958; M.K. Tarburton), and sometimes with Fairy Martins *Hirundo ariel* (Learmonth 1951). **FORAGING AND ATTACK BEHAVIOUR:** Typically circle through prey-rich sites; can make several attempts to catch prey in a pass through such concentrations but only take prey very close to line of flight; do not pursue individual insects (Cameron 1968; M.K. Tarburton). Also dive swiftly through swarms of insects, such as grasshoppers, regaining original height after each dive before making another attack; at Chinchilla, Qld, dived from c. 100 m above ground, each dive lasting c. 30 s, during which an average of five insects attacked, and perhaps three caught (Cameron 1968). Search along edges of low-pressure systems, which both lift food and assist flight; said that often follow these systems across Aust. (Boehm 1939). Although feeding flocks often associated with low-pressure systems and weather depressions, also often observed in clear skies and stable weather conditions (see Movements). Attracted to concentrations of food caused by natural events such as willy-willies (Campbell 1902) or fires; in 1926, at Murphys Ck, Qld, when fires driven by scorching nw. winds in middle of a long drought, large numbers of Needletails were seen to follow the smoke for several days (Lord 1936); and observed to forage in, above and at edges of pall of smoke (McCulloch 1966). Also forage where human activities concentrate food, e.g. at Chinchilla, Qld, c. 20 Needletails attracted to ploughing of paddock, which was causing masses of insects to take flight; numbers of feeding Needletails rapidly increased to c. 2000, and 10–20 returned on successive days and searched low over same area (Cameron 1968). A flock of 2000–3000 followed moving plague of locusts for 3 days (McMicking 1925). In Gippsland, Vic., a flock of c. 150 seen skimming low over mudflats taking insects, sometimes almost alighting while picking insects from surface of mud (Davis 1965). At Chinchilla, Qld, individuals occasionally dropped to ground from feeding circuit to feed on termites that were emerging (Carlyle 1982), and similar behaviour observed in Christchurch, NZ (McCaskill 1943). Also in Christchurch, a group of 15–20 birds seen hanging in closely packed cluster among hanging branches of trees, from where they sallied out after insects (McCaskill 1943). Near Macksville, NSW, one Needletail from a flock of birds feeding on insects taking off from a tree-trunk, landed on trunk for short period to pick insects off trunk (Qusted 1980). At Tumblong, NSW, seen feeding over hills covered with flowering eucalypts, at times landing and clinging to flowers for 1–2 s, apparently searching for insects (Wheeler 1956a). Suggested that Needletails time arrival in Tas. to coincide with swarming of ants and termites in Feb.–Apr. (Dove 1905; see Movements). **ADAPTATIONS FOR FEEDING:** Bill very small: culmen 7.0 mm (0.9; 58); gape as wide as head (16–17 mm). Pre- and supra-orbital ridges help protect large but recessed eyes from collisions with prey (M.K. Tarburton). In captive study, birds ate moving field crickets but not dead ones; mealworms taken only occasionally, even when moving (Cameron & Hinchey 1981). An injured bird was kept alive, in captivity, for 2 months while fed 4000 field cricket abdomens (Wheeler 1965; Pescott 1966, 1983). **DRINKING:** Drink water from rivers and sometimes from waterholes; at Mary R., Qld, c. 100 birds from a flock of 500–600 birds dived to surface of river and skimmed water with bill, while holding wings rigidly above their backs; individuals appeared to repeat circuit several times, then moved off to be replaced by others from flock (Wheeler 1959a); a single bird seen drinking in a similar manner from Snowy R. (Le Souéff

1930). At Chinchilla, Qld, often seen to drink by diving at shallow angle, with reduced speed, at surface of waterhole, and scooping up water with lower mandible (Cameron 1968). Another small group seen scooping up water, like swallows, from water-hole near Armidale, NSW, on a hot day (Morse 1919).

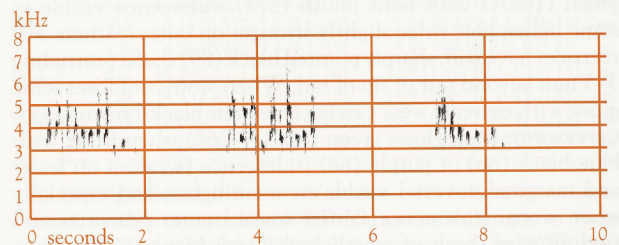
Detailed studies At SWANSEA, TAS. (112 insect items from 5 stomachs; Lea 1938): **INSECTS:** Coleoptera: unident. 1.8% no.; Buprestidae: *Melobasis* 1.8; Chrysomelidae: *Chalcolimna* 1.8; *Papopsis* 3.5; Curculionidae: *Gonipterus* 25.0; Diptera: Syrphidae 1.8; Hemiptera: Lygaeidae 0.9; Pentatomidae 3.5; Hymenoptera: Anthophoridae: *Exoneura* 20.5; Apidae: *Apis mellifera* 30; Formicidae: *Myrmecia* 5.0; Ichneumonidae 3.5; Thysanura: Phlaeothripidae: *Idolothrips spectrum* 0.9.

Other records **INSECTS:** Coleoptera: Unident. beetles^{2,19}; Carabidae³; Cerambycidae²²; Curculionidae³; Elateridae³; Lucanidae³; Tenebrionidae³; Diptera^{12,13}; Tipulidae²; Hemiptera¹²; Cicadidae: cicadas²¹; Hymenoptera: Formicidae^{1,2,3,10,16,18,19}; *Camponotus*^{8,9,14,15}; *Pheidole*²⁰; Isoptera: termites^{5,8,9,11,18,19}; Lepidoptera: ad. moths²; Orthoptera: grasshoppers^{4,6,7,17}. (**REFERENCES:** Dove¹ 1902, ² 1918; ³ Tryon 1908; ⁴ Currie 1916; ⁵ Banfield 1925; ⁶ Cohn 1925; ⁷ McMicking 1925; Campbell⁸ 1930a, ⁹ 1935; Lord¹⁰ 1936, ¹¹ 1961; ¹² McKeown 1944; ¹³ Salter 1958; ¹⁴ Wheeler 1960b; ¹⁵ Bedgood 1965; ¹⁶ Wall 1966; ¹⁷ Cameron 1968; Rose¹⁸ 1974, ¹⁹ 1997; ²⁰ Lepschi 1993; ²¹ Tarburton 1993; ²² FAB.)

For details of diet at breeding grounds, see Neufeldt & Ivanov (1960), Spangenberg (1960), Chunikhin (1963), Nechaev & Nazarov (1967), Kistayakovskiy & Smogorzhevskiy (1971), Lyuleeva (1991), and Dement'ev & Gladkov (1951).

VOICE Account prepared by M.K. Tarburton. Not well known. Call in flight (e.g. Campbell 1935; *contra* McCaskill 1943; Salter 1958); such calls can be loud, audible even when birds high in air, and may draw attention to birds that would otherwise be overlooked; particularly noticeable when one bird chasing another (Campbell 1935; D'Ombrain 1934; Wheeler 1960a; Lauder 1987). Call less often than Fork-tailed Swifts (M.K. Tarburton). **NON-VOCAL SOUNDS:** Swish or whoosh of bird and wings, in flight, can be very loud, particularly when flapping (Campbell 1930a, 1935; D'Ombrain 1934; Salter 1958; Veerman 1988). Also make audible *zip* or *swish* when drinking by skimming surfaces of dams or rivers (D'Ombrain 1934; Wheeler 1959b).

Adult FLIGHT CALLS: Rapid high-pitched twittering *chee-chee-chee...* (Tryon 1908; D'Ombrain 1934; Hyem 1936; Veerman 1988); sonagram **A** shows three twittering calls. Likened to calls of Welcome Swallows *Hirundo neoxena* (Veerman 1988; Mathews). Also utter loud sharp cry (Mathews); chirp (Wheeler 1958); piping, like calls of sandpipers (Veerman 1988); churring twittering (Smith 1990); and churr (M.K. Tarburton). **Other calls** Repeated loud *cheep* when injured captive bird, possibly a juvenile or immature, exposed to light (Cameron & Hinchey 1981). Uttered repeated querulous note when handled (Campbell 1930a, 1935).



A N. Robinson; captive, Canberra, ACT, Apr. 1963; P48

PLUMAGES Prepared by D.I. Rogers. Fledge in juvenile plumage, which is retained through s. migration to HANZAB region. Post-juvenile (first pre-basic) moult of most juvenile plumage occurs in HANZAB region during first austral summer, but juvenile primaries usually retained through first n. migration, beginning moult near breeding areas; moult of these feathers possibly finished in HANZAB region in second austral spring, after a suspension during migration. Resultant immature (first basic) plumage very similar to adult plumage but can be distinguished because primaries moult slightly earlier. Adult timing of moult attained after first breeding attempt; second post breeding (pre-basic) moult (during third calendar year) probably first moult timed as adults, but age of maturity not known. Nominate *caudacutus* described below.

Adult (Definitive basic; age at which attained not known, but not before third calendar year). **HEAD AND NECK:** Crown, nape, hindneck, ear-coverts and sides of neck, dark brown (121) to black-brown (119); crown appears slightly darker than hindneck and has an oily green (c162) sheen (appearing slightly purple in some lights, especially when plumage worn). Rear half of lores, black (89), darker than rest of head; feathers modified into short dense bristles. Anterior half of lores, white, forming broad band (c. 4 mm wide) above gape that usually meets narrowly above culmen; in some, narrow dark-brown (c121) line runs from culmen to midline of crown. In very fresh plumage, diffuse light grey-brown (119C–119D) tips to feathers near top and front of loreal patch can cause a subtle dusky wash. Chin and throat, white, forming sharply defined patch with smoothly rounded lower border. **UPPERPARTS:** Most of mantle and back, light brown (119C–119D), fading to grey-white (ne) with wear. Pale saddle grades to dark brown (119A) on uppermost mantle and on scapulars; outer scapulars can be tinged olive (ne); scapulars very small and do not obscure much of saddle. Saddle grades to brown (c119B) or dark brown (c119A) on midline of rump when fresh; upper rump fades when worn, eventually becoming concolorous with saddle. Sides of rump and all of uppertail-coverts, dark glossy green (162A) when fresh; lose much of green gloss with wear: at first, gloss becomes dark bluish (ne) and, when very worn, tracts become black-brown (119). **UNDERPARTS:** Mainly dark brown (121), becoming slightly warmer and lighter brown (119A) with wear. Feathers of sides of belly can have concealed white bases to outer webs (and, rarely, on part of inner web). Vent and undertail-coverts and rear-flanks, white, forming boldly contrasting, U-shaped marking. When very fresh, all undertail-coverts can have narrow dark-brown fringes at tips (<0.5 mm broad); these are wholly lost with wear, usually before arrival in Aust. (only likely to be seen in HANZAB region Mar.–Apr.). Longest, central, pair of undertail-coverts usually wholly white but sometimes have broad black-brown tips, up to c. 8 mm wide, though usually narrower and restricted to a subterminal spot or dark tip 1–2 mm wide, meeting dark distal shaft (rest of shaft of undertail-coverts white). **TAIL:** Strongly iridescent: dark glossy green (162A) with faint bluish (c73) iridescence visible in some lights; blue tinge slightly stronger on outer feathers. All rectrices have stiff, sharply pointed black (89) shafts protruding 3–5 mm beyond rest of tip of tail. When worn, tail loses some gloss; with extreme wear can become matt black-brown (119). **UPPERWING:** Dark glossy green (c162A–262) when fresh, with blue-black (ne) or purple (ne) iridescence (weakest on lesser and marginal coverts) visible in some lights, and especially when worn. Iridescence fainter toward outer primaries and trailing edge, both of which look black-brown (119) when worn. With wear, green gloss reduced (bluish gloss retained for

longer) and area of black-brown increases; when very worn, green gloss restricted to bases and inner webs of secondary coverts. Tertiaries, glossy green or bluish like rest of upperwing, but with strongly contrasting large white patches on inner webs; extent of white varies somewhat, some having wholly white inner webs to s8 and s9, while s7 has broad white inner edge; in others, inner webs white with dark-brown (121) to blackish-brown (119) tips from 1 to 5 mm wide (sometimes clear-cut, sometimes diffuse). **UNDERWING:** Remiges and greater coverts, dark glossy grey (83), appearing silvery grey (86), especially on inner webs of inner primaries, in some lights. Ground-colour of remiges slightly darker (c82) at leading edge of p10; greater primary coverts and primaries tend to be paler at bases than at tips, so tips of greater primary coverts look contrastingly darker than surrounding feathers. Median, lesser and marginal coverts, black-brown (119) with faint, dark-green (162A) gloss.

Juvenile Differences from adult: **HEAD AND NECK:** Crown, slightly less dark and much less glossy: dark brown (121) with very narrow light-brown (119C) tips to feathers, without strong green iridescence. On hindneck, ear-coverts and sides of neck, ground-colour grades to brown (119A–119B), again lacking green iridescence. Dark-brown (119A–119B) line in centre of forehead, joining culmen and midline of crown, is broader than in adult (if present) and white loreal patches are accordingly smaller. Diffuse grey-brown (119C) tips to feathers of loreal patch are larger than in adult and present even when worn. In some birds this simply makes loreal spot look smaller and more mottled than in adults; in others entire loreal patch is tinged light grey-brown (119C) and does not contrast strongly. **UPPERPARTS:** Olive tinge of outer scapulars and iridescence of uppertail-coverts and sides of rump less bold and extensive than in adults. Saddle (mantle and back) said to be duller and less pale than in adult (Chantler & Driessens 1995; BWP), but this not obvious in skins examined here. **UNDERPARTS:** Concealed white bases to feathers of belly more extensive than adult; generally both webs have white bases, broadest on outer webs; on sides of belly these white bases can be large enough to be exposed as slight white speckling at border of white U-shaped patch. Undertail-coverts have dark-brown (121) or black-brown (119) fringes at tips, 1–2 mm wide and thus broader than similar markings of very fresh adults. Two examined had broad black-brown (119) tips 2–4 mm wide to central 1–3 pairs of undertail-coverts, clearly defined, unlike generally smudgy tips occurring on these feathers in some adults. BWP reported that longest undertail-coverts fell 5–8 mm short of tips of webs of rectrices (cf. 0–3 mm in adults); Aust. material broadly consistent with this, but too few specimens with fully juvenile undertail-coverts available to be sure that no overlap occurs. **TAIL:** Rectrices slightly narrower than in adult. **UPPERWING:** Similar to adult, but coverts and remiges show much fainter green iridescence. Remiges slightly narrower than in adults, a trend most obvious on inner primaries, which usually show a slight indentation at tip of inner web (cf. more rounded tips in adults; see Fig. 1). White spots on tertiaries often look slightly less clean than in adults, with faint grey-brown (c119D) tinge, strongest at bases of feathers; on inner two tertiaries (s8 and s9), white inner webs have black-brown (119) fringes, c. 2 mm wide. **UNDERWING:** Similar to adult except that primaries slightly narrower.

Immatures (First and possibly some subsequent basic plumages). Very similar to adults but usually separable in HANZAB region because timing of moult differs; see Ageing for details. Said to have greater tendency to show grey-brown tinge on forehead than adults, and to have faint black fringes to

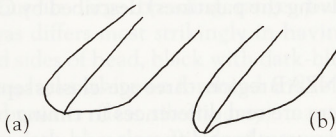


Figure 1 Primaries (p1) (a) Adult (b) Juvenile

smaller tertials and undertail-coverts (Chantler & Driessens 1995; BWP), but these differences not apparent in this study.

BARE PARTS From museum labels (AM, ANWC, HLW, MV, QM, QVM, SAM, TMAG), photos (Aust. RD; NZRD; Strahan) and BWP. **Adults, Juveniles and Immatures** Bill and gape, grey-black (82) to black (89). Iris, black-brown (119); red-brown reported on two labels. Feet, dark grey (c83) or dark blue-grey (c78), often with dirty-pink or purplish tinge; soles sometimes cream-white; claws, dark grey (c83), often slightly darker and browner than rest of feet.

MOULTS Based on A'asian skins of 51 adults and 49 younger birds (AM, ANWC, AIM, HLW, MV, NMNZ, QM, QVM, SAM, TMAG) and BWP. **Adult post-breeding** (Definitive pre-basic; probably second and subsequent pre-basic moults, but age at which first breeding occurs, and adult timing of moult attained, not known). Complete. Many, perhaps most, show no moult in breeding areas by end of Aug. and probably migrate before moult starts. Others, probably failed or non-breeders, can moult a few wing-coverts as early as mid-July and show slight moult of body, tail or tertials in Aug. before leaving breeding areas; some of these moult a few primaries too (PMS of 10 in Aug., 13 in Sept., 23 in Oct.) and possibly suspend moult while on s. migration (BWP). All Aust. adults examined had at least started moult of primaries and body, suggesting moult begins immediately upon reaching HANZAB region, but few data for recently arrived birds. Primaries moult outward; grow one (n=11) or two (n=10) feathers concurrently. In HANZAB region, most moult of primaries occurs during austral spring to late summer: in Oct., PMS 21; in Nov., 23 and 34; in Dec., 35, 40 and 42; in Jan., 39.0 (1.83; 37–41; 4). By Feb., PMS at least 40 and the first birds finish moult (two of eight examined); most birds finish moult in Mar. (10 of 16 examined had finished moult and others had PMS>47); last birds finish moult in Apr., before n. migration (of five, four had finished and one had PMS 49). In Aust., moult of body heavy in spring and almost finished by Nov., but moult of last few feathers protracted, often continuing till Mar. Unusually late moult of primaries observed in vagrant at Macquarie I. (MV): PMS only 12 on 7 Dec. **Post-juvenile** (First pre-basic). Probably complete (but see Subsequent moults below). Arrive in HANZAB region in complete, though slightly worn, juvenile plumage and perform most or all moult of body from Dec. to Feb.; a few continue moulting last feathers of body till Mar. or early Apr. Tail-coverts usually among first feathers to be moulted; tail, tertials, and most upperwing-coverts also begin moult at this time; feathers of nape and neck among last to be moulted. Also moult at least inner, and possibly all, secondaries while moult of body active; sequence of moult of tail and secondaries not known, but t1 often last rectrix to be replaced. Most birds probably migrate N before moulting any juvenile primaries; of 24 examined Jan.–Mar., 22 had not started moult of primaries. Such birds probably correspond with birds reported by BWP to start moult of flight-feathers near breeding areas in July–Aug.

of second calendar year. Two examined in this study began moult of primaries during first austral summer: PMS 3 on 24 Jan. and 2 on 12 Feb. It is possible that such birds suspend moult of primaries during n. migration; another possibility is that a few remain in Aust. through first austral winter (which would explain immature collected in se. Qld in June with active primary-moult N⁴1¹O⁴; see Movements). Time at which moult of primaries finished poorly known but probably a couple of months before adults finish moult of primaries. This interpretation supported by the few data from immatures actively moulting primaries (PMS near breeding areas: 4 in July; 2, 9 and 30 in Aug.; 28 in Sept.). At least some immatures probably suspend moult of primaries for s. migration and finish it in non-breeding areas; this supported by the only Aust. specimen available from Sept. (S⁶N⁴) and by an immature collected 1 Dec. with PMS 49. All other immatures available from (presumably) second austral summer and autumn were collected between mid-Dec. and mid-May; all (n=17) had finished moult of primaries and those collected from Feb. onward showed some wear of primaries (cf. very fresh primaries of adults at this time); this also supports idea that moult of primaries occurs earlier than in adults. **Subsequent moults of subadults** Adult timing of moult probably attained just after first breeding attempt, when first (or subsequent) basic primaries retained for c. 14 months (rather than 12) so that they are moulted at same time as in older adults. However, age of first breeding is not known, and it is possible that they go through a prolonged period of adolescence in which timing of several moults of primaries corresponds with timing of post-juvenile (first pre-basic) moult of primaries. Prolonged period of adolescence may explain puzzling anomaly with timing of moults of body: many Aust. immatures (in second or a subsequent austral summer or autumn) have no detectable wear of feathers of body, and the Aust. immatures examined in active moult of primaries also showed much moult of body (in June of austral winter, and in final stages, on 1 Dec. of second or subsequent austral summer) at times inconsistent with usual timing of post-juvenile or adult post-breeding moults. An alternative explanation for these observations could be that first pre-basic moult is partial, and the first moult to include primaries is actually a complete second pre-basic.

MEASUREMENTS (1–2) Aust. and NZ, skins; Tail includes spiny tips of shafts projecting c. 3 mm beyond webs of feathers (AM, ANWC, AIM, HLW, MV, NMNZ, QM, QVM, SAM, TMAG): (1) Adults, including birds with first basic primaries; (2) Juveniles and immatures with juvenile outer primaries.

		MALES	FEMALES	
WING	(1)	209.1 (4.78; 198–217; 32)	207.5 (4.93; 197–215; 13)	ns
	(2)	206.7 (5.29; 197–216; 22)	208.3 (4.72; 201–215; 6)	ns
TAIL	(1)	52.1 (1.84; 48–56; 37)	53.4 (2.39; 51–60; 16)	ns
	(2)	52.1 (1.62; 50–55; 22)	53.7 (2.34; 51–57; 6)	ns
BILL	(1)	8.14 (0.570; 7.0–9.6; 36)	7.94 (0.463; 7.1–8.9; 14)	ns
	(2)	8.26 (0.400; 7.4–9.2; 19)	8.43 (0.339; 8.0–9.0; 6)	ns
BILL S	(1)	14.3 (0.95; 12.2–16.3; 36)	13.9 (1.42; 10.3–15.9; 15)	ns
	(2)	14.3 (1.43; 10.4–16.6; 18)	14.4 (0.98; 13.1–15.7; 6)	ns
TARSUS	(1)	16.6 (0.93; 14.5–18.7; 29)	16.7 (0.57; 15.7–17.8; 15)	ns
	(2)	16.8 (0.78; 15.5–17.8; 18)	16.6 (0.56; 15.9–17.6; 6)	ns

No significant differences in size between sexes or age-classes, as also reported in BWP. Variation in length of wing with wear negligible. Additional measurements in BWP and Kleinschmidt (1970).

WEIGHTS (1–2) Aust., from museum labels (AM, ANWC, QM, QVM, TMAG): (1) Adults and second-year immatures combined; (2) Juveniles and immatures in first austral summer or autumn.

	MALES	FEMALES
(1)	97.9 (28.70; 47.4–169; 23)	88.5 (21.67; 64.5–120.6; 8) ns
(2)	96.6 (27.09; 58–135; 17)	99.2, 120

No significant differences apparent between sexes or age-classes.

Unsexed live birds, captured by flip-netting, se. Qld, 28 Dec. 1991: 114.6 g (5.55; 180–125.5; 13) (Tarburton 1993; M.K. Tarburton). No significant variation between weights in different months (ANOVA), but seasonal variation might easily be obscured by unsatisfactorily high variances. In most months, some weights appear to be improbably light; some of the lightest birds were found grounded, either through illness or injury: e.g. adults in this condition weighed 54, 64, 72, 75, 96 and 99 g. Specimens and banded birds are likely to include disproportionate number of sickly birds as healthy Needletails in HANZAB region difficult to collect or catch (e.g. Tarburton 1993); most weights available lacked details on condition of body and circumstances of collection, so a robust separation of typical and aberrant weights not possible. The few adequately documented data available suggest usual weights of Needletails in HANZAB region may be higher than above summaries imply. The possibility that some Needletails in Aust. are naturally light at times cannot be excluded; Pettigrew & Wilson (1985) describe an individual, arguably going through periods of torpidity as a result of an unseasonally cold period in Nov., that weighed 88 g shortly after discovery in a tree-hollow in ne. NSW and weighed 83 g two days later, despite feeding avidly in captivity.

In breeding areas, adult males 122.2 (109–140; 11), adult females 113.7 (101–125; 5) and juveniles 1 week before fledging, 107–110 g (n=6) (Neufeldt & Ivanov 1960); a few other weights from breeding areas in BWP.

STRUCTURE Wing long and narrow with sharply pointed tip. Eleven primaries: p10 longest; p9 1–4 mm shorter, p8 8–15, p7 18–32, p6 34–52, p5 51–70, p4 77–82; p3 94–111; p2 110–117; p1 126–137; s1 138–150; p11 minute, concealed by primary coverts. No emarginations, but all primaries gradually taper toward narrowly rounded tip. Nine secondaries, including three tertials; all secondaries short, so innerwing looks slightly narrower than outerwing; eutaxic. Outer secondary (s1) shaped like inner primaries rather than outer secondaries; i.e. shaft rather straight (cf. curved inward for other secondaries), so tip of inner web (not outer) forms most of trailing edge. Tail short (only projecting c. 5 mm beyond tips of undertail-coverts), square to very slightly rounded at tip; ten rectrices; stiff, spine-like shafts of rectrices project 3–5 mm beyond vanes of feathers. Bill very flat, short and as broad at base as it is long; width of bill at junction of gape, c. 14.5 mm, at junction with feathering of forehead, c. 8.0 (c. 3.5 mm deep at this point). Nostrils large, oval, set near ridge of culmen; gape exposed, extending back to below eye; lack rictal bristles. Tarsus and toes unfeathered; short but proportionately longer and more robust than in any other swifts of HANZAB region; anisodactyl. Middle toe longest, 16.9 (16–18; 10) including claw; outer toe c. 89% of middle, inner c. 90%, hindtoe c. 64%. Claws heavy and sharp; toes strong enough to have 'vicelike grip' (Tarburton 1993). Osteological differences between *Hirundapus* and other genera of

swifts (mainly involving the palatines) described by Collins & Brooke (1976).

AGEING In HANZAB region, three age-classes separable at all times. While there are real differences in timing of moult, especially of primaries, resultant differences in wear are subtle and difficult to detect without comparative material. This is mainly because primaries do not show wear readily, except for tendency to lose green gloss; wings usually spread when exposed to daylight, so tips of worn primaries do not become contrastingly paler than rest of feather. The age-classes are: (1) Juveniles and birds in post-juvenile moult of body (hereafter simply referred to as juveniles) from time of fledging, through first austral summer and autumn to end first n. migration; (2) Immatures, from July of second calendar year to about Apr. of third calendar year (or possibly, of a later year); and (3) Adults.

AUG.–NOV.: JUVENILES have full juvenile plumage and show no moult; always differ from older birds in having weaker, less green and more bluish sheen to upperwing-coverts, uppertail-coverts and rump, and narrower tips to primaries (see Fig. 1); usually also have distinct, narrow blackish tips to all undertail-coverts; and in some heavy grey-brown tinge to lores. ADULTS are in early to middle stages of moult of primaries and performing complete moult of body; differ from juveniles in lacking dusky tinge to lores or dark tips to undertail-coverts (except sometimes on longest central pair); and in having much stronger green gloss to upperwing, uppertail-coverts and sides of rump. IMMATURES resemble adults but are in later stages of moult of primaries (see Moults).

DEC.–FEB.: JUVENILES are undergoing a complete moult of body, tail, tertials and most wing-coverts, so ageing characters involving colour of these areas must be used with caution at this time. Juvenile primaries are retained and usually show detectable traces of wear; they show weaker green gloss than in adults or immatures. ADULTS are in middle to late stages of moult of primaries and are usually the only age-class with active moult of primaries at this time; newly grown inner primaries are very strongly glossed green. Very fresh undertail-coverts sometimes have narrow dark tips, inviting confusion with retained worn juvenile undertail-coverts in this period. IMMATURES differ from adults in that they have finished moult of primaries (except for a few that may be in very last stages of moult at start of Dec.). Differ from juveniles in lacking moult of body, and in having distinctly fresher primaries with much stronger green gloss (though gloss can be slightly weaker than in adults).

MAR.–APR.: JUVENILES have moulted most or all juvenile body-plumage but retain juvenile primaries, which are by now 9–10 months old and showing distinct signs of fading and wear. ADULTS have recently finished moult of primaries (a few are still in final stages) and primaries are very fresh and strongly glossed green. Often still have indications of very fresh plumage of body (such as dusky wash on lores or narrow dark tips to undertail-coverts). IMMATURES differ from adults in having slightly older primaries that show weaker green gloss; they may be less apt to show indications of very fresh plumage of body. Primaries have broader tips and are much less worn than in juveniles.

RECOGNITION For information on identification of extralimital *Hirundapus*, see Biswas (1951), Mees (1973, 1985), Collins & Brooke (1976) and Chantler & Driessens (1995).

GEOGRAPHICAL VARIATION Slight, mainly involving colour of top of head and upperparts. Two subspecies. Nominate *caudacutus*, described above, apparently uniform

throughout its large breeding range. Subspecies *nudipes* of Himalayas differs most strikingly in having forehead, crown, nape and sides of head, black with dark-blue or dark greenish-blue gloss; lacks white on forehead and lores (BWP); also has slightly browner (less silvery-grey) mantle and back; more extensive dark-blue gloss on side of rump and uppertail-coverts; and slightly darker olive-brown breast, belly and underwing-coverts. May also have slightly shorter wings than nominate: length of wing given as 206 (194–214; 6) by BWP, 208 (201–214; 10) by Vaurie (1965). *Nudipes* more sedentary than nominate, but two migrants have been collected in w. Java on 26 Nov. (Mees 1985).

REFERENCES

- Althofer, G.W. 1937. *Emu* 37: 158–9.
 Anon. 1930. *Emu* 30: 22–8.
 — 1985. *West. Aust. Bird Notes* 33: 8–10.
 Arnol'di, K.V. (Ed.) 1967. *Ecologia Klekopitayuschikh i Ptits*. Moscow.
 Ashburner, F. 1985. *Aust. Bird Watcher* 11: 100–1.
 Ashby, E. 1920. *S. Aust. Orn.* 5: 79–80.
 Backhouse, J. 1985. *Aust. Birds* 19: 56–61.
 Bailey, A.M., & J.H. Sorensen. 1962. *Proc. Denver Mus. Nat. Hist.* 10.
 Banfield, E.J. 1925. *Last Leaves from Dunk Island*. Angus & Robertson, Sydney.
 Barnard, H.G. 1926. *Emu* 26: 1–13.
 Batey, I. 1907. *Emu* 7: 1–17.
 Baxter, C.I. 1980. *S. Aust. Orn.* 28: 90–8.
 — 1989. *An Annotated List of the Birds of Kangaroo Island*. S. Aust. Natn Pks Wildl. Serv., Kingscote, Kangaroo I., SA.
 Bedgood, G.W. 1965. *Bird Obs.* 405: 6.
 Beehler, B.M., et al. 1986. *Birds of New Guinea*. Princeton Univ. Press, Princeton.
 Bell, B.D. 1959. *Notornis* 8: 121.
 Bell, H.L. 1969. *Emu* 69: 193–211.
 — 1970. *Emu* 70: 97–104.
 Berson, F., & K. Simpson. 1971. *Weather* 26: 23–32.
 Bielewicz, J., & F. Bielewicz. 1996. *Sunbird* 26: 81–120.
 Biswas, B. 1951. *Ardea* 39: 318–21.
 Blackburn, A. 1970. *Emu* 70: 90.
 Boehm, E.F. 1939. *S. Aust. Orn.* 15: 54–8.
 Bouchier, M., & D. Noonan. 1962. *Bird Obs.* 371: 2–4.
 Bourke, P.A., & A.F. Austin. 1947. *Emu* 47: 87–116.
 Brandis, C.C.P., et al. 1992. *Aust. Bird Watcher* 14: 165–79.
 Bravery, J.A. 1971. *Emu* 71: 182.
 Bridgewater, A.E. 1934. *Emu* 34: 97–9.
 Brooker, M.G., et al. 1979. *Emu* 79: 176–90.
 Brown, B., & P. Child. 1975. *Notornis* 22: 10–22.
 Buchanan, J.A. 1958. *Notornis* 8: 25.
 Cameron, A.C. 1952. *Emu* 52: 86–8.
 — 1968. *Emu* 68: 217–19.
 Cameron, R., & M. Hinchey. 1981. *Aust. Bird Watcher* 9: 68.
 Campbell, A.G. 1902. *Emu* 1: 149.
 — 1930a. *Emu* 29: 308.
 — 1930b. *Emu* 30: 147.
 — 1935. *Emu* 34: 312–14.
 Campbell, A.J., & H.G. Barnard. 1917. *Emu* 17: 2–38.
 Carlyle, J. 1982. *Bird Obs.* 611: 97.
 Chantler, P., & G. Driessens. 1995. *Swifts*. Pica Press, Robertsbridge, England.
 Chunikhin, S. 1963. *Ornithologia* 6: 484–5.
 Clark, G. 1976. *Canberra Bird Notes* 3: 2–14.
 Clayton, M. 1993. *Canberra Bird Notes* 18: 21–2.
 Coates, B.J. 1985. *The Birds of Papua New Guinea*. 1. Dove Pubs, Alderley, Qld.
 —, et al. 1997. *A Guide to the Birds of Wallacea*. Dove Pubs, Alderley, Qld.
 Cohn, M. 1925. *Emu* 25: 104–11.
 Collins, C.T., & R.K. Brooke. 1976. *Contrib. Sci. Los Angeles* 282: 1–22.
 Cooper, R.M., & I.A.W. McAllan. 1995. *The Birds of Western New South Wales: A Preliminary Atlas*. NSW Bird Atlasers, Albury, NSW.
 Cooper, R.P. 1971. *Aust. Bird Watcher* 4: 79–80.
 Corben, C., et al. 1982. *Sunbird* 12: 47–8.
 Coventry, P. 1989. *Aust. Bird Watcher* 13: 36–7.
 Crompton, A. 1936. *S. Aust. Orn.* 13: 183–4.
 Currie, C.C. 1928. *Emu* 28: 76.
 Currie, K. 1916. *Emu* 16: 108.
 D'Ombraïn, A. 1934. *Emu* 33: 271–2.
 Daley, M.R. 1961. *S. Aust. Orn.* 23: 64.
 Davidson, P. 1993. *Norfolk Nat. Notes* 9: 337–9.
 Davies, J. 1982. *Bird Obs.* 609: 76.
 Davis, W.A. 1965. *Aust. Bird Watcher* 2: 134–8.
 Dawson, P., et al. 1991. *Sunbird* 21: 93–111.
 Day, N. 1993. *Aust. Bird Watcher* 15: 43–4.
 de Schauensee, R.M. 1984. *The Birds of China*. OUP, Oxford.
 Dement'ev, G.P., & N.A. Gladkov (Eds) 1951. *Birds of the Soviet Union*. 1. Israel Prog. Scient. Transl., Jerusalem (1966).
 Diamond, J.M., & K.D. Bishop. 1994. *Emu* 94: 41–5.
 Dorizac, P. 1968. *Notornis* 15: 268.
 Dove, H.S. 1902. *Emu* 2: 19–22.
 — 1905. *Emu* 5: 32–3.
 — 1909. *Emu* 9: 37–9.
 — 1918. *Emu* 17: 223–5.
 — 1919. *Emu* 19: 53–5.
 — 1920. *Emu* 19: 314–15.
 — 1933. *Emu* 33: 67.
 — 1941. *Emu* 41: 53.
 Draffan, R.D.W., et al. 1983. *Emu* 83: 207–34.
 Dymond, J.N. 1990. *Bull. Afr. Bird Club* 1: 78.
 Eastwood, C.E., & P. Gregory. 1994. *Muruk* 6: 17–28.
 —, — 1995. *Muruk* 7: 128–42.
 Edgar, A.T. 1971. *Notornis* 18: 118–30.
 Edwards, E.O. 1948. *Emu* 47: 319.
 Emison, W.B., & J.W. Porter. 1978. *Emu* 78: 126–36.
 Fielding, P. 1979. *Tasm. Nat.* 57: 1–11.
 Flint, V.E., et al. 1984. *A Field Guide to Birds of the USSR*. Princeton Univ. Press, Princeton.
 Friend, G.R. 1982. *Emu* 82: 80–91.
 Glover, B. 1975. *S. Aust. Orn.* 26: 175–9.
 Gore, M.E.J., & P.-O. Won. 1971. *The Birds of Korea*. R. Asiatic Soc., Seoul.
 Gosper, D.G. 1981. *Corella* 5: 1–18.
 Green, R.H. 1969. *Rec. Queen Vict. Mus.* 34: 1–32.
 — 1989. *Birds of Tasmania*. Potoroo Pubs, Launceston, Tas.
 —, & A.M. McGarvie. 1971. *Rec. Queen Vict. Mus.* 40: 1–42.
 Gregory, P. 1995. *Muruk* 7(1): 1–38.
 Guest, R. 1992. *Notornis* 39: 319–21.
 Hermes, N., et al. 1986. *Notornis* 33: 141–9.
 Hicks, R.K. 1990. *Muruk* 4: 91–105.
 — 1991. *Muruk* 5: 43–8.
 Hill, G.F. 1911. *Emu* 10: 258–90.
 Hindwood, K.A. 1940. *Emu* 40: 1–86.
 —, & J.M. Cunningham. 1950. *Emu* 50: 23–35.
 Howard, H.H. 1936. *S. Aust. Orn.* 13: 184.
 — 1938. *S. Aust. Orn.* 14: 173–4.
 Hudson, F.P. 1968. *Notornis* 15: 42.
 Hutton, I. 1991. *Birds of Lord Howe Island Past and Present*. Author, Coffs Harbour, NSW.
 Hyem, E.L. 1936. *Emu* 36: 109–27.
 Imber, M.J., & D.F. Crockett. 1970. *Notornis* 17: 223–30.
 Inskipp, C., & T. Inskipp. 1985. *A Guide to the Birds of Nepal*. Croom Helm, Lond.
 Johnson, G. 1947. *Bird Obs.* 188: 2.
 King, B.F., & E.C. Dickinson. 1975. *A Field Guide to the Birds of South-East Asia*. Houghton Mifflin, Boston.
 Kistayakovskiy, A.B., & L.A. Smogorzhevskiy. 1971. *Proc. Nat. Res. Kedrovaya Pad.* 2: 187.
 Klapste, J. 1977. *Aust. Bird Watcher* 7: 65–6.
 Kleinschmidt, O. 1970. *Zool. Abh., Dresden* 31: 9–10.
 Knight, D. 1961. *Bird Obs.* 361: 8.
 La Touche, J.D.D. 1931–34. *A Handbook of the Birds of Eastern China*. 2. Taylor & Francis, Lond.
 Lauder, S. 1987. *OSNZ News* 44: 8.
 Lawrence, C.C. 1945. *Emu* 44: 226–9.
 Le Souëf, A.S. 1930. *Emu* 29: 234.
 Le Souëf, D. 1917. *Emu* 16: 190–1.
 Lea, A.M. 1938. *S. Aust. Orn.* 14: 177–8.

- Learmonth, N.F. 1950. *Emu* 50: 56–8.
 — 1951. *Emu* 51: 151–2.
- Legge, R.W. 1927. *Emu* 27: 19–23.
- Lepschi, B.J. 1993. *Emu* 93: 195–9.
- Littler, F.M. 1910. *A Handbook of the Birds of Tasmania and its Dependencies*. Author, Launceston, Tas.
- Lobko-Lobanovskii, M.I. 1956. *Zool. Zh.* 35: 1586–7.
- Longmore, N.W. 1978. *Sunbird* 9: 25–53.
- Lord, E.A.R. 1936. *Emu* 35: 216–18.
 — 1961. *Bird Obs.* 355: 2.
- Loyn, R.H. 1980. *Emu* 80: 145–56.
 — 1985. *Emu* 85: 213–30.
- Lyuleeva, D.S. 1991. *Proc. Zool. Inst., USSR Acad. Sci., Leningrad* 231: 117–37.
- MacGillivray, W. 1928. *Emu* 27: 230–49.
- Mackay, R.D. 1970. *The Birds of Port Moresby and District*. Thomas Nelson, Melbourne.
- Marshall, A.J. 1935. *Emu* 35: 36–48.
- McCaskill, L.W. 1943. *Notornis* 1: 38–40.
- McCulloch, E.M. 1966. *Emu* 65: 290.
- McDonald, N.H.E. 1938. *Emu* 38: 339.
- McFarland, D. 1988. *Emu* 88: 249–57.
- McGill, A.R., & S.G. Lane. 1955. *Emu* 55: 49–71.
- McKeown, K.C. 1944. *Emu* 43: 188–91.
- McMicking, F.V. 1925. *Emu* 25: 41.
- McNamara, E. 1948. *Austr. Nat.* 11: 191–210.
- Medway, Lord, & D.R. Wells. 1976. *The Birds of the Malay Peninsula*. 5. Witherby and Penerbit Univ. Malaya, Kuala Lumpur.
- Mees, G.F. 1973. *Zool. Meded.* 45: 225–44.
 — 1985. *Proc. Koninklijke Nederlands Akad. Wetenschappen*, C, 88: 63–73.
- Michie, R. 1968. *Notornis* 15: 35.
- Miller, P. 1980. *Notornis* 27: 44.
- Mitchell, A., et al. 1996. *Geelong Bird Rep.* 1995: 25–40.
- Moncrieff, P. 1936. *Emu* 36: 39.
 — 1943. *Emu* 42: 249.
- Morris, A.K. 1986. *Aust. Birds* 20: 65–81.
 — 1989. *Aust. Birds* 23: 7–21.
 —, et al. 1981. *Handlist of Birds in New South Wales*. NSW Field Orn. Club, Sydney.
- Morse, F.C. 1919. *Emu* 19: 68.
- Napier, J.R. 1969. *Aust. Bird Watcher* 3: 179–92.
- Nechaev, V.A., & Yu. N. Nazarov. 1967. Pp 316–29 In: Arnol'di 1967.
- Neufeldt, I., & A.I. Ivanov. 1960. *Br. Birds* 53: 433–5.
- Noonan, D., & W.R. Wheeler. 1965. *Bird Obs.* 408: 5–8.
 —, et al. 1963. *Bird Obs.* 383: 7–8.
 —, et al. 1964. *Bird Obs.* 396: 5–8.
 —, et al. 1966. *Bird Obs.* 420: 2–6.
 —, et al. 1967. *Bird Obs.* 433: 3–5.
- Onley, D. 1989. *OSNZ News* 50: 9–10.
- Orn. Soc. Japan. 1974. *Check-List of Japanese Birds*. Gakken, Tokyo.
- Paton, D.C., et al. 1994. *S. Aust. Orn.* 31: 151–93.
- Pescott, T. 1966. *Wild. Aust.* 3: 100–21.
 — 1983. *Birds of Geelong*. Neptune, Geelong, Vic.
- Pettigrew, J.D., & P. Wilson. 1985. *Emu* 85: 200–1.
- Pratt, H.D., et al. 1987. *A Field Guide to the Birds of Hawaii and the Tropical Pacific*. Princeton Univ. Press, Princeton.
- Pyke, G.H. 1985. *Emu* 85: 34–9.
- Quested, T. 1980. *Aust. Birds* 14: 52.
 — 1982. *Aust. Birds* 16: 64.
- Rand, A.L. 1942. *Bull. Am. Mus. Nat. Hist.* 79: 289–366.
 —, & E.T. Gilliard. 1967. *Handbook of New Guinea Birds*. Weidenfeld & Nicolson, Lond.
- Reilly, P.N. 1991. *Emu* 91: 100–6.
- Richards, A., & R. Rowland. 1995. *Muruk* 7(2): 75–95.
- Richardson, I.M. 1997. *PNG Bird Soc. Newsl.* 289: 4.
- Roberts, T.J. 1991. *The Birds of Pakistan*. 1. OUP, Oxford.
- Rose, A.B. 1974. *Aust. Birds* 9: 26–30.
 — 1997. *Aust. Bird Watcher* 17: 203–10.
- Salter, B.E. 1958. *Bird Obs.* 319: 2.
- Schodde, R., et al. 1983. *Aust. Natm. Parks Wildl. Serv. Spec. Publ.* 8.
- Schulz, M., & K. Kristensen. 1994. *Aust. Bird Watcher* 15: 265–72.
- Sedgwick, E.H. 1978. *West. Aust. Nat.* 14: 85–108.
- Serventy, D.L. 1948. *Emu* 47: 241–86.
- Shepherd, G.E. 1902. *Emu* 2: 31–2.
- Shilling, D. 1948. *Emu* 48: 64–72.
- Sibley, C.G., & B.L. Monroe. 1990. *Distribution and Taxonomy of Birds of the World*. Yale Univ. Press, New Haven.
- Slater, K.R. 1964. *Emu* 64: 72.
- Slater, P. 1995. *Emu* 95: 194–207.
- Smith, F.T.H. 1990. *Bird Obs.* 696: 25–6.
- Smith, P. 1984. *Emu* 84: 200–10.
- Smithers, C.N., & H.J. de S. Disney. 1969. *Aust. Zool.* 15: 127–40.
- Smythies, B.E. 1957. *Ibis* 99: 687–8.
 — 1981. *The Birds of Borneo*. Third edn. Sabah Soc. & Malayan Nat. Soc., Kota Kinabalu.
- Spangenberg, E.P. 1960. *Okhrana Prirrody Ozelenenie* 4: 135–43.
- Stidolph, R.H.D. 1927. *Emu* 26: 212–19.
- Stokes, T. 1983. *Sunbird* 13: 53–8.
 —, et al. 1984. *Emu* 84: 23–8.
- Stove, K. (Ed.) 1994. *S. Aust. Orn.* 31: 195–265.
- Sullivan, C. 1929. *Emu* 29: 39–44.
- Tarburton, M.K. 1993. *Emu* 93: 121–4.
- Templeton, M.T. 1973. *Aust. Bird Watcher* 5: 64.
 — 1991. *Sunbird* 21: 19–25.
- Thomas, D. 1979. *Tasmanian Bird Atlas*. Univ. Tas., Hobart.
- Tryon, H. 1908. *Qld Nat.* 1: 38–9.
- Vaurie, C. 1965. *The Birds of the Palaearctic Fauna*. Witherby, Lond.
- Veerman, P. 1988. *Canberra Bird Notes* 13: 130–1.
- Vincent, D. 1980. *S. Aust. Orn.* 28: 110.
- Wall, L.E. 1966. *Emu* 65: 310–11.
- Warham, J. 1957. *West. Aust. Nat.* 5: 232–3.
 — 1961. *Emu* 61: 189–90.
 — 1962. *Emu* 62: 99–111.
- Watling, D. 1982. *Bull. Br. Orn. Club* 102: 123–7.
- Watson, I.M. 1955. *Emu* 55: 224–48.
- Whackett, M. 1989. *West. Aust. Bird Notes* 50: 1.
- Wheeler, J. 1965. *Aust. Bird Watcher* 2: 152–3.
- Wheeler, W.R. 1950. *Bird Obs.* 221: 15.
 — 1952. *Bird Obs.* 249: 2–3.
 — 1953. *Bird Obs.* 261: 3–4.
 — 1954a. *Bird Obs.* 286: 2–4.
 — 1954b. *Bird Obs.* 287: 3.
 — 1956a. *Bird Obs.* 291: 3–4.
 — 1956b. *Bird Obs.* 297: 3–4.
 — 1957. *Bird Obs.* 309: 5–6.
 — 1958. *Bird Obs.* 322: 2.
 — 1959a. *Emu* 59: 229–49.
 — 1959b. *Bird Obs.* 334: 2–5.
 — 1960a. *Bird Obs.* 347: 3–4.
 — 1960b. *Bird Obs.* 348: 3–5.
 — 1970. *Bird Obs.* 468: 8.
 —, et al. 1961. *Bird Obs.* 359: 2–3.
- Whinray, J.S. 1971. *Tasm. Nat.* 24: 2–3.
- White, C.M.N., & W.M. Baird. 1977. *Auk* 94: 389.
 —, & M.D. Bruce. 1986. *BOU Checklist* 7.
- Whitlock, F.L. 1925. *Emu* 25: 69–89.
 — 1939. *Emu* 39: 47–56.
- Wilder, C. 1989. *West. Aust. Bird Notes* 50: 1.
- Wood, P.J. 1950. *Bird Obs.* 225: 3.
- Wright, A., & H.R. McKenzie. 1966. *Notornis* 13: 106.



Volume 4, Plate 48

White-throated Needletail *Hirundapus caudacutus* (page 1070)
 1-4 Adult; 5 Juvenile

Fork-tailed Swift *Apus pacificus* (page 1081)
 6-9 Adult; 10 Juvenile

House Swift *Apus affinis* (page 1090)
 11-13 Adult