

## Order PSITTACIFORMES

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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## Family PSITTACIDAE parrots and lories

Usually brilliantly coloured, and vary greatly in size. About 310–335 species in 70–87 genera (Schodde & Mason 1997); 46 species in 21 genera in HANZAB region. Distributed on all continents except Antarctica; most diverse in A'asia, but other centres of diversity in Old World (Africa and Indian subcontinent) and New World (S. America and s. N. America) (Smith 1975; Forshaw & Cooper 1989; Schodde & Mason 1997).

Taxonomy at subfamily level not clear at present time. Different authors have recognized 5–11 different groups within Psittacidae (see Smith 1975; Forshaw & Cooper 1989; Sibley & Ahlquist 1990; Collar 1997). Eleven infrafamilial groups have been recognized here, following Schodde & Mason (1997) for those with representatives in HANZAB region, and Collar (1997) for those wholly extralimital. The following four groups occur extraliminally: Psittrichadini (Pesquet's Parrot *Psittrichas fulgidus*, monotypic); Micropsittini (pygmy parrots, six species); Psittacini (Afrotropical parrots, 12 species); and Arini (Neotropical parrots, 148 species); these not considered further below.

Schodde & Mason (1997) recognized six infrafamilial groups in Aust. and its territories. However, since relationship between species in some of these groups is still not clear, they treated only the three more clearly defined groups as subfamilies (Nestorinae, Loriinae and Platycercinae) and considered the other three groups as unplaced tribes (Psittaculini, Cyclopsittacini and Polytelini). Another subfamily, Strigopinae, is endemic to NZ (NZCL). Collar (1997) differs slightly in which groups he treats as subfamilies and which he treats as tribes; also does not recognize Polytelini, which he includes within Psittaculini. The seven groups occurring in the HANZAB region (based on Schodde & Mason [1997] unless stated and which see for further references):

**SUBFAMILY STRIGOPINAE:** Monotypic Kakapo *Strigops habroptilus*; endemic to NZ. Large, flightless. Furcula cartilaginous; keel vestigial (Holyoak 1973; Smith 1975). Barred remiges and rectrices (Smith 1975). Scratch head over wing (Smith 1975).

**SUBFAMILY NESTORINAE:** Kakas. One genus, *Nestor*, with two species endemic to NZ, and a third isolated and extinct species on Norfolk I. Large and short-tailed, with spines extending from tips of rectrices. Remiges barred (Smith 1975). Parahyoid process joined; styohyoideus muscle reduced; left carotid superficial; tongue thick and muscular with fringe of hair-like papillae on outer edge; pigments fluorescent (Holyoak 1973).

**SUBFAMILY LORIINAE:** Lorikeets and lories. Small, brightly coloured, and arboreal parrots. Eleven to 13 genera, distributed across e. Indonesia, New Guinea, islands of sw. Pacific and Aust. with greatest diversity in New Guinea, where 8–10 genera occur; three genera in HANZAB region: *Glossopsitta*, *Psitteuteles*, *Trichoglossus* (Schodde & Mason 1997). Most have permanent underwing-stripes (Smith 1975; Forshaw & Cooper 1989; Courtney 1997b); present only in some juveniles of extralimital *Charmosyna* (Courtney 1997b). Parahyoid process joined; styohyoideus muscle reduced or absent; tongue has brush of papillae at tip (Holyoak 1973; Smith 1975; Forshaw & Cooper 1989). Also characterized by pointed wings and tails, dashing flight, and short intestinal tract with inelaborate crop and gizzard.

**SUBFAMILY PLATYCERCINAE:** Broad-tailed parrots. Diverse group of small to medium-sized parrots. About 14 genera containing 35–38 species distributed across Aust., NZ and New Caledonia and on some associated islands; 11 genera and 28 species in HANZAB region: *Barnardius*, *Cyanoramphus*, *Lathamus*, *Melopsittacus*, *Neophema*, *Neopsephotus*, *Northiella*, *Pezoporus*, *Platycercus*, *Psephotus*, *Purpureicephalus*. Underwing-stripe present in juveniles and most adult females, but usually 'deciduous' in adult males (Holyoak 1973; Courtney 1997c); permanent in *Melopsittacus* and *Pezoporus* (Courtney 1997b,c); absent in extralimital *Prosopieia* (Courtney 1997c). Characterized by crescentic auditory maetus; foss at base of zygomatic process; orbit open below (except *Melopsittacus*); parahyoid process more or less converging; tongue has shallow grooves; furcula cartilaginous (except *Lathamus*); styohyoideus muscle often wide; left carotid often superficial; fluorescent yellow pigment in plumage; scratch head over wing (Holyoak 1973). Except for *Geopsittacus* and *Pezoporus*, all have small patch of feathers on nape with white or pale yellow bases, instead of the usual grey, and which forms a nape-spot (Smith 1975), though spot hidden unless feathers of the region are erected or worn.

**Unplaced tribes: PSITTACULINI:** Palaeotropic parrots. Medium-sized arboreal parrots with heavy bills. Composition uncertain; about 11 genera, distributed from India to A'asia. Two genera in Aust.: *Eclactus* and *Geoffroyus*. Both tongue and dental pad ridged or grooved. No stripe on underwing.

**CYCLOPSITTICINI:** Fig-parrots. Small, green, arboreal fruit-eating parrots. Five species in 1–3 genera, with distribution centred in New Guinea; single species in genus *Cyclopsitta* in HANZAB region. Have stout ridged bills; wedge-shaped tails; marked sexual dimorphism; permanent double stripes on underwing; and completely ossified orbital ring free from well-developed zygomatic processes (Smith 1975; Courtney 1997b).

**POLYTELINI:** Long-tailed parrots. Slender medium-sized parrots. Eight species in three genera, with distribution centred in Aust. Five species from all three genera in HANZAB region: *Alisterus*, *Aprosmictus* and *Polytelis*.

Characterized by long, attenuated pink-tipped tails (Schodde & Mason 1997); inner webs of lateral rectrices have rose-pink edging, a character not possessed by any other parrot (Courtney 1997a). Other characters include: marked sexual dimorphism; no stripe on underwing; tongue ridged or grooved; soft palate; extrinsic syringeal muscles evidently attached to lung membrane.

Generally slim bodied, with short necks and short bills. Plumage coloured by carotenoid pigments and back-scattering of light through hollow cortical cylinders in feather barbs (Dyke-texture or Tyndall-texture). All feathers of body (except nape of some groups) have grey bases. None has erectile crests, though Horned Parakeet *Eunymphicus cornutus* of New Caledonia has elongated feathers on crown forming an immovable crest (Forshaw & Cooper 1989). Maxillae attached to skull by a flexible joint. Carotid arteries paired, fused, or left carotid superficial. Syrinx bronchial, the first rings upcurved, ossified and fused (except in Nestorinae). Zonary proventriculus present. No gall bladder. See introduction to order for characters shared with Cacatuidae.

Adult plumage often bright and colourful; ground-colour commonly green, with blue, red or yellow markings. In most, sexes similar or differ only slightly in plumage; in *Eclectus*, *Psephotus* and some *Neophema*, sexual dimorphism in plumage marked. In those groups that have stripe on underwing, presence often related to age or sex. Adult bare parts vary greatly: dull greys, browns and creams in many, but can be bright red or orange in many others. In most species, males slightly larger than females. Adult post-breeding (pre-basic) moult usually complete. Moult of primaries centrifugal; usually begins from p6, but in some can begin with any primary between p5 and p8. Nestlings usually hatch with sparse covering of down; a few hatch naked or nearly naked. A second, mesoptile, down develops in many species. In most, juvenile plumage duller than that of adults (and often resembles dull version of adult females in species where sexes differ). Post-juvenile (first pre-basic) moult partial in most species. Time to attain adult plumage varies greatly between species; in some, young birds not separable from adults after a few months, in others, adult appearance not attained until c. 4 years old. Similarly, time of first breeding can vary between species, from within first year to 4 years or older.

Occur in most habitats, from arid and semi-arid zones to tropical rainforest. Some species wholly arboreal, e.g. Loriinae, Cyclopsittacini, Eclectus Parrot *Eclectus roratus*; most others at least partly arboreal; a few strictly terrestrial, e.g. Night Parrot *Pezoporus occidentalis*, Ground Parrot *P. wallicus*. Though recorded in most habitats, some are specialists: e.g. fig-parrots *Cyclopsitta* mostly restricted to tropical and subtropical rainforests; Kaka *Nestor meridionalis* mostly inhabits temperate beech, broadleaf or podocarp rainforests; and Ground Parrot mainly confined to heathland in s. and e. Aust. In contrast, rosellas *Platycercus* may occur in a wide variety of treed habitats. Most require hollows, and therefore old trees, in which to nest, and are adversely affected by the removal of hollow-bearing trees (see Introduction to Order).

Patterns of movements vary greatly: from sedentary (e.g. Ground Parrot, Kakapo *Strigops habroptilus*), resident (e.g. Australian Ringneck *Barnardius zonarius*), to highly nomadic or dispersive (e.g. Budgerigar *Melopsittacus undulatus*). Several species migratory: Swift Parrot *Lathamus discolor* and Orange-bellied Parrot *Neophema chrysogaster* breed in Tas. and most or all of population moves to mainland Aust. for non-breeding season; further, Tas. breeding population of Blue-winged Parrot *Neophema chrysostoma* also apparently mostly migratory, moving to mainland Aust. Kakapo of NZ flightless. As with Cacatuidae, movements of many species poorly known, and many types of patterns have been attributed to them (e.g. Superb Parrot *Polytelis swainsonii*), probably in ignorance of actual movements, but possibly because movements vary between years or areas. Movements of lorikeets in Aust. (Loriinae) often considered to be related to flowering of food-trees. Many other species in HANZAB region appear to move in response to rainfall; in Budgerigar, both rainfall and temperature act indirectly on control of movements and breeding by affecting production of food (Wyndham 1980, 1983). Some species might make altitudinal movements (e.g. Eastern Rosella *Platycercus eximius*). Even suggested that movements of Golden-shouldered Parrots *Psephotus chrysopterygius* possibly linked to those of Black-faced Woodswallows *Artamus cinereus* (Garnett & Crowley 1995). Major studies of movements have been carried out on some species in HANZAB region (e.g. Crimson Rosella *Platycercus elegans*), using standard leg-banding, radio-tracking, and, in case of Ground Parrot, even cotton and spool method (Jordan 1987, 1988).

Almost all are herbivorous, feeding mainly on seeds, though many also take insects and their larvae. Most gregarious. Feed on ground, in trees, or both. Drink water by lapping, ladling or suck-pumping. All (except monotypic Psitttrichadini of New Guinea) husk seeds in same way: seed held between tip of lower mandible and notch on horny palate of upper mandible (which also corrugated to improve grip); the tip of the lower mandible driven into husk, between seed and husk, which is thus removed. The seed is then split and eaten; very hard nuts are held in part of bill nearest gape, where pressure between mandibles greatest (Collar 1997). Handling of other items similar. In HANZAB region, groups show variety of adaptations and behaviour; the following based on Forshaw & Cooper (1981), Schodde & Mason (1997), Forshaw, and species accounts, unless stated. **LORIINAE:** Almost exclusively arboreal, feeding mainly on nectar and some pollen and fruit. Specialized for harvesting pollen and nectar, with: narrow and protruding bills, brush-tipped tongues (see Churchill & Christensen 1970; Hooper & Burbidge 1979), non-muscular gizzard, and compound glands arranged linearly along wall of proventriculus (Steinbacher 1934). Gizzards of lorikeets much

smaller than those of seed-eating parrots of similar body weight, and intestine substantially shorter (Richardson & Wooller 1990). Gregarious, feeding in noisy flocks that continually move from one stand of flowering trees to another. When feeding, very active, clinging to and climbing all over flowering branches. PSITTACULINI: Arboreal, mainly in canopy of rainforest trees. Feed on fruits, seeds, flowers and nectar; said to prefer rainforest fruits. Usually feed in pairs or small flocks. CYCLOPSITTICINI: Wholly arboreal, but may descend to c. 1 m from ground to feed on low branches and trunks of fig-trees. Frugivorous, eating mainly figs, though tend to extract seeds from fruit and discard pulp rather than eat fruit. Bills broad, stout and ridged. Feed in pairs or small parties. POLYTELINI: Arboreal and terrestrial, granivorous. *Alisterus* and *Aprosmictus* arboreal, feeding mainly on seeds of native trees, such as *Eucalyptus*; *Polytelis* spend more time on ground feeding on seeds of grasses and herbaceous plants. Feed in pairs or small flocks, though *Polytelis* usually feed in flocks. PLATYCERCINAE: Terrestrial and arboreal. Diet: (1) mainly seeds of grasses, herbs and trees, procured from ground or from shrubs and trees (*Barnardius*, *Neopsephotus*, *Northiella*, *Platycercus*, *Polytelis*); (2) mainly seeds of grasses and herbs obtained almost exclusively from ground (*Melopsittacus*, *Neophema*, *Pezoporus*, and *Psephotus* [except Mulga Parrot *P. varius*, which feeds both on ground and in trees]); (3) nectar (*Lathamus*); (4) leaves of grasses and sedges (*Cyanoramphus*). Some highly specialized, e.g. Red-capped Parrots *Purpurecephalus spurius* have narrow projecting bill and feed on seeds extracted from capsules of Marri *Eucalyptus callophylla*. Many also supplement main diet with flowers, nectar, or fruits, and almost all take some invertebrates. One, Antipodes Island Parakeet *Cyanoramphus unicolor*, known to take dead and nesting seabirds. Most feed in small flocks; some feed in large flocks (e.g. Budgerigar); others often feed singly or in pairs (e.g. *Platycercus*). Feeding behaviour varies widely depending on nature of food and where obtained; for details see individual species accounts. NESTORINAE: Mainly herbivorous but omnivorous, taking wide range of plant foods and invertebrates. Arboreal and terrestrial, forage at all levels from ground to canopy of trees. Use wide range of foraging methods, including gleaning, probing, digging, stripping and chiselling bark, excavating wood, and licking nectar from flowers; unlike other parrots, feed on sap by stripping bark and exposing cambium, and then lick sap from damaged surface. Feed singly, in pairs or small flocks, though Kaka more often singly. STRIGOPINAE: Mainly herbivorous, partly granivorous. Forage at all levels, including canopy of tall forest, but most foraging on or near ground. Sense of smell thought to be well developed and of importance in foraging, and at least some birds can locate foods by smell alone. Short, powerful and compressed bill, and short, broad and thick tongue adapted for browsing, crushing, grinding and extracting juices from fibrous plant tissues. Solitary.

In HANZAB region, all species gregarious to some extent with notable exception of Kakapo. In most species, flocks typically of up to c. 30 birds. However, some species in flocks of 100s and, in Budgerigars, 1000s. Most species more gregarious in non-breeding season, though even in breeding season, many species often form flocks when feeding. All monogamous, with exception of Kakapo, in which the sexes come together only at leks. Pair bonds lifelong and mates remain together year round. Co-operative breeding does not occur, with probable exception of Eclectus and Red-cheeked *Geoffroyus geoffroyi* Parrots (Psittaculini) and possibly, but rarely, Regent Parrot *Polytelis anthoepus* (Polytelini). Only female incubates but both sexes involved with feeding of young, except in Kakapo, in which female raises young alone, and possibly Ground Parrot, in which male appears responsible for feeding of young. In most species, young generally leave natal area by 3–6 months old. Aust. lorikeets, *Polytelis*, *Eclectus*, and some *Neophema* often nest in loose colonies; others strictly solitary nesters. Generally defend only nest-hole. Most gregarious species roost communally, at least when not breeding.

Often conspicuous, vocal and active but may be hard to observe when feeding in tree-tops or on ground. All species courtship feed, except Kakapo; in some, occurs year round e.g. *Trichoglossus*. Many known to, or likely to, allopreen, except rosellas *Platycercus*, Australian Ringneck, *Cyanoramphus*, *Neosephotus*, *Neophema*, Red-winged Parrot *Aprosmictus erythropterus*, Australian King-Parrot *Alisterus scapularis*, possibly Red-cheeked Parrot, and assumed not to in Kakapo. Sexual and aggressive displays generally fairly simple, consisting of actions such as bobbing, eye-blazing, arching of wings, fanning and wagging of tail and calls. However, in *Trichoglossus* and Varied Lorikeet *Psitteuteles versicolor* (Loriinae), displays complex and performed in many social contexts; in *Trichoglossus*, displays often performed either reciprocally or in unison by both members of a pair. Other notable displays are aerial circling performed by Eclectus and Red-cheeked Parrots, and distinctive calling behaviour of Kakapo and Ground Parrot.

Calls usually described as whistles, chatterings or pipings, though some are shrieks. Calls often melodic and some are extraordinarily complex, such as Warble song of Budgerigar, and highly varying yodelling calls of Kaka *Nestor meridionalis*. Booming of Kakapo at lek unique form of vocalization in parrots. Sexually differentiated calls known in many species in most genera. Food-begging Call of all Aust. lorikeets a repeated sharp high-intensity hissing note that begins with a structureless hiss, which gives way abruptly to a brief high-energy blip preceding a structured hiss (see Courtney 1997b). For details of Food-begging and other calls of platycerine parrots see Courtney (1997c, which was not available for summary in species accounts).

Breeding well known in HANZAB region. Extralimitally, breeding of most species of Loriinae, Platycercinae and Cyclopsittacini virtually unknown; some species of Psittaculini moderately well known. Plum-headed Parrot *Psittacula cyanocephala* and some lovebirds *Agapornis* (Psittaculini) breed colonially (Forshaw & Cooper 1981), and Large Fig-Parrot *Psittaculirostris desmarestii* (Cyclopsittacini) thought to breed colonially within hollow trunks of large



trees (Rand 1942; Beehler 1982). Breeding generally seasonal but some species will breed at any time of year if conditions suitable, and some species can raise two or more broods in a season. Most species nest in hollows in trees, though some nest on ground, under rocks, vegetation or in burrows; some species excavate tunnels in termite mounds. Extralimitally, Red-flanked Lorikeet *Charmosyna placentis* (Loriinae), Orange-breasted Fig-Parrot *Cyclopsitta gulelimitertii* (Cyclopsittacini) and some *Agapornis* (Psittaculini) nest in holes excavated in arboreal termitaria (Rand 1942; Bell & Coates 1979; Forshaw & Cooper 1981; Coates 1985). Hollows generally unlined, or lined with wood dust chewed from sides of hollow; extralimitally, *Agapornis* and hanging parrots *Loriculus* (Psittaculini) line hollow with pieces of leaves or bark or both; female carries material in bill or tucked among feathers of rump, flanks or lower back (Abdulali 1964; Ali & Ripley 1969; Forshaw & Cooper 1981). Eggs invariably white but can become stained in nest. Mean size of eggs varies from  $19.5 \times 16.4$  for Little Lorikeet to  $50.5 \times 37.2$  for Kakapo. Extralimitally, smallest egg ( $16.8 \times 13.5$ ) laid by Pygmy Lorikeet *Charmosyna wilhelminae* (Forshaw & Cooper 1981). Loriinae, Nestorinae, Strigopinae, Cyclopsittacini, Ground Parrot and most Psittaculini generally lay small clutches (2–4); a few species of Psittaculini and most Platycercinae generally lay 4–7 eggs, but can lay up to nine. Incubation lasts 18–23 days for most species; up to 25 days for Rainbow Lorikeet *Trichoglossus haematodus*, 26 days for Eclectus Parrot, between 3 and 4 weeks for Kea *Nestor notabilis* and 25–30 days for Kakapo. In all species, female incubates; male usually feeds female at nest or nearby. Young altricial, nidicolous. Most hatch naked and develop whitish to grey down in first few days. Generally, young fed by regurgitation, by female only, or by female for first few days then assisted by male; only male Ground Parrots feed young; male Kakapos play no part in nesting. Young of most species fledge at 5–7 weeks, 7–10 weeks for Rainbow Lorikeet, Kaka and Kakapo, 11–12 weeks for Eclectus Parrot, and 13 weeks for Kea; Ground Parrot has the shortest fledging period, c. 24 days. Fledgelings usually remain with parents for some time (Forshaw & Cooper 1981).

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## Nestor notabilis Kea

COLOUR PLATE FACING PAGE 640

*Nestor notabilis* Gould, 1856, *Proc. Zool. Soc. Lond.* 1856: 941 — Murihiku district, South Island, New Zealand.

The generic term is derived from the name *Psittacus nestor* given to the Kaka by Latham (1790, *Index Orn.* 1: 110) with reference to its grey hoary head; in Greek mythology, Nestor was an old king of Pylos renowned for his sagacity, and present at the siege of Troy. The specific name is Latin for distinguished, remarkable.

**OTHER ENGLISH NAMES** None. Sometimes called Mountain Parrot in early literature.

**MONOTYPIC**

**FIELD IDENTIFICATION** Length 46–50 cm; weight: male 960 g, female 780 g. Large, stocky broad-winged and short-tailed parrot. Similar in shape and proportions to Kaka *Nestor meridionalis* but slightly bigger, with distinctly longer, more tapered and decurved upper mandible. Unmistakable: mostly olive-green with dark scaling, dark-red rump and uppertail-coverts, bold orange-red underwing-coverts, and broken yellow barring on underwing. Sexes differ slightly in shape of bill. Some seasonal variation in colour of bare parts of adult female. Juvenile and immatures separable. **Adult male** Head, neck and underbody, olive, with diffuse darker patch on ear-coverts and dark streaking to cap, malar area and throat that grades into dark scaling over rest of head and neck. Saddle and tertials, olive-green, with obvious dark scaling. Rump and uppertail-coverts, orange-red to dark red, contrasting with rest of upperparts in flight. Uppertail, dark green with diffuse narrow blackish subterminal band. Folded wing mostly as saddle, with blackish folded primaries. In flight, olive-green secondary coverts contrast with secondaries, which grade from slightly brighter green on innermost to green-blue on outermost; outerwing, blackish with diffuse green-blue patch on primary coverts and bases of primaries. Undertail, olive with narrow broken yellow to orange barring and prominent narrow blackish subterminal band. Underwing: most coverts, bright orange-red, with narrow dark leading edge; greater primary coverts and remiges, grey-black, with prominent broken yellow barring across base and, in some, orange-red suffusion at tips of coverts. Bill has long, tapering, strongly decurved upper mandible; dark brown to black. Cere, dark grey-brown. Iris, dark brown. Legs and feet, dark grey. **Adult female** As male except upper mandible shorter (obvious in direct comparison) and curvature may differ (see Sexing). In summer, some also differ in having bright orange-yellow in mouth at gape and at base of lower mandible. **Juvenile** Sexes alike. Very similar to adult. Best distinguished by colour of bare parts: cere, most of lower mandible, orbital and periphthalmic rings, orange-buff to orange-yellow; legs and feet paler, grey to light grey or yellowish grey. Further differ by contrasting paler-yellowish cap and spiny projections to rectrices (the latter lacking in adult and soon lost with wear). **Immatures** Birds in second year resemble adults in plumage but retain pale-yellow cere. Lower mandible and orbital ring: yellow at first darkening in successive years till full adult colour attained. Immatures 3–4 years old retain an incomplete yellow orbital ring but otherwise resemble adult.

**Similar species** Unmistakable if well seen, but beware confusion with **Kaka**; Kea easily distinguished by much greener (cf. olive-brown) coloration; lack of pale areas on head, neck and underbody (Kaka has pale cap, yellowish patch on ear-coverts and crimson hindneck-collar and lower underbody);

and much more slender and tapered upper mandible (cf. rather heavy-billed appearance of Kaka).

Gregarious; usually seen in small groups, though juveniles form flocks of 20–30 birds in autumn. Common inhabitants of alpine and subalpine areas of SI. Can be noisy and conspicuous but often silent when feeding. Bold and inquisitive round human habitation, where freely scavenge for food scraps. Forage on ground but also in trees. Flight strong and direct; often ride updrafts and circle in thermals like a raptor. Main call a loud raucous *kee-aah*, uttered mainly in flight; also utter screeches and variety of softer and conversational notes.

**HABITAT** Based on contribution by K.-J. Wilson and R. Brejaart. Usually montane to alpine habitats, up to 2100 m asl, though uncommon in truly alpine areas; sometimes near sea-level (Jackson 1963; Clarke 1970; Wilson *et al.* 1988; Temple 1996; CSN). Mostly in vegetated areas of moraine, talus or other rocky outcrops on steep slopes: in beech *Nothofagus* forest; temperate rainforest; broadleaf or podocarp forest, vegetated with Totara *Podocarpus totara* and Miro *Podocarpus ferrugineus*, rata *Metrosideros*, Kamahi *Weinmannia racemosa* or *Dracophyllum*; or tall woody subalpine scrub dominated by Toatoa *Phyllocladus glauca*, *Coprosma*, *Dracophyllum*, *Hebe* and *Olearia*; often just above or below tree-line, in subalpine tussock grassland, fellfields, meadows or herbfields (Jackson 1960, 1963; Dawson 1964; Porter & Dawson 1968; Clarke 1970; Child 1975; Guest 1975; Wilkinson & Guest 1977; Wilson 1990; Clout & Hay 1981; Temple 1996; CSN). Only once recorded in logged forest (Onley 1983). Sometimes in open, among grass or scrub on river-flats or banks of creeks (Jackson 1960, 1962, 1969); or in pasture, often near edge of forest (Jackson 1962). Also recorded among grassy tussocks in colonies of Hutton's Shearwaters *Puffinus huttoni* (Harrow 1976; Temple 1996). Very occasionally occur on coastal flats or intertidal areas (CSN 19, 19 Suppl.). Often visit villages, huts, camping grounds, ski-fields, carparks and rubbish tips (Brejaart 1994; R. Brejaart; K.-J. Wilson).

Often breed within forests, often near edge or in clearings. In crevices and natural holes, usually among rocks of moraine, talus or outcrops among trees; rarely in hollow logs or among roots of tree (McCaskill 1954; Jackson 1963; Child 1978; Temple 1996; K.-J. Wilson). Mostly in *Nothofagus* forest, but sometimes in broadleaf forest, rainforest, subalpine scrub or tussock grassland (Jackson 1963; Temple 1996; R. Brejaart; K.-J. Wilson); location probably determined by availability of suitable holes rather than surrounding vegetation or other habitat features (R. Brejaart; K.-J. Wilson). Rarely, nest in hollow in live Rata tree (R. Brejaart; K.-J. Wilson) or at base of standing tree (G.P. Elliott); one nest on ledge of cliff (Jackson

1963). Of 36 nests in Arthurs Pass NP, 32 in Mountain Beech *Nothofagus solandri* forest, one in Westland rainforest, and three in subalpine scrub (Jackson 1963). Said to avoid nesting in cold microclimates, e.g. bottoms of gorges or steep S-facing slopes (Jackson 1963), but have been recorded nesting in these situations (G.P. Elliott).

Feed in all habitats and at all levels, with no obvious preference. Forage in canopy of fruiting or flowering trees or shrubs; also among leaves, shoots or buds at ends of branches; sometimes among understorey in forest; or in clumps of flowering flax, or stunted shrubs in high-altitude meadows (Jackson 1960, 1962; McCann 1963; Clarke 1970; Child 1978; Brejaart 1988; Oliver). Also forage in leaf-litter on floor of forest, or dig up succulent roots from moist or stony soil; also on ground among rocks, or low vegetation, such as grass or herbs, on open river-flats (Jackson 1960, 1962, 1969; Clarke 1970; Brejaart 1988, 1994; Temple 1996; Oliver). Sometimes feed on carrion in pasture, especially near edge of forest (Jackson 1960, 1962). Recorded feeding on ground among grassy tussocks in colonies of shearwaters (Harrow 1976; Temple 1996). Once recorded feeding on seaweed *Homosira* in intertidal zone (CSN 19). Often feed at sites of human activity where food scraps can be scavenged (Jackson 1960, 1969; Clarke 1970; Bond & Diamond 1992; Brejaart 1994; Temple 1996; CSN).

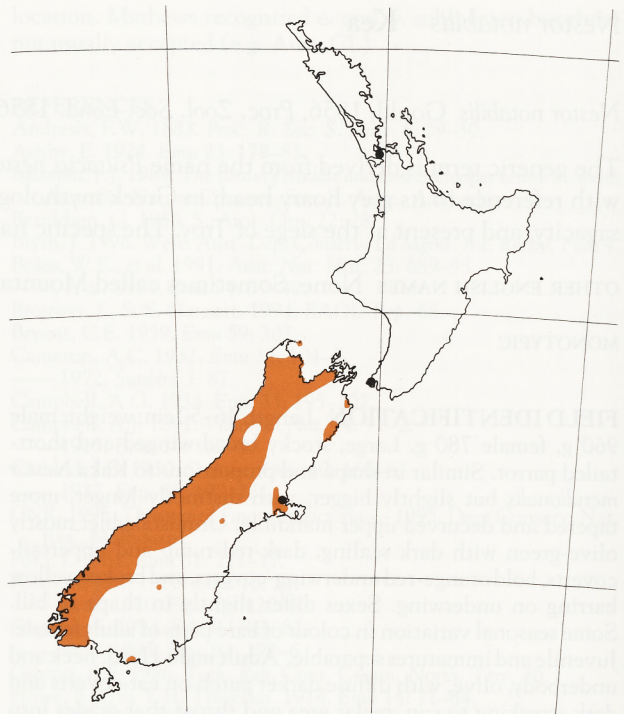
Mostly roost in trees in forest (Jackson 1963; R. Brejaart; K-J. Wilson). During breeding season, non-incubating birds roost on rocks near nest, and may very occasionally shelter in nest-cavity (Jackson 1963). Rarely roost on rocky bluffs (Clarke 1970). Loaf and sunbathe in tree-tops (Jackson 1960, 1963). Often perch on structures and objects, such as roofs and cars (Marriner 1908; Scarlett 1967; Temple 1996); also perch on people or backs of sheep (Jackson 1962; Temple 1996).

Adversely affected by clearance of forest and conversion of montane scrub and tussock grassland to improved pasture for grazing (Jackson 1962; Temple 1996; R. Brejaart; K-J. Wilson).

**DISTRIBUTION AND POPULATION** Endemic to NZ. Mainly confined to SI; vagrant to NI.

**NI** Vagrant to Tararua Ra.: single, unconfirmed, 1942 (Oliver); single, 8 Jan. 1974 (Cunningham 1974); single, 2–3 Mar. 1974 (Cunningham 1974). Records in 1974 may refer to escapes from captivity (Cunningham 1974). Probably resident on NI during Otiran glaciation, >10,000 years ago (Holdaway & Worthy 1993). **SI** Widespread in W, on slopes of Southern Alps and associated ranges, from Nelson and w. Marlborough S to Fiordland in w. Southland (CSN; NZ Atlas). In **MARLBOROUGH** and **CANTERBURY**, scattered mainly in NW and W, E to line from Bull Ra., Mt Richmond State Forest Park, Raglan, Spenser, Mt Somers and Winterslow Ras; also round L. Tekapo and in Ben Ohau Ra. Also farther E in Inland and Seaward Kaikoura Ras; rarely on Kaikoura Pen.; vagrants at Seddon, Waiau, Oxford and on Banks Pen., from Christchurch to L. Ellesmere. Widespread in nw. **OTAGO**, round Ls Hawea and Wanaka; also round w. L. Wakatipu, and sometimes farther E at Queenstown. Absent from e. and s. **SOUTHLAND**, though once recorded at Bluff; also absent on Stewart I. and islands in Foveaux Str. Widespread in Fiordland, W from Ls Poteriteri, Hauroko, Monowai and Te Anau. Widespread in **WEST COAST** and **NELSON**, N to Motueka and Goulard Downs, and rarely farther N at Farewell Spit Lighthouse (Williams 1960; Scarlett 1967; Harrow 1976; Child 1978; Dennison & Robertson 1979; Sherley 1992; Temple 1996; CSN; NZ Atlas).

**Chatham Is** Claim of subfossil records (Oliver) not acceptable (Dawson 1959; Millener 1996).



**Breeding Throughout range.**

**Change in range** Since European settlement, suggested that range has expanded into n. parts of SI, and that population has increased (Marriner 1908; Myers 1924; Oliver). However, range expansion unlikely; Keas probably already inhabited nw. Nelson before 1870s, and increased number of records probably reflected increased number of observers, combined with effect of bounties stimulating reports (Brejaart 1988; Holdaway & Worthy 1993).

**Status** Threatened (Grant 1993); category B threatened species (Molloy & Davis 1994). **Populations** Total population roughly estimated at 1000–5000 individuals (Anderson 1986). Population at Haplin Ck, Arthurs Pass NP, 1989–91, estimated at 88–119 birds, at density of 0.018–0.040 birds/ha (Bond & Diamond 1992); in 1956, population at Temple Basin, Arthurs Pass NP, estimated at 218±40, at density of 0.032 birds/ha (Jackson 1960). At Cupola Basin, Nelson Lakes NP, 1964–66, population density estimated at 0.062 adults (+juveniles)/ha (Clarke 1970).

First reported killing sheep in late 1860s (Benham 1907; Marriner 1908; Jackson 1962; Temple 1996; Oliver), mostly sheep trapped by snow, or sick or injured animals; also feed on dead sheep (Jackson 1962). In c. 1870, bounty placed on Keas, varying from two shillings and sixpence to £1; till 1970, when bounty removed, c. 150,000 Keas had been killed, mostly by shooting or poisoning; sometimes killed with sticks (Marriner 1908; Jackson 1962; Temple 1996). In one 8-year period, c. 29,000 bounties paid; between 1898 and 1929, bounties paid on 54,204 birds (Temple 1996; Oliver). Birds sometimes attracted to hunters by decoys (tethered or in cages), whistles or brightly coloured cloth (Marriner 1908; Temple 1996); a single hunter shot 400 Keas one winter, and up to 67 birds in single night (Temple 1996). After 1970, granted partial protection, but farmers were allowed to shoot Keas known to cause damage; fully protected since 1986 (Temple 1996). Once shot because thought to have been killing racing pigeons (CSN 19). Often

attracted to sites of human activity, and often damage property, vehicles and dwellings; sometimes killed by electrocution, motor vehicles, choking on plastic, poisoning by chewing 'leadhead' nails, or drowning in water tanks (Kinsky 1957; Jackson 1969; Grant 1993; Brejaart 1994; Temple 1996; CSN 19 Suppl., 23, 24). Sometimes illegally poached and smuggled for aviculture (Hutching 1990; Temple 1996). Formerly eaten by desperate pioneers (Temple 1996). Possibly adversely affected by competition with introduced herbivores (Child 1978; R. Brejaart; K-J. Wilson); also killed by introduced Stoats *Mustella erminea* (R. Brejaart; G.P. Elliot; K-J. Wilson; *contra* Jackson 1969).

**MOVEMENTS** Based on contribution by K-J. Wilson and R. Brejaart. Resident; probably occupy overlapping home-ranges (Brejaart 1994). Much information from banding studies. At least some remain in area where banded, though commonly move up to 10 km and some farther; maximum displacement of banded bird, 98 km (see Banding and Radio-tracking). Altitudinal movements occur, possibly in response to snow cover, weather conditions, availability of food or all these (Hutton & Drummond 1904; Jackson 1960, 1962; Clarke 1970; Brejaart 1988, 1994). Also congregate to exploit seasonal sources of food, such as nectar from *Phormium* or Southern Rata *Metrosideros umbellata* (J. Beggs; R. Brejaart). Recorded flying from mountain to mountain (Oliver).

At Mt Cook, known breeding males seldom moved more than 1.5 km from nest, while presumed non-breeding males had core areas covering 6 km of valley, but were commonly sighted farther afield (Wilson 1990). In Nelson Ls area, breeding birds sighted between 6 and 15 km from nests (G.P. Elliott). Scavenging groups (mainly males) visit villages, ski-fields and refuse dumps within their range (Bond & Diamond 1992; Wilson & Brejaart 1992; Brejaart 1994). Might move considerable distances to flocking areas, e.g. during winter birds came to Arthurs Pass Village from 13–24 km away (Jackson 1960). Frequency with which individuals used rubbish dump at Arthurs Pass varied greatly, some being seen almost every day while others seen only once (Bond & Diamond 1992; M. Jarrett).

**Altitudinal movements** At Nelson Lakes NP, observed in alpine grassland and shrub communities (1220–1370 m asl) throughout spring and summer when food most plentiful at these altitudes; in autumn, fed on berries at 1525–1830 m asl, perhaps reflecting later flowering or fruiting of plants at higher altitudes (Clark 1970). At Craigieburn, fed almost exclusively in tussock grasslands and alpine herbfields in spring; used these communities less through summer and autumn, and fed almost exclusively in montane forest in winter (Brejaart 1988). Said to descend to gullies in winter (Moncrieff Undated). Often almost reach sea-level along w. coast at times of heavy snowfall on hills (NZCL); said to reach coast in Nelson and Westland in winter (Marshall *et al.* 1975); also seen at sea-level close to coast in summer at Westland and once in Fiordland (K-J. Wilson). Said that in storms or heavy and extensive snowfall wander 20–30 km beyond normal range (NZRD).

**Dispersal of young** Five of nine colour-banded fledgelings that were seen 2.5–13.75 km from their natal area during first 6 months after fledging were later resighted near their nest-site (Wilson & Brejaart 1992). One seen at sites 15 km apart on same day (Wilson 1990). Banded juveniles recorded 13.5 km from their banding site in Fiordland (Campbell 1976), and two juveniles resighted c. 15 and c. 17.5 km from their natal area in Nelson Lakes NP (Clarke 1970). A fledgeling banded at Fox Glacier, Westland, resighted 7 months later at Mt Cook on

other side of main divide (Wilson & Brejaart 1992). Wilson & Brejaart (1992) suggested that dispersal appears to be most common in birds 12–18 months old, but little evidence.

Of 137 banded at Craigieburn and Arthurs Pass, over 58 months, 54 (37.4%) were resighted during last 12 months of that period (Brejaart 1994). Females were far less likely to be resighted than males, but no significant difference between probability of sighting adults and non-adults. Thirty-two were resighted at banding location only, 20 were resighted up to 10 km from banding site, two were seen 20 km from banding site, and one seen 60 km from banding site. Some banded during study were resighted by other observers; most of these resightings were <12.5 km from place of banding, three moved 20 km, one moved 33 km, four moved 60 km, and one moved 98 km. By end of 58-month banding period, 35 (25.5%) had not been resighted since banding (Brejaart 1994).

During study at refuse dump at Arthurs Pass (20 days in each of three consecutive summers) 76.9% of adult males, 80% of subadult males, 7.7% of male fledgelings and juveniles, and 66.7% of female fledgelings and juveniles banded at dump were resighted there at least once in following 2 years. Others commonly seen at dump had been banded up to 8.4 km away (Bond & Diamond 1992).

**Banding and radio-tracking** Of 24 banded at Cupola Basin, Nelson Lakes NP, between June 1964 and July 1966 (Clarke 1970), six resident in Basin were seen often; others recorded moving from 4.5 to 20 km from Cupola Basin, with 2–15 months between banding and resighting (though time not known for some); most moved to S or NE.

At Mt Cook, radio-tagged birds recorded moving between 2.5 and 13 km; banded birds commonly sighted 10 km from previous sightings; greatest distance between sightings 25 km (Wilson 1990; K-J. Wilson). At Arthurs Pass, flights of 5 km in one day were common; longer movements ranged from 19 to 37 km, with most of these sightings more than 1 month apart; once, 6 days between resightings 22 km apart (Jackson 1960).

**FOOD** Account prepared by R. Brejaart and K-J. Wilson. Omnivorous but mainly herbivorous. Take roots, seeds, leaves, stems and flowers. In separate studies, plant material comprised 70% (Brejaart 1988), 75% (Clarke 1970) and 96% (Campbell 1976) of diet. **Behaviour** Forage at all levels, from ground to canopy. In forested areas, dig on downhill side of logs and rocks and under loose materials. During spring and early summer at Craigieburn consistently fed along interface of snow and tussock, mostly on downhill side of snow patches where they probed in freshly exposed soil. When feeding in trees, feed mostly in canopy; glide, climb or fly from site to site. When foraging in alpine tussock grasslands and herbfields, either feed on ground or on vegetation they are eating (Brejaart 1988). **SIZE OF FORAGING GROUPS:** Feed alone, in pairs or in small groups of up to ten. Juveniles seldom feed alone and, except in dumps and villages, size of groups appears unrelated to sex (Brejaart 1988; R. Brejaart; K-J. Wilson). Foraging congregations at Arthurs Pass refuse dump were mostly composed of males (90% of groups were male) (Diamond & Bond 1991; Bond & Diamond 1992); similar trends observed in Mt Cook Village (K-J. Wilson) and Arthurs Pass Village (Brejaart 1994). Family groups including females commonly sighted at Craigieburn Valley (Brejaart 1994). When feeding in groups, not all feed at same time (Campbell 1976). Distance between feeding birds varies; seen feeding up to 20 m apart in tussock grasslands or alpine herbfields, or within 30 cm of each other on ground in forest (Brejaart 1988). **AGE-RELATED BEHAVIOUR:** In study of

foraging behaviour in refuse dump at Arthurs Pass, characteristic differences in foraging ability between four age-classes (fledgelings, juveniles, subadults and adults): adults did most excavating that uncovered new food; fledgelings explored and manipulated objects almost continuously, but discovered little food and were commonly fed by adults; juveniles had highest foraging yields for time spent searching, but this aided by appeasement behaviour that gave them preferential access to food discovered by adults; subadults fed mainly by kleptoparasitism, and were otherwise poor at discovering and retaining food (Diamond & Bond 1991). Observations in captivity show that Kea take a long time to learn foraging behaviours and to forage efficiently (Zeigler 1975). Fledgelings inefficient foragers (e.g. taking 3–4 times as long as 1-year-old birds to excavate roots) and wasteful (e.g. pulling out more than they eat, dropping berries) (Campbell 1976). Fledgelings observed to follow, watch and copy subadults and adults and to pick up foods sampled or rejected by older birds (Campbell 1976; Brejaart 1988). At Arthurs Pass, fledgeling males spent more time searching for food (30%) and less time feeding (11%) than subadult (27% searching, 24% feeding) or adult males (25% searching, 29% feeding) (Diamond & Bond 1991). Also at Arthurs Pass, feed mostly on artificial foods; spend less time foraging and more time feeding than at Craigieburn Valley where feed on naturally occurring foods (Brejaart 1994; R. Brejaart; K-J. Wilson). **FORAGING TIMES:** At refuse dump at Arthurs Pass, peaks of foraging activity of males 1–2 h after dawn and 1–2 h before dusk (Diamond & Bond 1991). At Craigieburn, activity peaked mid-morning (Brejaart 1994). At Routeburn Basin, Fiordland, nearly 70% of active hours during winter spent feeding; prolonged heavy rain, light snowfalls, winds up to 15–20 knots and very low temperatures adversely affected ability to find food (Campbell 1976). **SEARCH BEHAVIOUR:** Search for food with slow movements; walk, hop, climb, glide, fly, fly-hop, run and skip (Diamond & Bond 1991; A.B. Bond; R. Brejaart; J. Diamond). Use bill to investigate possible foods, and carry food items in one foot (Diamond & Bond 1991). In addition, manipulate objects, dig, tear and pull (R. Brejaart). **FEEDING ON GROUND:** When searching for invertebrates in soil, dig, probe and rake with feet (once seen raking with bill) (Campbell 1976; Brejaart 1988; Diamond & Bond 1991). At Craigieburn, use feet and bill to remove up to 2 cm of leaf-litter, moss, roots and soil from areas up to 10 × 20 cm; also turned over stones, moss, twigs and bark to expose soil, and then dug holes 3–5 cm deep in exposed soil looking for food (Brejaart 1988; R. Brejaart); dig holes up to 15 cm deep in alpine herbfields (Campbell 1976). Seek out moist soil to probe and dig (Clark 1970; Campbell 1976) and excavate dead or rotting wood to search for invertebrates (R. Brejaart). **FEEDING ARBOREALLY IN TREES AND SHRUBS:** Glean and probe while perched. When taking nectar from Mountain Flax *Phormium colensoi*, perch on ground or flower-stalk and reach for flowers, or use feet to grasp flower-stalk to bring flowers within reach of bill (R. Brejaart). When taking nectar from flowers of Southern Rata *Metrosideros umbellata*, move through canopy, pecking and pulling at flowers, virtually destroying them in process (R. Brejaart). When searching for *Astelia* plants, land in tussock grassland or herbfield, usually on a ridge or rise, then hop about till plant sighted, then hop or glide straight to it and feed on fruit (Campbell 1976). **FOOD-HANDLING:** Use bill to snip and tear leaves off plants, to bend back blades of tussock grasses to get to middle of clump, and to scrape soft parts of leaves. Uproot plants and shake soil off roots mostly using bill. Chew, nibble, rasp and scrape foods before swallowing. Sometimes food im-

paled on upper mandible and held there with lower mandible, which is scraped up and down against food (Potts 1969). Use tongue to roll soft food, such as berries or pith of stems, round in bill before swallowing it (Jackson 1960; R. Brejaart). Use feet to grasp and lift food to bill; to hold food on ground while pecking, nibbling or tearing at it with bill; or to scratch soil before probing (Campbell 1976; Brejaart 1988; Diamond & Bond 1991). **DRINKING:** Drink by ladling water with lower mandible and swallow by lifting head (Keller 1976; Brejaart 1988; Diamond & Bond 1991), or by dipping partly open bill in water and quickly moving tongue up and down (lapping), drawing in water (Potts 1969). Observed to dunk food in water before eating it, in wild (Diamond & Bond 1991; R. Brejaart) and captivity (Potts 1969; Keller 1976). **ADAPTATIONS FOR FEEDING:** Culmen elongated, which permits excavation or removal of obstructions when in search of food. Shape of bill suggests that Kea feed on softer food (pulp of fruit, soft-bodied animal foods); hard stones of fruit rejected (McCann 1963). To fragment food, grind sharp edge of lower mandible against horny plate on inside of maxilla (Campbell 1976). The inside tip of maxilla has only weak grooves (or fluting), so seeds, kernels or nuts cannot be husked or cracked efficiently (Hombberger & Ziswiller 1972). Use feet to: (1) grasp objects and lift them to bill (all weight placed on one foot, tail used to steady body); (2) clamp objects to ground (clamping leg resting on tibia or tibiotarsal joint) while using bill to tear or nibble (Campbell 1976); (3) clasp branchlets while climbing or reaching for foods. When climbing, bill used for locomotion and balance (Campbell 1976; R. Brejaart). Tongue is narrow and muscular; used to hold food against maxilla palate while it is being shredded (Campbell 1976). Minute hairs at tip of tongue allow feeding on nectar and sap from trunks and branches (McCann 1963) and trapping of juice and juicy parts while eating fruits (McCann 1964). Tongue not specialized, consistent with diversity of food eaten.

**Detailed studies** In CUPOLA BASIN, NELSON LAKES NP (201 items observed eaten; Clarke 1970): **Plants** GYMNOSPERMS: Podocarpaceae: *Podocarpus nivalis* fru. 4.5% of total no. of items. MONOCOTYLEDONS: Juncaceae: *Luzula campestris* 0.5 fl.; Liliaceae: *Astelia nervosa* 2.0 fru., sds. DICOTYLEDONS: Asteraceae: *Celmisia coriacea* 7.5 roots, fl.; *C. discolor* 1.0 fl.; *C. spectabilis* 1.0 fl.; *Cotula pyrethrifolia* 1.0 fl.; *Gnaphalium traversii* 0.5 lvs; *Haastia pulvinaris* 5.0 fl.; *Lagenophora petiolata* 0.5 lvs; Brassicaceae: *Notothlaspi australe* 0.5 roots; Epacridaceae: *Cyathoides colensoi* 1.5 fru.; *C. fraseri* 1.5 fru.; *Pentachondra pumila* 3.0 fru.; Ericaceae: *Gaultheria depressa* 1.0 fru.; Fagaceae: *Nothofagus solandri* var. *cliffortioides* 4.0 lvs; Gentianaceae: *Gentiana bellidifolia* 3.0 lvs, fl.; *G. patula* 1.5 fl.; *G. spenceri* 1.0 lvs, fl.; Pittosporaceae: *Pittosporum anomalum* 0.5 sds; Plantaginaceae: *Plantago raoulia* 0.5 sds; Polygonaceae: *Muehlenbeckia axillaris* 3.0 fru.; Ranunculaceae: *Ranunculus insignis* 3.0 entire plant; Rubiaceae: *Coprosma perpissilla* 0.5 fru.; *C. pseudocuneata* 34.0 fru.; *C. serrulata* 3.0 fru.; Schrophulariaceae: *Euphrasia zelandia* 0.5 lvs; *Hebe ciliolata* 0.5 sds; *H. pauciramosa* 1.0 lvs; *H. vermicosa* 2.0 lvs; *Ourisia caespitosa* 0.5 entire plant; *O. macrophylla* 1.0 entire plant; *O. sessifolia* 0.5 entire plant; Thymelaceae: *Pimela oreophila* 0.5 sds; Umbelliferae: *Aciphylla colensoi* 2.0 sds; *A. ferox* 0.5 sds; *A. monroi* 1.0 sds; *Anisotome aromatica* 1.0 entire plant; *A. pilifera* 0.5 roots; *Gingidium montanum* 1.0 roots. **Animals** INSECTS: Unident. larvae 3.5; *Brachaspis collinus* 1.0.

ROUTE BURN BASIN, FIORDLAND (156 items observed eaten; Campbell 1976): **Plants** GYMNOSPERMS: Podocarpaceae: *Podocarpus nivalis* fru. 3.8% no. of items. MONOCOTYLEDONS:

Liliaceae: *Astelia nivicola* 8.3 fru.; Poaceae: *Poa* 1.5 roots, stems. DICOTYLEDONS: Asteraceae: *Celmisia* 2.5 roots, stems; *C. coriacea* 1.2 roots, stems; *C. du rietzi* 12.2 roots, stems; Fagaceae: *Nothofagus solandri* var. *cliffortioides* 36.5 lvs, buds; Gentianaceae: *Gentiana* 0.6 roots, stems; *G. montana* 1.2 roots, stems; Ranunculaceae: *Ranunculus insignis* 0.6 roots, stems; *R. lapaceus* 10.7 roots, stems, lvs, buds; Rubiaceae: *Coprosma cheesemani* 3.2 fru.; *C. depressa* 3.7 fru.; *C. perpisilla* 0.6 fru.; *C. pseudocuneata* 0.6 fru.; *C. serrulata* 7.6 fru.; Scrophulariaceae: *Hebe* 1.3 roots, stems; Umbelliferae: *Aciphylla* 0.6 sds. **Animals** INSECTS: 3.0.

At CRAIGIEBURN VALLEY (54 min obs.; Brejaart 1988): **Plants** GYMNOSPERMS: Podocarpaceae: *Podocarpus nivalis* fru. 1.8% of total obs. time. DICOTYLEDONS: Asteraceae: *Celmisia* 5.5 stem pith; *C. hieracifolia* 27.7 stem pith; *C. lyallii* 3.7 stem pith; *C. viscosa* 7.4 lvs; *C. viscosa* 13.0 lvs, stem pith; Epacridaceae: *Dracophyllum pronum* 3.7 fl.; Fagaceae: *Nothofagus solandri* var. *cliffortioides* 37.0 sds. **Animals** INSECTS: Unident. larvae 3.7.

**Other records** **Plants** Seeds<sup>3,4,6,8</sup>; lichen-moss<sup>4</sup>. GYMNO-SPERMS: Podocarpaceae: *Podocarpus nivalis* fru., sds<sup>9,10</sup>. MONOCOTYLEDONS: Agavaceae: *Phormium colensoi* nectar<sup>9</sup>; Liliaceae: *Astelia nervosa* sds<sup>4</sup>; *Bulbinella gibbsii*<sup>10</sup>. DICOTYLEDONS: Apiaceae: *Anisotome haastii*<sup>10</sup>; Asteraceae: *Celmisia* sds, lvs, roots, stems, fl.<sup>9</sup>; *C. coriacea*<sup>10</sup>; *Leucogenes grandiceps*<sup>10</sup>; Epacridaceae: *Cyathoides* lvs<sup>4</sup>; Ericaceae: *Gaultheria* lvs<sup>4</sup>; *G. crassa*<sup>10</sup>; Fagaceae: *Nothofagus solandri* var. *cliffortioides* lvs, shoots, fl., nectar, sds<sup>9,10</sup>; Gentianaceae: *Gentiana bellidifolia*<sup>10</sup>; Lobeliaceae: *Pratia* sds<sup>4</sup>; Myrtaceae: *Metrosideros umbellata* nectar<sup>9</sup>; Ranunculaceae: *Ranunculus enusii*<sup>10</sup>; *R. lyallii*<sup>10</sup>; *R. sericophyllus*<sup>10</sup>; Rubiaceae: *Coprosma*<sup>4</sup>, fru.<sup>13</sup>; *C. cheesemani*<sup>10</sup>; *C. depressa*<sup>4,10</sup>; *C. pseudocuneata*<sup>4</sup>; *C. serrulata*<sup>4</sup>; Umbelliferae: *Aciphylla* lvs, roots, sds<sup>9</sup>. **Animals** INSECTS<sup>4,7</sup>. BIRDS: Hutton's Shearwater eggs, chicks<sup>5,10</sup>. MAMMALS: Sheep<sup>1,2,10</sup>. Fatty food scraps<sup>4,8</sup>. CARRION<sup>11,12</sup>.

REFERENCES: <sup>1</sup>Marriner 1908; <sup>2</sup>Aspinall 1967; <sup>3</sup>Clarke 1970; <sup>4</sup>Campbell 1976; <sup>5</sup>Harrow 1976; <sup>6</sup>O'Donnell & Dilks 1986; Brejaart <sup>7</sup>1988, <sup>8</sup>1994; <sup>9</sup>Wilson & Brejaart 1992; <sup>10</sup>Temple 1996; <sup>11</sup>CSN 21; <sup>12</sup>R. Brejaart; <sup>13</sup>K-J. Wilson.

**SOCIAL ORGANIZATION** Account prepared by K-J. Wilson and G.P. Elliott. Gregarious; form groups of 2–20+; at Arthurs Pass, mean size of groups 1.9 (1–9) and at Craigieburn, 3 (1–21). Most commonly seen singly or in pairs; often in small groups of 3–6; and infrequently in larger groups of 7–10+, except at sites of human occupation, such as ski-fields and rubbish tips, where 10–20+ common (Brejaart 1994). Individuals move between flocks. At any location, numbers vary widely as visiting birds come and go (Clarke 1970). Congregate at seasonally available sources of food, such as nectar (J. Beggs; R. Brejaart). Flocks near human development composed mainly of males of all ages; elsewhere sex-ratio in flocks approximately equal (Wilson & Brejaart 1992; K-J. Wilson & R. Brejaart). Young males appear to remain in flocks till first breed at 3 or more years old; young females remain in flocks only during first year. Flocks are mobile, and older males join them when flocks are within their home-range but remain behind when flock moves on. Pairs with fledgelings sometimes form flocks (Bond & Diamond 1992; Wilson & Brejaart 1992; Brejaart 1994; G.P. Elliott). Suggested that immatures more gregarious than adults (Clarke 1970; Campbell 1976). Frequency with which individuals used dump at Arthurs Pass varied greatly, some being seen almost every day, others only once (Bond & Diamond 1992; M. Jarrett). Wilson & Brejaart (1992) suggested dispersal

of juveniles from natal site appears most common in birds 12–18 months old, but little evidence. Five of nine birds seen 2.5–13.75 km from natal area within 6 months of fledging, later resighted near natal site (Wilson & Brejaart 1992); one of these seen at sites 15 km apart on same day (Wilson 1990; see Movements for other details).

**Bonds** Thought to be monogamous with long-term pair-bonds, but no long-term studies to confirm this; of three pairs observed in consecutive years at Mt Cook, all remained intact (Wilson 1990; Wilson & Brejaart 1992; G.P. Elliott; K-J. Wilson). Previously suggested to be polygamous (Jackson 1960, 1963), but no evidence for this. Age of first pairing not known, but only birds >3 years old breed. Appears to be high proportion of non-breeding adults in population. Paired and unpaired birds, both adult and immature, seen socialising near established nesting sites (Jackson 1960; Wilson 1990) and unpaired adults of both sexes occasionally seen to enter nests. Relationship to nesting pair of adults and immatures seen near nests not known. Neither paired nor unpaired birds ever seen to give parental care at nest or to fledged young; status of paired birds socializing at nest-site not known. Extra-pair courtship seen but not extra-pair copulation (K-J. Wilson). **Parental care** Little studied; preliminary observations (Jackson 1963; Wilson 1990; K-J. Wilson & G.P. Elliott) suggest that female incubates and broods for first few weeks after chicks hatch; female fed by male during incubation and brooding, near nest (also see Breeding). For rest of nestling period, both parents gather food for chicks but only female feeds them, male feeding female close to nest. One male seen entering nest and claimed to feed both incubating female and older nestlings (Jackson 1963). After chicks fledge, pair shares parental care almost equally (Wilson 1990; G.P. Elliott; K-J. Wilson; *contra* Jackson 1963). Young remain with parents at least 4–6 weeks after fledging (Jackson 1963), up to 8 weeks (G.P. Elliott).

**Breeding dispersion** Nest solitarily. At Mt Cook NP, known nests at least 1 km apart (Wilson & Brejaart 1992). At Nelson Ls, closest known nests 800 m apart (G.P. Elliott). Thought not to be territorial (Wilson 1990; Wilson & Brejaart 1992), despite early suggestions to contrary (Jackson 1960, 1963). Nests re-used in subsequent, but not always successive, years; three pairs at Mt Cook (K-J. Wilson) and six pairs at Nelson Ls (G.P. Elliott) used same or nearby nest for 3 consecutive years. At Nelson Lakes NP, pairs mostly solitary and sedentary, remaining within few kilometres of nest-site year-round; adult males sometimes join flocks of unpaired adult males at feeding sites, but breeding females rarely leave vicinity of nests (G.P. Elliott). At Mt Cook, known breeding males rarely moved >1.5 km from nest; presumed non-breeding males had linear core areas covering 6 km of valley but were commonly sighted farther afield (Wilson 1990). In Nelson Ls area, breeding birds sighted 6–15 km from nests (G.P. Elliott).

**SOCIAL BEHAVIOUR** Account prepared by R. Brejaart. Well known. Studied in wild at Arthurs Pass (Diamond & Bond 1991) and in captivity (Keller 1975, 1976; Ziegler 1975; Zander 1976; Potts 1969, 1976, 1977; Kubat 1990). Readily observed at human refuse dumps but, as mostly males present at such sites (see above), behaviour mostly consists of feeding, comfort behaviour and playing with objects (see below). Away from human habitation, can be difficult to observe and breeding sites difficult to get to. Often noisy in flight or on ground when in flocks; lone birds generally silent while feeding, but will call to Keas flying overhead (Brejaart 1988, 1994; Wilson 1990; Wilson & Brejaart 1992; K-J. Wilson). Vocal communication well

developed (see Voice). **Comfort behaviour** Described in captivity and wild; all behaviours seen in captivity occur in wild (Jackson 1963; Potts 1969, 1975, 1976; Keller 1975, 1976; Zeigler 1975; Campbell 1976; Brejaart 1988; Diamond & Bond 1989; J. Diamond & A.B. Bond). Usually performed during periods of rest in bouts of two or more movements rather than isolated events. **HEAD-SHAKE**: Shake head from side to side, several times, usually within 1–3 s; intensity varies; bill sometimes partly open. Often follows sneezing, drinking or feeding; used to clean bill. **BODY-SHAKE**: Fluff entire plumage then twist body sharply from side to side; probably used to rearrange or clean feathers. **FLUFF**: Briefly raise feathers of most of body; not accompanied by lateral movement of Body-shake. **TAIL-WAG**: Shake tail, which is sometimes slightly fanned, from side to side; repeated several times in 3–5 s; often occurs after Body-shake. Appears to be used to rearrange feathers of tail. **WING-AND LEG-STRETCH**: Extend wing and leg on same side, downward and backward from body, while fanning tail to same side; often performed after long periods of inactivity; lasts c. 5 s. **BOTH-WINGS STRETCH**: Raise both wings, slightly bent at carpal joints, over back till wing-tips come close together; held for several seconds, then wings folded; sometimes accompanies defecation. **JAW-STRETCH**: Hold mandibles wide open for several seconds as if yawning; possible response to inactivity, internal irritation or tense neck and head from vigorous scratching. **OVER-WING HEAD-SCRATCH**: Bring one leg behind and over lowered wing and use longest claw to scratch neck and head. **UNDER-WING HEAD-SCRATCH**: Pull leg forward under wing to scratch head. **BILL-WIPE**: Rub bill against solid surface, first on one side, then other; sometimes raise one foot and hold bill between two toes and draw foot directly down bill; nearly always follows feeding, sometimes drinking. Sometimes repeatedly rub head and throat against branch instead of scratching. **BILL-GRINDING**: Rasp lower mandible against upper, as if chewing, but without food. **CHEEK-RUB**: Lower head to branch or other object and rub side of head against it, starting toward base of bill and moving toward back of head; rub one side of face, then other. **FOOT-AND-LEG NIBBLE**: Stand on one leg and bring other up to bill to nibble at it; sometimes lower bill to foot or leg instead. **PREENING**: Occurs as short isolated event (e.g. preening of breast during pause in feeding), or for extended periods, usually following feeding or bathing; sometimes preceded by slight ruffling of plumage, which allows individual feathers to be grasped and preened. Draw longer feathers of wings and tail upward through bill while simultaneously nibbling them. **DEFECATION**: When perched, often preceded by Both-wing Stretch; before wings brought back to rest, tail raised slightly as bird defecates. When on ground, often walk stiffly backward for several metres before suddenly stopping and simultaneously raising tail and defecating. **PANTING**: Open bill to maximum extent and flutter throat; possible thermoregulatory behaviour. **Bathing** Observed in captivity (Potts 1969, 1976); in wild, seen bathing in puddles (G.P. Elliott). **HEAD-DIPPING**: Normally occurs first when bathing; stand in or at edge of water and immerse bill and part of head; then lift head and flick it sideways to direct water onto back. **WING-THRASHING**: Beat both wings in water, more or less simultaneously; often forceful and rapid and bird tends to spring up as it beats wings. Often crouch in water and, shaking, splash water onto exposed parts of body. Bathing sessions last 1–5 min during which leave water 2–3 times to Head-shake, Body-shake and Tail-wag before re-entering water. **Play** Described in captivity (Potts 1969; Keller 1975; Zander 1976; A.B. Bond & J. Diamond) and wild (Diamond & Bond 1991; Brejaart 1994; R. Brejaart); anecdotal

accounts common, e.g. seen sliding down snowy slopes, roofs of huts and windscreens of cars (Temple 1996; R. Brejaart). Play alone or in groups, with and without natural or anthropogenic objects. Manipulation of objects associated with exploration and exploitation of resources considered part of learning process of young; novelty and oddity suggested to determine attractiveness of objects (Diamond & Bond 1991, Kubat 1990). **CHEWING**: Hold object in bill, often steadied by tongue, and chew with lower mandible. **PECKING**: Peck at objects; will hold objects down with foot. **PULL-TEAR**: Grab object with bill, plant both feet on ground, with hallux flexed, and pull object toward bird. If object held down with foot and held with bill, quickly jerk head upward to tear object. **PRY**: Draw maxilla over a surface and, when tip catches in a crevice, pull and twist to enlarge opening and break off pieces of object. **THROWING (TOSS UP)**: Hold object in bill and jerk head vertically, tossing object into air; sometimes accompanied by hop or flap of wings just before object released; can be repeated for several minutes. Seen tossing pebbles and pieces of twigs high up in air, rolling pebbles down hills, and dropping walkers' mugs from great heights (Temple 1996; R. Brejaart). **RUMMAGE**: Pick up object with bill and, with quick lateral movement of head, fling it away. **CARRY**: Carry object in bill while walking or running, or in feet while flying. **ROLL**: Bend forward and push round objects with head, running or hopping after them and repeating actions for several minutes. **FUN FIGHTING**: Includes Bill-gaping, Clawing, Pecking, Turning Toward, Sidling, Chasing, Wing-flapping and Wing-holding (see below), but at low intensity (Potts 1969). Juveniles and immatures in such fights will roll down slopes together (R. Brejaart). Juvenile observed lying on back with another bird >1 year old jumping on top, kicking with feet in the air (Temple 1996; R. Brejaart). **ACROBATICS**: Similar to behaviour described for Galahs *Eolophus roseicapillus* by Rowley (1990); fledgelings and immatures hang upside down, swinging back and forth, from branches or rope and flapping wings to rotate, often while uttering squealing or warbling calls (Brejaart 1994). **PLAYING WITH MIRROR IMAGE**: Observed in captivity; examine reflection and touch it with bill; perform submissive displays and other non-aggressive displays (Diamond & Bond 1989). In wild, move up and down, out of sight and back again, touching reflection with bill and calling (Brejaart 1994). **Aerial activity** Does occur but not described.

**Agonistic behaviour** Based mainly on captive studies by Potts (1969, 1977) with additional information from J. Diamond & A.B. Bond. All behaviours except Wing-hitting and Bill-lock observed in wild (R. Brejaart). Hunching, Chasing and Run-rush threats and aggressive calling observed in wild, mainly in defence of food; no body-contact occurred between adults, but juveniles often did make contact with pecks, lunges, pushing and clawing (Campbell 1976). **Threat displays** **TURN-TOWARD**: Faces opponent, who may flee. **RUN-RUSH**: With head lowered and body held almost parallel to substrate, aggressor walks rapidly toward opponent; often accompanied by Bill-gaping; if very aggressive, holds wings slightly or straight out from body. **LUNGEING AND PECKING**: Sharply thrusts head toward feet, legs, bill or head of opponent; usually accompanied by Bill-gaping. If opponent fails to retreat, lunge can be followed by pecking, and this usually causes opponent to flee. Often gives rasping call, indicative of high level of aggression, before or after Lungeing or Run-rush. Brejaart (1988) observed Lungeing used to displace others at food. **SHORT PECK**: Quickly thrusts closed bill into feathers of opponent. **BITE**: Grasps opponent with bill, particularly its feet and legs. **BILL-LOCK**: Opponents grab bill of each other and pull, twist and push,

using weight of body and head for leverage. **CLAWING:** Occurs when birds perched close together; aggressor sidles toward opponent, turns partly toward it, raises a claw and strikes out sideways in pushing motion. Clawed bird may respond by walking or sidling away, usually slowly. Probably used to maintain individual distance. In fighting, more intensive Clawing occurs, often together with Pecking or Bill-gaping; bird usually confronts opponent head-on and raises claw and strikes out in pushing or swiping motion. **BILL-GAPING:** Holds bill open for several seconds while turning toward opponent; apparently indicates readiness to bite; often performed in association with, or in response to, Lungeing or Run-rush. **CHASING:** Less stereotyped than Run-rush; usually occurs when opponent fleeing; can be accompanied by Lungeing and Bill-gaping. **CROUCHING:** Lowers body so breast almost touches ground, spreads legs, extends head forward, raises and holds wings slightly away from body. Often associated with Bill-gaping and Pecking. Can precede Lungeing; stance often held by two opponents, neither of which appears to be dominant. **WING-HITTING:** Sometimes performed by subordinates in response to continuing attacks or pursuit by one or more aggressors, if adoption of submissive hunched posture does not completely reduce attack. If approached from side-on, suddenly flicks wing straight out from body and strikes; if approached from front, flicks wing slightly forward while simultaneously twisting body so that opponent struck with completely extended wing, thus increasing range of strike and force of impact. Usually accompanied by Bill-gaping and sleeking of plumage. **WING-HOLD: CARPAL HOLD:** Holds wings in normal position but with carpal joints held slightly away from body, exposing red underwing; associated with Run-rush (R. Brejaart; K-J Wilson). **WING HOLD: OPEN HOLD:** While facing opponent, unfolds and holds wings straight out from body or over back, exposing red underwing; indicates strong motivation to attack; can precede Lungeing, Pecking or Run-rush; sometimes associated with Bill-gaping; often develops into Wing-flapping. **WING-FLAPPING:** Flaps wings rapidly and powerfully; characteristic of high-intensity aggression; often associated with fighting, as aggressor pecks and beats wings against opponent. Opponents can face each other and jump up and down while flapping. Also performed as intimidatory display: opens and flaps wings several times, as if flying, with legs stretched and body held almost vertical, exposing red underwing. **REDIRECTED AGGRESSION:** When fleeing from aggressor, sometimes attacks others, usually with Lungeing, Pecking and Bill-gaping. **Appraisal displays SIDLING:** Sideways movement; in agonistic context often appears to indicate ambivalence between attacking and fleeing. **HUNCHING:** Sometimes adopted when pursued; fluffs feathers of rump and fans tail; lifts innerwing slightly away and up from body and lowers outerwings; while stationary, lowers head and crouches but, if walking, can raise head slightly and hold body more erect. Hunched bird can be side-on to or facing aggressor. If pecked, can respond by raising head to Bill-gape, slowly moving away, or both. Lowering of head perhaps serves a cut-off function, in that bill, a potential weapon, is hidden from view of opponent and therefore does not act as stimulus for aggression (Potts 1969, 1977). **Social dominance** Strict hierarchy suggested to exist by Jackson (1969), though not observed by others, except in all-male groups at Rainbow Ski-field, where older birds dominant over younger (G.P. Elliott).

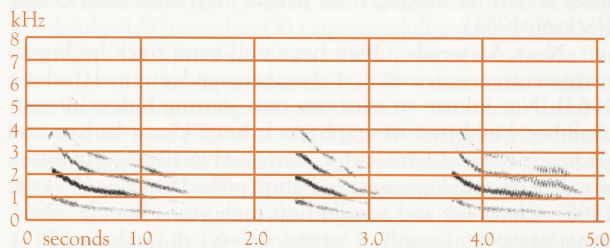
**Sexual behaviour** Extra-pair courtship (allopreening and display) observed between nesting male and female of unknown status, but not extra-pair copulation (K-J. Wilson). Courtship observed between juveniles (Diamond & Bond 1991).

**Courtship feeding** Male holds upper mandible of female with own and passes regurgitated food; accompanied by shaking movement of both birds (Keller 1975). Usually followed by rubbing bill against branch and cleaning it with tongue (J. Diamond & A.B. Bond). Male feeds incubating female at prominent perch within several metres of nest, several times a day (Jackson 1963; Wilson 1990; G.P. Elliott; K-J. Wilson). **Allopreening** Can be reciprocal or non-reciprocal. Usually preen head and neck of recipient, especially crown, nape, throat and round eyes. Recipient usually remains still but sometimes moves head to facilitate preening; can also be accompanied by crouching and fluffing of plumage by recipient. Can pause during reciprocal allopreening and look round, or begin autopreening, or one stops while other continues to allopreen. Both males and females engage in non-reciprocal allopreening of birds of same or opposite sex, though females and younger birds (<3 years old) not seen to preen adult males (see also Relations within family group). Reciprocal allopreening common between immatures (Jackson 1963; Potts 1969, 1977). One may chase another, then pursuer allopreens other, leading to reciprocal allopreening. Chasing may also end in aggressive withdrawal of one of participants. Reciprocal allopreening common among juveniles (J. Diamond & A.B. Bond).

**Relations within family group** While fledgelings still dependent, male and female seen feeding together, with male making space for female to feed and only taking food himself once female has fed; male observed feeding female and fledgelings for up to 8 weeks after they have left nest (R. Brejaart; G.P. Elliott; see Breeding). **Feeding of young** Fledgelings beg by crouching with wings spread, and uttering soft meowing calls (Jackson 1963; R. Brejaart; K-J. Wilson). Fledgelings and immatures engage in reciprocal allopreening (Jackson 1963); adults will also non-reciprocally allopreen fledgelings and immatures (R. Brejaart).

**VOICE** Account prepared by R. Brejaart. Often noisy in flight or on ground when in flocks but generally silent when feeding. Raucous calls are feature of mountains of SI, yet vocalizations not adequately described and no studies of function of calls. Period of calling not studied. No information on sexual or seasonal differences or individual or regional variation.

**Adult KEE-E-AH CALL** (sonagram A): Raucous *kee-e-ah*; also described as *kee-aah* (Falla *et al.* 1978; Forshaw & Cooper 1989). Given in flight, or just before taking flight, or in answer to another bird giving this call at some distance; commonly given by birds separated by c. 200 m or more. When given by bird in flight and heard by bird on ground, latter responds by



A K. & J. Bigwood; no details; P102

giving this call (J. Diamond & A.B. Bond). **TERRITORIAL CALL:** *Kua-ua-ua-ua*; given when another Kea sighted (Jackson 1960). **KUER CALL:** Given in flight, when searching for mate; also draws reply from other neighbouring birds (Jackson 1960). **BLEAT-**



**TRILL CALL:** Not described. Contagious; commonly used within a group before taking flight or when disturbed. In Arthurs Pass, given when trains pass (J. Diamond & A.B. Bond). **SQUEAL:** High-intensity and modulated sound; given during aggressive interactions. Probably rasping call described by Potts (1977) before Lungeing or Run-rush. **SCREAM:** Series of continuous high-intensity shrieks, without modulation; often given by several individuals from group. At Arthurs Pass, given in response to fire at refuse dump (J. Diamond & A.B. Bond). **Other calls** **SOFT COOING CALL:** Given by male from outside nest, to chicks inside (Jackson 1962). **WA-WA-WA CALL:** Series of low-intensity sounds given repeatedly by solitary captive to its mirror image (J. Diamond & A.B. Bond).

**Young** **GURGLE CALL:** Highly varying sound; may grade into a whistle or chuckle. Given when young near another bird and, in areas where Keas fed by people, can be given in response to presence of a person (J. Diamond & A.B. Bond). Possibly same as contagious warbling call used when playing and at times of high-intensity vocal activity in group (R. Brejaart). **MEOW CALL:** Given when sitting alone and may be repeated many times. Not contagious; not produced in social interactions (J. Diamond & A.B. Bond). Probably same as soft meowing used between fledgelings and adults (R. Brejaart). **SQUEAL:** Similar to Squeal of adult. Given during Bill-lock, Wing-flap and other displays during social interactions.

**BREEDING** Account based on contribution by K-J. Wilson. Reasonably well known, with detailed study by Jackson (1960, 1963) and additional information from K-J. Wilson (1990; unpublished) and G.P. Elliott. Nest solitarily (Jackson 1963).

**Season** Laying, July–Jan., with most July–Oct. (when snow cover can be extensive); fledge, Dec.–May, with peak in Jan. (Jackson 1960, 1963; K-J. Wilson; G.P. Elliott). Laying times may vary from year to year.

**Site** On ground, in well-drained area, at end of natural tunnel, usually near a conspicuous feature, such as a large rock or dead tree; under boulder or in crevice between rocks, sometimes in hollow among tree-roots. Also on ledge behind tree on cliff-face; one nest in trunk of live Rata *Metrosideros umbellata* in rainforest, 3 m above ground; and one nest in trunk of fallen Red Beech *Nothofagus fusca* 1.5 m above ground (Jackson 1963; Temple 1996; R. Brejaart; G.P. Elliott; K-J. Wilson). Of 36 nests at Arthurs Pass, 34 (94%) faced other than S (Jackson 1963); three nests at Mt Cook had easterly aspect (K-J. Wilson). Sites traditional; females may use same site for life; nests may be re-used in subsequent years but not always in successive years (Jackson 1963; Temple 1996; G.P. Elliott; K-J. Wilson). Both sexes search for nesting sites; female may make final choice (Jackson 1963).

**Nest, Materials** Often have well-worn track leading to narrow entrance of nests; nest-chamber at end of tunnel (Jackson 1963). Not known to excavate own nesting holes. In nest-chamber, build nest of epiphytic lichens *Usnea barbata* and *Anzeya*, dried moss, ferns, twigs, leaves and small pieces of rotten wood; in nests in logs, use wood-chips picked from log (Jackson 1963). Clean out and rebuild nest each year (Temple 1996). **MEASUREMENTS:** Length of tunnel, 0.9–6.1 m (Jackson 1963). Females begin nest-building in third year; may work on same nest for several years before laying (Jackson 1963).

**Eggs** Elliptical; granulate or nearly smooth; white (Forshaw & Cooper 1989; Oliver). **MEASUREMENTS:** 44.8 (41.4–47.5; 11) × 32.8 (31.0–33.5) (Forshaw & Cooper 1989); 44.2 (2.6; 40.8–49.3; 13) × 33.5 (0.8; 31.0–33.5) (CM); 47.5 × 33.5, 43.5 × 32.5, and 42 × 32.5 (Oliver).

**Clutch-size** Deduced from number of eggs and young in nests: mean 2.5: C/2 × 11, C/3 × 8, C/4 × 1 (Jackson 1963). In captivity, C/3 × 1, C4 × 7 (Forshaw & Cooper 1989).

**Laying** Eggs laid at intervals of 2 days (Temple 1996).

**Incubation** Probably by female only; female fed by male, by regurgitation, at a prominent perch near nest. Males feed female several times throughout day; also claimed that females leave nest for 1 h at daybreak and for 1 h at dusk to be fed by male or to feed herself (Jackson 1963; Wilson 1990; Temple 1996; G.P. Elliott; K-J. Wilson). **INCUBATION PERIOD:** Between 3 and 4 weeks (Jackson 1963).

**Young** Altricial, nidicolous. At hatching, covered with white first down and eyes closed; second down, grey (see Plumages: Downy young). Nestlings fed by female only, who is fed by male; when young several weeks old, female will leave nest to forage but will continue to be fed by male (Jackson 1963; Wilson 1990; Temple 1996; G.P. Elliott; K-J. Wilson; see Social Organization: Parental care). When feeding a 5-week-old chick, female grasped base of chick's bill in hers, then regurgitated food and pushed it into chick's mouth with her tongue (Temple 1996). In captivity male will enter nest to remove eggshells and other debris, keeping nest clean and dry (Temple 1996). **Growth WEIGHT:** Recently fledged chicks: males 856 (81.0; 650–975; 25), females 726.9 (52.8; 620–820; 21), though fledgelings may not always be reliably sexed (K-J. Wilson).

**Fledging to independence** When young close to fledging, female spends most of day in nest and male stands guard at entrance to nest (Jackson 1963). **FLEDGING PERIOD:** 13 weeks (Jackson 1963). After fledging, remain with and fed by both parents (*contra* Jackson 1963) for 4–6 weeks (Temple 1996), or up to 8 weeks (G.P. Elliott). Jackson (1963) says female fledgelings fed for at least 6 weeks, male fledgelings independent at c. 4 weeks.

**Success** From 50 eggs, 38 (76%) hatched, 32 (64%) fledged, equalling 1.9 young hatched and 1.6 fledged per nest (Jackson 1963); from 20 nests at Nelson Ls, 1.2 young fledged per nest (G.P. Elliott); of six nests at Mt Cook, most fledged two or three young (Wilson & Brejaart 1992). In one nest, chicks 2–3 weeks old probably killed by visiting Keas; fledgelings killed by New Zealand Falcons *Falco novaeseelandiae* (Jackson 1963).

**PLUMAGES** Prepared by A.M. Dunn. Begin pre-juvenile moult to juvenile plumage at c. 20 days old (Mallet 1973). Undergo complete post-juvenile (first pre-basic) moult to adult plumage, probably near end of first year. Thereafter, complete post-breeding moults each year produce successive adult plumages without change in appearance. Adult coloration of bare parts probably attained after 2–3 years. Sexes similar. Probably mature at 4–5 years (Mallet 1973). No subspecies.

**Adult** (First and subsequent basic). **HEAD AND NECK:** Forehead, crown, nape and sides of neck, grey-olive (43) with black (89) fringes to feathers. Loes, olive-grey (c42) with black (89) spines extending beyond tips of feathers, forming fine bristles. Ear-coverts, black (89) to black-brown (119) with narrow light brown-grey (45) shaft-streaks. Cheeks, throat and foreneck, light brown-grey (45) with narrow black (89) fringes to feathers. Chin bare. Feathers of hindneck, olive (51) to dark olive (46) with narrow black (89) fringes to feathers. **UPPERPARTS:** Mantle, back and scapulars, olive (51) to dark olive (46) with narrow black (89) fringes to feathers and narrow black (89) shaft-streaks; feathers closest to rump suffused with red (14). Rump and uppertail-coverts vary individually; in some, feathers mostly red (14) to orange-red (15) with narrow black (89)

fringes and shafts and concealed grey-olive (43) bases; in others, feathers mostly grey-olive (43) to dark olive (c46) with red (14) to orange-red (15) suffusion near tips of feathers and narrow black (89) fringes and shafts. **UNDERPARTS:** Breast, belly, vent, undertail-coverts and flanks, light brown-grey (45) to grey-olive (43) with narrow black (89) fringes to feathers and narrow black (89) shaft-streaks; sometimes lightly washed rufous or orange on breast and belly. Axillaries, orange (16) to orange-red (15) with black (89) shafts. **UPPERTAIL:** Central rectrices (t1), dark green (c146) to dark olive (c47) with a black (89) subterminal band that grades into yellow-olive (52) at tip; has bluish sheen at some angles. T2–t6, similar to t1 but with yellow (55), orange-yellow (18) or orange (c17) half-bars or triangular spots along inner edge. **UNDERTAIL:** As upperside but ground-colour yellow-olive (c52) rather than dark green to dark olive. **UPPERWING:** All secondary coverts, olive (51) to dark olive (46) with narrow black (89) fringes, narrow black (89) shaft-streaks, and concealed light-brown (25) bases to feathers. Lesser and median primary coverts, grey-olive (c43) to brownish grey (c79) with narrow black (89) fringes. Alula and greater primary coverts, brown (219) with greyish-blue (ne) outer web. Secondaries, dark brown (219) with dark-green (146) outer web, narrow black (89) fringes to outer web, and yellow (55) to orange-yellow (18) triangular spots or half-bars, speckled with brown (c121), along basal half of inner edge. Primaries, dark brown (219) to black-brown (119) with greyish-blue (ne) basal half of outer web, and with pale-yellow (c157) half-bars speckled with brown (c121), along basal half of inner edge; distal third of outer web and tip often tinged with grey-olive (c43), which fades with wear. **UNDERWING:** All lesser coverts and median primary coverts, pale yellow (c157) with dark-brown (121) fringes and shafts and orange (c17) suffusion to distal half of feathers; often have some dark-brown (121) smudging or blotching near centre of feathers. Median and greater secondary coverts, mostly orange (c17) with pale-yellow (c157) bases and narrow dark-brown (121) fringe at tip. Greater primary coverts, brown (28) with pale-yellow (c157) barring, which is often broken near centre of feather, and some feathers suffused with orange (c17) near tips. Remiges, dark brown (c121) with pale-yellow (c157) half-bars along basal half of inner edges, speckled brown (c121).

**Downy young** At hatching, down white (Mallet 1973; photo: Temple 1996). Develop second down at unknown age: Head, neck and breast covered with thick very pale grey (pale 86) to off-white down; little or no down on face, chin, throat and foreneck; rest of body covered in thick brownish-grey (c79) down.

**Juvenile** Very similar to adult; feathers of forehead, crown and nape slightly paler than in adult, olive-grey (c42), forming slightly paler cap. Also differ by structure of primaries and rectrices (see Structure, Ageing). Differences in bare parts best way to determine age (q.v.).

**Aberrant plumages** Birds with mostly canary-yellow plumage have been recorded (Temple 1996; Oliver), as have albinos (Temple 1996).

**BARE PARTS** Based on photos (Moon & Lockley 1982; Hadden 1990; Moon 1992; Temple 1996; NZRD) and published descriptions (McCaskill 1954; Mallet 1973; Forshaw & Cooper 1989; Moorhouse & Greene 1995; Temple 1996; Oliver; NZRD). **Adult** Bill, black (89); also said to be dark brown to black (NZRD), though suggested brown a result of discoloration from digging in soil (R. Brejaart). Cere, dark greyish-brown (c121). Iris, dark brown (219). Orbital ring and

periophthalmic ring, dark greyish-brown (c121). Legs and feet, dark grey (83). In summer, some adult females have bright orange-yellow in mouth at gape and at rear of lower mandible (Temple 1996). **Downy young** At hatching: bill, pink (108D); legs, cere and bare skin round eyes, pink (7). Bill, legs and bare skin round eyes change to greyish green a few days after hatching (Mallet 1973). Within 5 weeks, upper mandible and tip of lower mandible, black (89); cere and most of lower mandible, yellow-orange (17–18). After c. 8 weeks, bill and legs gradually turn black (Mallet 1973). **Juvenile** Upper mandible, black-brown (c119) to black (89); sometimes slightly paler near base; lower mandible, orange-buff (153) to orange-yellow (18) with black (89) tip. Orbital ring, periophthalmic ring and cere, orange-buff (153) to orange-yellow (18), as lower mandible. Legs and feet, grey (84); also described as yellowish grey (Forshaw & Cooper 1989); said to darken to darker yellow-grey within 2 months (NZRD). **First immature to adult** Bill of first immature similar to that of juvenile, but with larger proportion of lower mandible, black (89). Cere and orbital ring of first immature, pale yellow (c157). Yellow of bill and cere gradually fades over c. 2 years (Moorhouse & Greene 1995; Temple 1996). Some yellow retained in orbital and periophthalmic ring till 3–4 years old (Moorhouse & Greene 1995; Temple 1996); periophthalmic ring turns grey before orbital ring (from photos). Iris, legs and feet, as adult.

**MOULTS** Based on examination of 24 adult and 17 juvenile skins (AIM, CM, MV, NMNZ). **Adult post-breeding** (Second and subsequent pre-basic). Complete. Primaries centrifugal; can begin with any primary, but usually one of p5–p8 (Holyoak 1973). Inner three or four primaries often replaced out of sequence, e.g. one in Mar. had sequence N<sup>1</sup>2<sup>1</sup>N<sup>2</sup>2<sup>1</sup>N<sup>4</sup>2<sup>1</sup>O<sup>2</sup> and another in May had sequence 2<sup>1</sup>S<sup>1</sup>O<sup>2</sup>O<sup>2</sup>. Primaries replaced rapidly, often with two or three growing at once. Moulting of primaries begins about Jan. and is finished about May. All six adults collected between Feb. and May had active moult of primaries, with mean PMS 18.8 (9.32; 4–30; 6); none of 18 collected between June and Dec. had active moult of primaries. Timing of moult of body not certain; some (n=4) had slight moult of body in July and Sept. and one had active moult of body in Mar. No information on moult of tail. **Post-juvenile** (First pre-basic). Very little information. Probably complete. Occurs in early spring (Temple 1996). Only four juveniles had active moult of primaries; all were just beginning moult, at p6, in Nov., Jan. and Feb. Moulting of body active in birds with active moult of primaries. No information on moult of tail.

**MEASUREMENTS** (1–2) SI, skins (AIM, CM, MV, NMNZ): (1) Adults; (2) Juveniles. (3) Captive adults, skins (AIM, MV, NMNZ). (4) Captive (86 skins of unknown age and nine live adults sexed using laparoscope); Bill W = maximum width of maxilla at anterior edge of cere; Bill D = maximum distance between anterior edge of cere and posterior edge of mandibular symphysis when bill closed; Bill CU = length of culmen along dorsal curvature; Toe S = distance between metatarsal joint and distal edge of penultimate phalangeal scute (Bond *et al.* 1991). (5) Live wild adults, sexed on basis of cluster analysis; measurements as (4) (Bond *et al.* 1991).

	MALES		FEMALES		
WING	(1)	322.5 (5.55; 314–331; 17)	316.4 (9.88; 303–330; 8)		ns
	(2)	316.4 (8.88; 297–328; 13)	309.0 (11.97; 298–326; 4)		ns
	(3)	321.8 (7.28; 307–332; 9)	292, 311, 318		
	(4)	307 (3.0; 63)	301 (4.0; 32)		**

TAIL	(1)	157.2 (7.76; 143–171; 18)	158.9 (9.69; 142–171; 8)	ns
	(2)	159.3 (9.41; 146–178; 13)	161.5 (9.33; 154–175; 4)	ns
	(3)	150.0 (14.33; 130–171; 8)	143, 155, 160	
	(4)	155 (3.0; 63)	154 (4.0; 32)	ns
BILL	(1)	49.1 (2.78; 43.4–54.0; 16)	44.3 (4.28; 39.3–50.6; 7)	**
	(2)	46.4 (2.72; 40.4–49.7; 14)	36.5, 37.7, 39.2	**
	(3)	50.2 (3.32; 44.4–55.0; 9)	43.7, 43.8, 45.1	
	(4)	49.5 (0.9; 63)	43.7 (1.5; 32)	**
	(5)	48.2 (0.4; 91)	41.3 (0.8; 37)	**
BILL W	(4)	13.1 (0.1; 62)	12.4 (0.2; 32)	**
	(5)	13.2 (0.1; 90)	12.1 (0.2; 34)	**
BILL D	(4)	28.4 (0.6; 62)	27.2 (1.1; 32)	ns
BILL CU	(4)	55.7 (1.2; 63)	48.1 (2.1; 32)	**
	(5)	55.3 (0.6; 90)	46.4 (0.9; 34)	**
TARSUS	(1)	47.5 (2.10; 43.2–51.2; 17)	46.8 (2.72; 41.6–49.6; 7)	ns
	(2)	46.2 (2.42; 41.7–50.4; 15)	45.3 (1.91; 43.2–47.8; 4)	ns
	(3)	47.7 (1.44; 46.0–50.0; 9)	43.4, 47.7, 51.4	
	(4)	42.6 (0.7; 63)	41.5 (1.0; 32)	ns
	(5)	45.8 (0.5; 89)	44.8 (0.8; 33)	*
TOE C	(1)	51.1 (3.54; 44.1–57.3; 13)	49.3 (4.43; 41.6–54.5; 6)	ns
	(2)	48.8 (3.63; 41.9–52.0; 11)	45.2, 47.7	ns
	(3)	52.7 (1.79; 50.5–55.4; 6)	–	
TOE S	(4)	40.0 (0.5; 63)	37.3 (0.8; 32)	**
	(5)	44.1 (0.4; 89)	41.6 (0.5; 32)	**

Juvenile males had significantly shorter wing than adults ( $P < 0.05$ ) and juveniles of both sexes had significantly shorter bills ( $P < 0.05$ ). Additional measurements in Forshaw & Cooper (1989).

(6) Live, wild, unsexed; measurements as (5) (Bond *et al.* 1991).

		JUVENILE	SUBADULT	ADULT
BILL	(6)	45.4 (48)	46.9 (17)	46.7 (59)
BILL W	(6)	12.8 (48)	12.7 (17)	13.0 (59)
BILL CU	(6)	51.8 (48)	54.0 (17)	53.4 (59)
TARSUS	(6)	45.1 (48)	46.7 (17)	45.6 (59)
TOE S	(6)	43.4 (48)	44.1 (17)	43.3 (59)

Analysis of variance revealed significant differences in bill and tarsus of wild juveniles, subadults (= immatures), and adults (Bond *et al.* 1991).

**WEIGHTS** (1–2) From museum labels (NMNZ): (1) Adults; (2) Juveniles. (3) Live wild adults, sexed on basis of cluster analysis (Bond *et al.* 1991).

	MALES	FEMALES	
(1)	824.6 (136.52; 595–960; 5)	807, 915	
(2)	840	435, 525	
(3)	956 (18; 91)	779 (22; 38)	**

(4) Live, wild, unsexed (Bond *et al.* 1991).

	JUVENILE	SUBADULT	ADULT
(4)	876 (48)	927 (17)	922 (59)

Analysis of variance revealed no significant differences in weight of juvenile, subadult (= immatures), and adults (Bond *et al.* 1991).

**STRUCTURE** Wing broad and rounded, with indentation in trailing edge between primaries and secondaries. Ten primaries: p7 longest; p10 17–31 mm shorter, p9 2–6, p8 0–2, p6 6–10, p5 35–42, p4 53–67, p3 68–86, p2 83–98, p1 95–108. About

14 secondaries, including about four tertials; tips of longest tertials fall between p3 and p4 on folded wing. Tail short and square; 12 rectrices; t1 longest, t6 5–14 mm shorter. Primaries of juveniles much more pointed at tips than in adult; when fresh, rectrices have pointed tips and spines that project c. 5 mm past tip of feather, but these lost with wear. Bill long, curved and sharply pointed. Oliver claimed males have more strongly curved upper mandible than females, but results of Bond *et al.* (1991) suggest opposite (see Sexing below). Cutting edges of upper mandible sharp and strongly downcurved; tip sharply pointed. Lower mandible scoop-like, with rounded tip and sharp cutting edges; grooves on inner edges of lower mandible. Large bare cere along base of upper mandible, in which small rounded nostrils situated close to top. Tarsus medium-length, strong and rounded; granulate. Tibia fully feathered. Outer toe directed backward. Outer hindtoe 82–94% of outer front, inner front 68–73%, inner hind 49–59%.

**AGEING** Juveniles and immatures readily separated from adults on colour of bare parts, particularly bill, cere and orbital ring which are yellow in young birds and grey to black in adults. Juveniles can also be separated from other ages by presence of very pointed tips to primaries and rectrices.

**SEXING** Sexes differ in several measurements, but size and shape of bill probably most useful in separating sexes in field. Bill of males 12–14% longer than that of females. Using sexed museum specimens of wild birds, Bond *et al.* (1991) estimated that 79% of specimens with bill <43.9 mm were females and 90% of those with bill  $\geq 43.9$  were males. These estimates are not useful for captive birds as captive individuals often have much larger bills (Bond *et al.* 1991).

Oliver recognized differences between sexes in curvature of bill and believed that males had more strongly curved bills. Bond *et al.* (1991) estimated the radius of curvature of bills of specimens of known sex (museum specimens and sexed captive birds) and found that mean radius of males was 34.2 mm and females 33.6 mm, but difference not significant. However, from a sample of live birds from wild, sexed on basis of cluster analysis, males had a mean radius of curvature of bill of 31.6 mm and females 29.3 mm, and these were significantly different ( $P < 0.05$ ) (Bond *et al.* 1991). These results suggest that bill of males may be less strongly curved than bill of females.

**GEOGRAPHICAL VARIATION** None.

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Volume 4, Plate 29

Kea *Nestor notabilis* (page 613)

1 Adult male; 2 Adult female; 3 Juvenile female; 4 Immature male; 5, 6 Adult

Kaka *Nestor meridionalis* (page 623)

NOMINATE MERIDIONALIS: 7-9 Adult

SUBSPECIES SEPTENTRIONALIS: 10 Adult male; 11 Juvenile; 12 Adult

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