Order **PASSERIFORMES**

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

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

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

The Passeriformes divide into two main groups:

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

SUBORDER PASSERI (OSCINES OR SONGBIRDS): Cosmopolitan in distribution. Within the HANZAB region there are 36 families of Passeri. The Australo-Papuan Passeri can be subdivided into several supra-familial groups, but those recognized differ between authors (for further information, see Sibley & Ahlquist 1985, 1990; DAB). Oscines are characterized by acromyodian syrinx, with three or four pairs of intrinsic syringeal muscles (van Tyne & Berger 1976; Campbell & Lack 1985; Sibley& Ahlquist 1990; DAB).

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

MENURIDAE (lyrebirds): two species in one genus; endemic to Aust.;
ATRICHORNITHIDAE (scrub-birds): two species in one genus; endemic to Aust.;
CLIMACTERIDAE (A'asian treecreepers): six species in two genera breeding in Aust.;
MALURIDAE (Australopapuan fairy-wrens, emu-wrens and grasswrens): 22 breeding species in three genera in Aust.;
MELIPHAGIDAE (honeyeaters and Aust. chats): 76 species in 26 genera in Aust. and NZ, all breeding;
PARDALOTIDAE (pardalotes, scrubwrens, thornbills and allies): 51 species (one extinct) in 15 genera in HANZAB region, all breeding;
PETROICIDAE (A'asian robins): 23 species in eight genera in HANZAB region, all breeding;
ORTHONYCHIDAE (logrunners): two breeding species in one genus in Aust.;
POMATOSTOMIDAE (A'asian babblers): four breeding species in single genus in Aust.;
CINCLOSOMATIDAE (whipbirds, wedgebills, quail-thrushes and jewel-babblers): eight breeding species in two genera in Aust.;
NEOSITTIDAE (sitellas): single species breeding in Aust.;
PACHYCEPHALIDAE (whistlers, shrike-thrushes and allies): 17 species in seven genera in HANZAB region, all breeding;
DICRURIDAE (monarchs, flycatchers, fantails and drongos): 19 species in seven genera in HANZAB region, all breeding;
CAMPEPHAGIDAE (cuckoo-shrikes, trillers and minivets): eight species (one extinct) in two genera in HANZAB region, all breeding;
ORIOLIDAE (Old World orioles and figbirds): three species in two genera in Aust., all breeding;
ARTAMIDAE (woodswallows, butcherbirds and currawongs): 14 species in four genera in HANZAB region, all breeding;
PARADISAEIDAE (birds of paradise): five breeding species in two genera in Aust.;
CORVIDAE (crows and jays): six breeding species in single genus in Aust. and NZ, including one introduced to NZ;
CORCORACIDAE (Aust. mudnesters): two species in two monospecific genera, endemic to Aust.;
CALLAEIDAE (NZ wattlebirds): three species (one extinct) in three monospecific genera, endemic to NZ;
LANIIDAE (shrikes): two species in HANZAB region, one accidental to Prince Edward Is, the other accidental to Christmas I.;
PTILONORHYNCHIDAE (bowerbirds): ten species in seven genera in Aust. (nine species) and NZ (one species), all breeding; Piopio of NZ probably extinct (Heather & Robertson 1997);
ALAUDIDAE (larks): two breeding species in HANZAB region (including one successfully introduced to Aust. and NZ);
MOTACILLIDAE (wagtails and pipits): eight species in two genera in HANZAB region, only two breeding (one on South Georgia), the rest non-breeding visitors or accidentals;
PRUNELLIDAE (accentors): one species successfully introduced to NZ;
PASSERIDAE (Old World sparrows and A'asian finches): 22 species in nine genera (including four successful introductions) in HANZAB region, all breeding;
FRINGILLIDAE (Old World finches): seven species in four genera in HANZAB region, all introduced except one naturally occurring vagrant to South Georgia;
EMBERIZIDAE (buntings, cardinals, tanagers and allies): two successfully introduced species, occurring NZ and Lord Howe I.;
NECTARINIIDAE (sunbirds and spiderhunters): single breeding species in Aust.;
DICAEIDAE (flowerpeckers): single breeding species in Aust.;
HIRUNDINIDAE (swallows and martins): eight species in four genera in HANZAB region, including four breeding species in Aust. and NZ, one non-breeding visitor and three accidentals;
PYCNONOTIDAE (bulbuls): one successfully introduced species in Aust.;
SYLVIIDAE (Old World warblers): 13 species in eight genera in HANZAB region, including ten breeding species (one extinct) in Aust. and NZ, and three accidental to region;
ZOSTEROPIDAE (white-eyes): seven species (one extinct) in single genus in HANZAB region, all breeding;
MUSCICAPIDAE (Old World flycatchers, thrushes and chats): eight species in six genera in HANZAB region, including five breeding species (two introduced), and four accidentals (including one on Prince Edward Is);
STURNIDAE (starlings and mynas): five species in four genera, four breeding in HANZAB region (including two species successfully introduced, and one species now extinct), and one accidental.

The Aust. oscines fall into two distinct clusters, each with at least three major supra-familial lineages (DAB): One cluster is the Passerida, comprising the Muscicapoidea (including true thrushes and allies), Sylvioidea (true warblers and babblers, and swallows, and others), and Passeroidea (including larks, pipits, sunbirds, flowerpeckers and all finches and their allies). The other cluster is the Corvida, which is centred on the Australo-Papuan region (though its origins are not certain) and which also comprises three main lineages: Menuroidea (lyrebirds, scrub-birds, treecreepers and bowerbirds), Meliphagoidea (A'asian wrens, pardalotes, acanthizid warblers, and honeyeaters), and Corvoidea (A'asian robins, logrunners, A'asian babblers, whipbirds and quail-thrushes, sitellas, whistlers, fantails and monarchs, birds of paradise, butcherbirds and woodswallows, cuckoo-shrikes, Old World orioles, crows and mudnesters).

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

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

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

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

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

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

Arboreal or terrestrial or both; some strictly arboreal (e.g. Hirundinidae), others strictly terrestrial (e.g. Menuridae, Pittidae); most combine both arboreal and terrestrial foraging to varying degrees, but usually with one predominating. Feed on almost all known food, from plant material to vertebrate animals, but most show some specialization for certain food, such as feeding on nectar (Nectariniidae), seeds (Passeridae), fruit (Zosteropidae), small vertebrates (Artamidae) and, commonly, insects (e.g. Maluridae, Pardalotidae, Petroicidae and others). Mostly feed by gleaning and probing, including probing flowers for nectar; and other substrates for invertebrates; also feed by sallying, including various sallying techniques (sally-hovering, sally-striking and sally-pouncing), each suited for one group of prey, particularly moving animals.

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

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

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

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

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

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

Extended tracheae are found in the genus *Manucodia* (Paradisaeidae), the calls of which are deep, loud or far-carrying (Frith 1994). In the only species occurring in our area, the Trumpet Manucode M. *keraudrenii*, the trachea forms a flat coil between the skin and the pectoral muscles, sometimes extending over the abdominal muscles as well, and may be up to 828 mm in length, compared with body-length, from bill to pygostyle, of *c.* 150 mm (Ames 1971; Clench 1978).

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Family **CORVIDAE** crows and jays

A rather large and fairly diverse family of medium to large passerines with world-wide distribution, occurring in North, Central and South America, across most of Eurasia, Africa, Indian subcontinent, s., e. and se. Asia, including Wallacea, to A'asia and islands of the Pacific Ocean. Sibley & Monroe (1990) and Monroe & Sibley (1993) recognize 118 species in 23 genera. Other works (BWP; DAB) recognize 100–115 species in 24–25 genera. Most species, and all genera, occur in the n. hemisphere. In the HANZAB region there are seven species in a single genus *Corvus*: five endemic to Aust.; Rook *Corvus frugilegus*, occurring naturally in n. Eurasia and introduced to NZ; and House Crow *C. splendens* endemic to Africa and Asia and occurring only as a ship-assisted vagrant to HANZAB region (see species accounts). There was also an attempt to introduce Jackdaws *Corvus monedula* to NZ, with a few apparently released in Canterbury in 1867–72, but none was present in 1916 (Thomson 1922; Long 1981).

Views concerning the taxonomy of the group vary considerably. Ridgeway (1904) recognized 13 genera and provided details of morphological characteristics shared by these (see below for summary). Amadon (1944) recognized two subfamilies within the Corvidae: **Corvinae**, comprising crows, jays, jackdaws, nutcrackers, Eurasian magpies (i.e. not including Australian Magpie *Gymnorhina tibicen* from A'asia), Old World choughs and Old World orioles; and **Paradisaeinae** comprising the birds of paradise. Mayr & Amadon (1951) largely followed this, but placed birds of paradise in a separate family. The latter taxonomic arrangement has been accepted by many other authors (Stresemann 1927–34; Wolters 1975–82; Goodwin 1986; Christidis & Boles 1994; Peters; DAB). However, based on DNA–DNA hybridization data, Sibley & Ahlquist (1985, 1990) expanded the traditional limits of the Corvidae to include *c.* 650 species in 127 genera, most being Australo-Papuan taxa (see below). They divided this expanded family into the following seven subfamilies:

CINCLOSOMATINAE: Quail-thrushes *Cinclosoma*, whipbirds and wedgebills *Psophodes*, Papuan jewel-babblers *Ptilorrhoa*, and Malaysian Rail-Babbler *Eupetes macrocercus* (see *HANZAB* 6: Family Cinclosomatidae); largely distributed in Australo-Papuan region, with last species occurring s. and se. Asia.

CORCORACINAE: White-winged Chough *Corcorax melanorhamphos* and Apostlebird *Struthidea cinerea* (see Family Corcoracidae, this volume); endemic to Aust.

PACHYCEPHALINAE: Includes sittellas *Daphoenositta*, whistlers *Pachycephala*, shrike-thrushes *Colluricincla*, shrike-tits *Falcunculus*, Crested Bellbird *Oreoica gutturalis*, NZ *Mohoua*, and pitohuis *Pitohui* (see *HANZAB* 6: Family Pachycephalidae); distributed in A'asia, se. Asia, including Wallacea and the Philippines, and islands of se. Pacific Ocean.

CORVINAE: Comprising four tribes: *CORVINI* (crows, jays, magpies, choughs, and nutcrackers [see below]); *PARADISAEINI* (birds of paradise [see Family Paradisaeidae, this volume]); *ARTAMINI* (Australian Magpie, currawongs *Strepera*, butcherbirds *Cracticus*, woodswallows *Artamus*, peltops *Peltops* and Bornean Bristlehead *Pityriasis gymnocephala* [see Family Artamidae, this volume]); and *ORIOLINI* (Old World orioles, trillers and cuckoo-shrikes [see Families Oriolidae and Campephagidae, this volume). Distributed almost world-wide (see above).

DICRURINAE: Includes fantails, monarchs, drongos and magpie-larks *Grallina* (see Family Dicruridae, this volume); distributed over much of Africa, s., e. and se. Asia, A'asia and islands of the sw. Pacific Ocean.

AEGITHININAE: Ioras; distributed from the Indian subcontinent to e. and se. Asia, including Wallacea and the Philippines.

MALACONOTINAE: Predominantly African taxa, including bushshrikes, boubous, gonoleks, tchagras, vangas, wattle-eyes, puffbacks and their allies; some species occur in s. and se. Asia.

This arrangement has yet to find general acceptance, and is not followed here, but it may be largely valid (Christidis & Boles 1994). Here we follow Christidis & Boles (1994) and DAB in accepting the conventional species limits for the family, including only those species in the tribe Corvini of Sibley & Ahlquist (1985, 1990).

Size varies greatly. The Common Raven *Corvus corax* is the largest, and the largest known passerine (length *c.* 64 cm, weight *c.* 1.2 kg [BWP]); the smallest is probably the Tibetan Ground Jay *Pseudopodoces humilis* (slightly larger than House Sparrow *Passer domesticus* [Goodwin 1986]). In the HANZAB region, there is little variation in size among endemic species: largest is Forest Raven *Corvus tasmanicus* (length *c.* 52 cm, weight *c.* 650 g) and smallest is Little Crow *C. bennetti* (length *c.* 47 cm, weight *c.* 400 g); vagrant House Crow is smallest species recorded in HANZAB region (length *c.* 42 cm, weight *c.* 320 g). Corvids share the following morphological and osteological characteristics (Bock 1962; BWP; DAB): Wings usually rather long and broad. Ten primaries; p10 fairly long. Nine to 11 secondaries (*Corvus* with 11, including four tertials). Tail rather long in many species; some species, such as magpies *Pica*, have elongated central rectrices; 12 rectrices. Bill usually robust with small notch near tip of upper tomium. Nostrils usually rounded and in several species, including *Corvus*, nearly fully covered by nasal bristles. Some species with gular pouch used to transport food. Tarsus rather long; scaling laminiplantar. Feet large and powerful. Dorsal feather-tract often has elongated apterium. Single humeral fossa. Fore-cranium well rounded, with temporal fossa flanked by simple zygomatic processes and large post-orbital processes. Palate openly aperturate. Ectethmoids medium-sized and subtended by large lachrymals, fused laterally to frontal bone where forming long slit-like ectethmoid foramen. Inter-orbital septum and front of cranium heavily ossified. *Corvus* have: rather broad medial shelf of palatines; broadly crested and slightly swollen maxillo-palatine processes that approach each other at sides of broad bi-crested vomer; fully perforate nares; and long rictal bristles.

Following summarized from various sources (Goodwin 1986; BWP, DAB; this study). Plumage varies considerably, from wholly black (*Corvus*) to pied (e.g. Daurian Jackdaw *C. dauricus*) or varying patterns of blue, green or purple (e.g. jays, magpies). All species of *Corvus* in HANZAB region are wholly black or blackish, with varying greenish or bluish sheen. Sexes usually very similar or indistinguishable by plumage (e.g. *Corvus*). Naked or with sparse down at hatching. Juveniles similar to adults, but with softer and more loosely textured feathers of head and body. Undergo a partial post-juvenile (first pre-basic) moult to adult-like first immature (first basic) plumage. Acquire adult plumage in complete first immature post-breeding (second pre-basic) moult, when *c.* 1 year old. Adults undergo a complete post-breeding (pre-basic) moult each year, with no change in appearance. Primaries moult outward, starting at p1. Moult of tail centrifugal. Moult of tail and body start during early stages of moult of primaries, or just before start of moult of primaries.

Ian Rowley and his colleagues (Rowley 1969, 1970, 1971, 1973a,b,c,d, 1974; Rowley & Vestjens 1973; Rowley *et al.* 1973) conducted long-term and detailed comparative studies of the ecology of all five species of Aust. *Corvus*: the three ravens, Australian *C. coronoides*, Little *C. mellori* and Forest, and the two crows, Little and Torresian *C. orru*. Their work included studies of impact on the sheep industry, food and feeding behaviour, social organization and behaviour, breeding, and their external morphology. These studies were concentrated in se. Aust., but with collection and compilation of data from throughout Aust. As such, most information was obtained for Australian and Little Ravens, with less known of the other three species. Comments on Aust. species below largely from these papers and species accounts (which see for further details).

In Aust., crows mainly inhabit tropics and arid interior, while ravens tend to occupy more southerly and temperate areas. All mainly found in open or sparsely treed habitats such as grassland with scattered trees or bordering forested habitats, eucalypt or acacia woodland or open forest, and farmland with scattered trees or bordered by treed habitats. Less common in denser forests, except Forest Raven, which is largely restricted to high-rainfall wet sclerophyll and beech *Nothofagus* forests in mainland Aust., while occupying a wider variety of forested habitats in Tas. Other habitats used include alpine herbfields and shrublands, heaths, woodlands and shrublands with dominants such as chenopods, paperbarks or casuarinas, and coastal habitats such as beaches, mudflats and mangroves. Adult breeding pairs of Australian and Forest Raven and Torresian Crow maintain permanent, all-purpose territories, and are thus restricted to habitats that provide necessary resources for whole year. In contrast, Little Crow and Little Raven, and non-breeding individuals of the territorial species, are mobile when not breeding, allowing them to exploit habitats only seasonally rewarding, such as post-harvest stubble and desert after irregular rainfall. In NZ, introduced Rook most commonly in cleared agricultural land with nearby stands of trees for roosting. Extralimitally, most species of the Palaearctic, and tropical and subtropical Asia and America, at least partly arboreal, using trees for nesting or roosting or both. Many African species nest on cliffs, in low bushes or on the ground and do not need wooded habitats; Palaearctic choughs *Pyrrhocorax* generally occupy rocky regions; and ground jays *Podoces* are terrestrial birds of high desert steppes in central Asia. Many species are commonly associated with human habitation, including villages, towns and cities, or considered commensal with humans. Several species of *Corvus* are widely distributed and occupy a broad range of habitats, e.g. the Common Raven is found from sea level to 5800 m asl, nests in trees, cliff-faces or buildings and forages over virtually any open area (Rowley 1973d; King *et al.* 1978; Maclean 1985; Goodwin 1986; Orn. Soc. Japan 2000; Robson 2002; BWP).

In Aust., adult breeding pairs of Australian and Forest Raven and Torresian Crow are sedentary, defending permanent, all-purpose territories throughout the year. In contrast, Little Raven and Little Crow are dispersive, defending small territories round nests when breeding and joining mobile flocks after breeding. In all species, juveniles, immatures and non-breeding adults form non-territorial flocks that move to varying extents; adult breeding Little Ravens and Little Crows join or form such flocks after breeding. Flocks may travel over hundreds of kilometres, with a tendency for juveniles and immatures to move farthest (Rowley 1967, 1969, 1971, 1973b; Frith 1969; Aust. Atlas 1; Vic. Atlas). In NZ, Rooks are resident or sedentary, though partly migratory in Eurasia (Bull 1957; Heather & Robertson 2000). Extralimitally, exhibit wide range of movement patterns, with species variously described as resident or sedentary and defending territories throughout year (e.g. Brown-necked Raven *C. ruficollis*, Siberian Jay *Perisoreus infaustus*), to altitudinal migrants (e.g. Alpine Chough *Pyrrhocorax graculus*), dispersive (e.g. Pinyon Jay *Gymnorhinus cyanocephalus*), to partly migratory, with movements varying with populations (e.g. Eurasian Jackdaw *Corvus monedula*, American Crow *C. brachyrhynchus*). The rate of participation in migration may increase with latitude, e.g. the Carrion Crow *C. corone* tends to be sedentary in s. and w. Europe but migratory or partly migratory in n. and e. Europe. Migration rates in the Rook increase during cold winters, with juveniles generally far more mobile than adults (Wilmore 1977; Goodwin 1986; BWP).

Omnivorous and opportunistic, feeding on a wide variety of plant and animal items, including carrion. Forage on and above ground: choughs and crows feed mainly on ground, while jays, magpies and nutcrackers are more arboreal, though still feeding much on ground; some species also take food in flight or from water. When foraging, use bill to probe, tear or turn over objects or substrates; food may be held or carried in the feet, and may be manipulated (e.g. broken or torn apart, dehusked or dunked in water) before ingestion. Some *Corvus* gain access to food items (e.g. shellfish, tortoises, nuts) by dropping them onto hard surfaces. Caching of food is common, and some species have morphological adaptations (such as gular pouch) that are used to transport food to cache-sites. Some species considered pests, primarily of agriculture, and persecuted by humans (see below for Aust. species). Most probably drink regularly; with exception of Spotted Nutcracker *Nucifraga caryocatactes* (which drinks by sucking), drink by dipping bill into water and then lifting head (Goodwin 1986; BWP; DAB).

There have been several detailed studies of food and feeding behaviour of Aust. species (Rowley 1969, 1970, 1971, 1974, 1973a,b,d, 1982; Rowley & Vestjens 1973), as well as summaries of available knowledge of individual species in Goodwin (1986). As other members of family, Aust. *Corvus* omnivorous and opportunistic, often scavenging; show seasonal changes in diet with changes in abundance of three main sources of food: invertebrates (mainly insects), seeds and fruit, and flesh (including much carrion, as well as predation of live birds, mammals and reptiles). FORAGING ASSOCIATIONS: Vary with breeding and mating system, but all species forage in flocks at times. Australian and Forest Ravens and Torresian Crows usually forage in pairs or small groups (though subadults and non-breeding birds form loose, nomadic flocks of *c.* 30), whereas Little Ravens and Little Crows forage in larger groups of varying size, often between 50 and 300 birds. All species can gather in large numbers at temporary sources of abundant food. Aust. *Corvus* also often forage in mixed-species feeding flocks where their ranges overlap, especially Australian and Little Ravens and Little Crows; there is usually a fair degree of interspecific tolerance when feeding, though larger species tend to dominate the smaller ones if any competition occurs (see below); when dispersing from source of food, each species leaves independently as a flock. SWAMPING: While intruders usually repelled from territories, when a source of food, such as a large piece of carrion, discovered on a territory, flocks of subadults or non-breeding birds, often joined by other locally resident pairs (or other species of *Corvus*), may temporarily swamp territories of a resident pair. While resident pairs can drive off up to six other birds invading territory, they stop defending territory when more than that invade. HIERARCHIES: Within a species, strongest birds always feed first, which often leads to squabbling and actual physical combat. INTERSPECIFIC CONFLICT: Size of bill correlates with dominance in competitive feeding situations, with smaller-billed species giving way to larger. The larger species (Australian and Forest Ravens and Torresian Crow) often begin exploitation of a carcass, as their larger bills enable more rapid and varied penetration; the smaller species (Little Raven and Little Crow), with their more slender bills, then remove scraps unavailable to the larger birds. Conflicts between Little and Australian Ravens can arise over a carcass, with Australian always dominant. However, if groups of ten or more Little Ravens invade the territory of an Australian Raven, they are left alone, and can forage with impunity. Occasionally similar conflict observed between territorial Australian Raven and Torresian Crow, but this uncommon as Torresian breed later than Australian Raven. In ne. NSW, when Torresian Crows forage closely with Forest Ravens on coastal dunes and rubbish tips, species segregate and, when many more of one species than another, they would exclude the other from foraging area (Secomb 1997). Rowley recorded no instances of conflict between Little Crow and other *Corvus*. The smaller, more dispersive *Corvus*, such as Little Ravens and Little Crows, tend to minimize conflict with the larger territorial *Corvus*, such as Australian and Forest Ravens and Torresian Crows by: leading fledgelings into mobile flocks soon after they leave the nest, ending dependence on breeding territory; having greater flexibility in times of breeding, enabling them to respond to unusual seasonal conditions and breeding at times other than spring; spending much of the year foraging in habitats unsuitable for breeding; and eating different foods, or at least different proportions of the same foods. FORAGING SITES, HEIGHTS: Mainly forage on ground in open habitats, though all Aust. species at least sometimes forage above ground, in trees, shrubs and grain-crops. Most insects taken from just below ground level to 40–50 cm above ground. All species recorded using artificial sites, such as rubbish dumps and picnic grounds. FORAGING METHODS: Spend most foraging time walking on ground in open habitats, turning over earth, dead wood, cow dung, and so on in search of invertebrates, mainly insects and their larvae, which taken mostly by gleaning. Use bill to lift clods of earth, bits of sticks, small logs and pieces of bark; rarely scratch ground with feet. Adults quick to locate any dead animals within territory, usually by aerial search when patrolling territories, often soon after dawn; flock birds also usually find food by aerial search. Often patrol roads, up to several times a day, looking for road-kills; most mammals and many birds eaten are road-kills or other carrion. All Aust. species said to be adept at finding nests of other birds and eating eggs and nestlings, though this largely not reflected in detailed studies of diet or observations of foraging (see species accounts) and statements by same authors that most birds and mammals eaten are road-kills or other carrion. Food usually eaten where it is found, except when feeding nestlings, though sometimes carrion or roadside garbage taken away to be eaten away from others, carried to water to dunk it before consumption, or to be cached. In se. Aust., and especially Australian Raven, often eat highly nutritious first faeces passed by lambs (contains 21–44% crude protein, 9–37% fat, and 10–30% carbohydrate); birds probe anal region of the usually sleeping lamb with a vigorous peck, the lamb usually jumping up and defecating. In captive experiments, Australian and Forest Ravens, which have large and powerful bills, were fastest at removing eyeballs from lamb carcasses (Australian Raven, 2.38 min [1–6.5; 39 tests, of 8 birds]; Forest Raven, 3.20 [1–7; 33, 6]); Little Raven, with a smaller bill, took longer (7.85 min [1.5–28; 40, 11]); Torresian Crow, with a bill almost as large as Australian and Forest Ravens, took longer than Little Raven (9.80 min [2–22; 40, 17]); while Little Crow, with its very small bill and lighter weight, was the slowest (13.77 min [5–27.5; 35, 11], though these figures are underestimates). Four methods were used to remove eyes (and for other foraging): *PICKING*: Performed with one foot firmly anchoring head of lamb, bill lowered at 90° to neck, then raised *c.* 10–15 cm, and driven into eye with much force; this usually bursts eyeball and deflated tissue easily removed and eaten. *PECKING*: Delivered from any position without special preparation, and lacks purposefulness and strength of picking. *BEAKING*: An exploratory action which, while initially gentle, may lead to pinching a piece of flesh in mandibles and removal by pulling. *SPREADING*: Most commonly used by smaller *Corvus*, to explore orifices; closed bill inserted into orifice closed, and mandible then parted to expand orifice; used especially when removing tongue or probing anal region. **HANDLING OF FOOD**: Food usually carried in bill or gular pouch when in flight; rarely with feet. However, use feet to hold items of food being eaten. Food may be carried to water and dunked before being swallowed, especially when feeding on carrion. **CACHING**: Observed in several species in wild, but few observations. In captivity, all species seen to cache meat: taking flesh from dead lambs, packing it into gular pouches to move it round aviary, then caching it. **TIMES OF FEEDING**: Usually forage early and late in day, with most birds resting in middle of day, especially if it is hot. However, when food scarce, or days are short in winter, rest may be shortened or omitted. Flock birds usually conduct aerial search of territories early in morning. **SEASONAL VARIATION**: Diet of all species in HANZAB region said to change seasonally with changes in availability of main food classes. In general among Aust. species: invertebrates, mainly insects (such as cicadas, grasshoppers and beetles), largest component of diet in summer; in autumn, proportion of plant material (mainly grain seeds from stubble after harvesting) increases; in winter, flesh the major component of diet (mainly because ewes lamb at this time in se. Aust., providing most flesh) and insects become less active and seeds either eaten or ploughed; and, in spring, proportion of invertebrates (mainly insects) in diet again increases as their numbers increase. Also said to spend much time in spring searching for and raiding nests. In NZ, Rooks feed mostly on invertebrates (mostly insects) during summer, then switch to plant material in early autumn when invertebrates become scarce, though some invertebrates still eaten; during winter, when little food available, feed mainly on grain, especially from stubbles and stock-feed, though large numbers of earthworms eaten in late winter; in spring, feed on invertebrates and carrion (Purchas 1973, 1980; Porter 1979). **INTERSPECIFIC COMPARISON**: Foraging habits of Australian and Forest Ravens similar, both preferring carrion where available, their massive bills enabling them to penetrate carrion more easily than other species. Torresian Crows eat more grain than other Aust. *Corvus*, especially in e. Aust. where more cultivated grain is grown; Little Crow has most versatile diet; and Little Raven is more of a specialist insectivore. Australian Raven eats more flesh (mainly carrion) in winter and spring than Little Raven, which eats more seeds (grain from stubble) in late autumn and early winter, switching to insects (mainly caterpillars) in late winter and spring; peak of flesh-eating by Australian Raven coincides with main lambing season in se. Aust., whereas Little Raven shows no such peak. Australian and Forest Ravens, with greater weight, longer reach and larger bills, claimed to be only *Corvus* physically able to harm a healthy lamb, though rarely do so (see below). These two species are the most effective at eating carrion, while Little Crow, with its more slender bill, tends to feed last after other *Corvus* present have finished, using finer bill to penetrate crevices unavailable to others and to manipulate food ignored by others. When foraging around dead and dying cattle, Little Crow possibly seeking associated insects. **PEST STATUS**: *Corvus* species are almost universally regarded as pests in regions of primary production, though this largely not supported by detailed studies of Rowley and colleagues. Formerly thought responsible for killing many sheep but this shown to be false. While they do congregate in lambing paddocks, and do kill some lambs, these almost always already weak or sick and there are few instances of killing healthy stock; most lambs eaten are already dead. Also eat placentas and first faeces from lambs. After the birth of lambs, often dash in and grab bills-full of membranes and attendant fluids adhering to the coat of the newborn lamb; also grab afterbirths hanging from ewes, and sometimes a 'tug-of-war' develops. All *Corvus* eat commercial seed and grain (including Oats, Wheat, Maize, Corn, Rice and Sorghum) to varying degrees; Torresian Crow is most widely regarded as pest of agriculture, especially in e. Aust. where more crops grown. Often raid poultry farms for eggs, and orchards for fruit. Contrary to their 'pest' status, *Corvus* play a valuable role in disposing of rotting carcasses and decaying animal matter from lambing paddocks, thus preventing potential disease and stopping spread of blowflies, which can lead to disease and sheep becoming 'blown'. **DRINKING**: Said to drink often in hot weather, especially when feeding on carrion; said that at farm dams, often drink water from puddles or hoofprints round dam, rather than cooler and cleaner water of dam.

Social organization of the family quite varied, but with many common themes. Aust. species studied in detail by Rowley (1970, 1973a,b,d). Most are gregarious to some extent. Some gregarious throughout the year (e.g. Rook) but many only form flocks in the non-breeding season and are usually seen singly or in pairs during the breeding season. Tend to be particularly sociable when migrating and when roosting; also juvenile or immature birds, or both, and adults without territories, often form flocks at any time of the year. Most, if not all species, usually monogamous, at least socially. Polygyny occasionally recorded, e.g. recorded twice in Australian Raven. Most appear to form long-term pair-bonds, with many probably pairing for life (Goodwin 1986; BWP; see species accounts). Several species breed co-operatively, and some of these have been much studied, e.g. Florida Jay *Aphelocoma coerulescens* (Goodwin 1986; Stacey & Koenig 1990). In most species, only female incubates and broods, but both sexes incubate in the nutcrackers *Nucifraga*, and perhaps also in a few other species. While incubating, the female is usually fed on nest by male, and by helpers in co-operatively breeding species. Feeding of nestlings and fledgelings and removal of faecal sacs usually shared between sexes, and with helpers in co-operatively breeding species. Most species nest solitarily, but some nest in colonies (e.g. Rook), and some nest semi-colonially (e.g. Little Crow). All are thought to be territorial, though some species do not show any overt aggression in maintaining territory (e.g. Spotted Nutcracker); some species defend large all-purpose territories in which they spend most of their time throughout the year, while colonial species only defend the nest-site and a small area round it. Some co-operatively breeding species defend territory as a group. In Aust., Australian and Forest Ravens and Torresian Crows maintain permanent territories year-round, in which most or all foraging takes place, though they occasionally forage outside territories when locally abundant source of food discovered (such as large piece of carrion); subadults up to *c.* 3 years old and non-breeding birds live in mobile flocks. Little Ravens and Little Crows occupy a breeding territory only for the minimum time required for breeding (*c.* 3 months), and soon after young fledge, family joins large, mobile foraging flocks. When defending territory, males and females tend to defend most fiercely against others of their own sex. Most species form social hierarchies in captivity, but whether they do so in the wild is uncertain. Many species roost communally. Social behaviour is well known in many species. Detailed studies of all Aust. *Corvus* made few observations of them bathing or entering water, and thus claimed that appear not to like getting wet and to avoid bathing. However, detailed observations of Little Ravens in urban Melbourne found that they bathe regularly and often; and other observers have also recorded Australian Raven and Torresian Crow bathing in water (see species accounts). Where known, all extralimital species bathe in water, and none dust-bathe. Many species have been recorded anting. Most species, including Aust. *Corvus*, scratch indirectly over lowered wing, though some extralimital *Corvus* have been observed to scratch both directly and indirectly.

Often use threat signals in agonistic interactions. When threatening others, often adopt postures in which plumage fluffed and bill partly opened and pointed at opponent, or adopt posture with plumage sleeked, head held high and bill pointed slightly upward. Encounters sometimes result in actual physical combat, but seldom in injury. In many species, submission shown by giving a display in which the wings or tail, or both, are quivered; while displaying, bird usually adopts horizontal posture with wings slightly lowered and held away from body. The same display is used by the female to invite copulation. In most species, male feeds female when she is laying, incubating and brooding nestlings, and in some species, at any time of year. The degree to which pairs maintain individual distance varies across family; in some species, pairs often sit side by side in contact and also allopreen each other (e.g. Eurasian Jackdaw), but others maintain a high degree of individual distance and the only physical contact between pair occurs when male feeds female or during copulation (e.g. Eurasian Jay *Garrulus glandarius*). All Aust. *Corvus* allopreen regularly (Rowley 1970, 1973a,b,d; Goodwin 1986; Talmage 2003; BWP; see species accounts). In Aust., several displays were shared between different species. All five species perform Reduced Amplitude Flight in which birds fly with shallower wing-beats and faster rate of flap than normal flight. Returning-home Display, which is Reduced Amplitude Flight accompanied by Returning-home Call, was also performed by all five species in similar contexts and with similar frequency. An Aerial Wing-flick is performed by Australian and Forest Ravens and Torresian Crow as part of territorial advertisement, and a similar wing-flick is given by Little Ravens from a perch; Little Crow does not appear to give wing-flick. The two Crows both perform Currawong Flight, which resembles flight of currawong *Strepera*; this display not given by ravens. The function of Currawong Flight appears to differ between the two; in Little Crow it appears to be used in territorial defence, but in Torresian Crow it is not used aggressively, and appears to function in contact (see species accounts).

Crows and ravens typically have an extensive vocabulary. Calls, such as territorial calls, can be very loud and sometimes, to human ears, harsh and discordant. Song or its equivalent is given by both sexes and seems to resemble the subsong or whisper song of other passerines; it has been little reported in Aust. Typically it consists of a medley of calls from the repertoire of the species, sometimes with the addition of vocal mimicry, and is given by a bird perched alone or flying alone, and appears to have no territorial function; it is often rather quiet, but may sometimes be quite loud (Campbell & Lack 1985; Goodwin 1986). Each of the five Aust. *Corvus* has a wide variety of calls, and voice is the most useful character for distinguishing between them (Debus 1995; see Australian Raven: Identification of Aust. *Corvus*). The emphasized frequencies of the Territorial Calls of the larger species (Australian and Forest Ravens, and Torresian Crow) are deeper than those of the smaller species (Little Raven and Little Crow), but the presence of harmonics in the Territorial Calls of the Australian Raven and Torresian Crow produces purer tones, which have a clearer, higher sound to the human ear (Lawrence 2005), so that the Australian Raven and Torresian may be regarded as tenors, the Little Raven and the Little Crow as baritones, and the Forest Raven as a bass (Debus 1984). The calls of the different species may be more distinct, and hence more easily distinguished, where they are sympatric, rather than where they occur alone (Debus 1982). Juvenile begging calls are insistent, often speeding up as food is delivered, then 'gagging' over the food (Debus 1995). Vocal mimicry is widespread (Goodwin 1986), although there appears to be only one report from Aust., that of a captive bird imitating the cackling of a hen (Chisholm 1965).

Usually monogamous, but polygyny recorded occasionally and some species breed co-operatively. Most species breed in solitary pairs, but some nest colonially or semi-colonially (see above). In HANZAB region, most breeding Aug. to Nov.–Dec., but season generally extends from early winter through to autumn, and Australian Raven and Torresian Crow have been recorded breeding in all months of year (see species accounts). Among Aust. species, breeding season said to be regular in more sedentary species (e.g. Australasian and Forest Ravens, Torresian Crow), and to vary more in more mobile Little Raven and Little Crow, both of which may initiate breeding in response to environmental stimuli, usually rainfall. Within family, nest-site varies, both between species and between locations; choice of site depends on habitat and potential sites available. Most species usually build nest in forked branches, usually close to or in crowns of trees or, less often, shrubs; in HANZAB region, nests most commonly built in tall eucalypts or acacias. However, many species also nest in other sites, including artificial structures (such as pylons, telephone and light poles, windmills, buildings, and nest-boxes), cliff-faces and caves, tree-hollows or on ground, particularly if trees or shrubs unavailable or unsuitable for nesting; and some species display preference for such sites, e.g. Choughs *Pyrrhocorax pyrrhocorax* and Alpine Choughs nest mainly in caves and cliff-faces, Hume's Ground Jay *Pseudopodoces humilis* nests habitually in holes in earth-banks, and Lidth's Jay *Garrulus lidthi* nests habitually in tree-hollows. Nests or nest-sites may be used for several seasons in succession. Most species build cup- or bowl-shaped nests, but a few (e.g. *Pica*) construct roofed or globular nests. Nests typically consist of loosely constructed base or outer frame of sticks, twigs or large stems, and interior layer and inner lining composed of finer material, including grass, bark, roots, moss, lichen, leaves, wool, hair and feathers. Nests of some species (including some Aust. species) can also include layer of mud, earth, dung or clay, or incorporate artificial materials, such as paper, cloth, wire, pieces of metal; in urban areas, House Crow often builds nests made solely of metal and wire. Both sexes participate in construction, but role or input of sexes varies between species and, in some species (e.g. Little Crow, Common Raven, Eurasian Magpie *Pica pica*, Chough, Spotted Nutcracker), role or input of sexes can vary at different stages of construction. In some New World jays, helpers may assist breeding adults with construction. Construction begins with placement of sticks to form a platform; nest-bowl then raised to form an open cylinder, which shaped by bird pressing its breast, wings and feet against wall and its tail against rim and rotating slowly. Once shaping is complete, bowl is lined. Construction time varies from <1 week up to *c*. 10 weeks, but most species finish nests within 3–4 weeks; building time tends to be shorter for replacement nests. Eggs vary in shape from sub-elliptical to long oval, extending to pyriform in some *Corvus* (e.g. Australian, Forest and Little Ravens, House Crow); usually smooth and glossy. Colour varies, but typically greenish or bluish with spots and blotches of brown, olive or grey, sometimes concentrated or forming zone round large end, and often with underlying markings of shades of grey or mauve or both (though whitish, creamy or buff eggs with reddish markings are occasional variants in most species, and normal in African Black Crow *Corvus capensis* and some American jays); in a few species, eggs can be unmarked. Within family, eggs range from 24–30 × 18–22 mm in Azure-winged Magpie *Cyanopica cyanus* to 42–68 × 29–39 mm in Common Raven; size can vary considerably within species, as illustrated by range of measurements for Common Raven just presented. Most species usually lay clutches of 3–6 eggs, but clutches may consist of a single egg and clutches of ≥10 have been recorded; among Aust. corvids, clutch-size tends to be slightly larger in the larger species (i.e. Australian Raven and Torresian Crow). Eggs usually laid at intervals of *c*. 24 h, but in some species laying intervals of up to 5 days recorded; intervals of ≥48 h more common between eggs laid later in clutch. Many, and probably most, species lay early in morning. Usually single-brooded, but some species re-lay after failure of first or (rarely) second nests, and a few species (e.g. House and Little Crow, Chough) capable of rearing two broods in a season; among Aust. corvids, replacement clutches rarely laid >5 weeks after first clutch completed and are rarely successful. In most species, females incubate alone and are fed on or near nests by males (sometimes assisted by helpers in some New World jays); in some species, males may occupy nests briefly, but true shared incubation is confirmed only in nutcrackers *Nucifraga*. Within family, incubation can begin with any egg of clutch, but usually begins before clutch complete. Incubation period usually 16–22 days, but may be 1–2 days shorter or longer in some species; in Aust., incubation period tends to be shorter in mobile species than in larger resident species. Hatching usually asynchronous. In most species, young brooded by female only. Nestlings fed by both parents and, in some species, by any helpers present (e.g. New World jays such as Green *Cyanocorax yncas* and Brown *Psilorhinus morio* Jays). During early stages of nestling period, males provide brooding females with food, some of which is fed to nestlings. Both adults remove or swallow faecal sacs; among Aust. corvids, this occurs during first 4 weeks or so of nestling period, after which time young defecate outside nest. Among Aust. corvids, nestlings hatch blind and naked except for some sparse down; at 6–12 days old feathers develop beneath skin and begin to erupt; by 13 days feathers have burst through skin in all feather-tracts, with primaries more advanced than others; and by 14 days true feathers begin to emerge from sheaths, though much of body still appears naked at up to 18 days old; eyes open during this period (13–18 days); nestlings completely feathered at 19–25 days, but it is not until at least 33 days that wing-coverts completely conceal sheaths of primaries and plumage appears as a uniform surface. Nestlings become more active in nest, including wing-flapping, from 33 days old, and fledge soon after (see below). During nestling period, young grow from c. 15 to c. 500 g. Within the family, fledging period varies, from 12–14 days in Purplish-backed Jay *Cyanocorax beecheii* and 14–19 days in Azure-winged Magpie to up to 48 days in Torresian Crow and 49 days in Common Raven. However, most species fledge between 3 and 7 weeks; in Aust., mobile species tend to have shorter fledging periods than larger, resident species. In some species, young may leave nests before capable of flight. Fledgelings usually fed by parents for several weeks after leaving nest, but may not become fully independent until 5–6 months after fledging (Rowley 1973c; Goodwin 1986; BWP). In Aust., a pair of ravens produce on average c. 1.5 young/year; while data for crows less adequate, they suggest lower success, with a pair of Torresian Crows producing on average one young every 2 years. Major causes of nest failure include depredation of nests (primarily by a variety of mammalian and avian predators, including other corvids) and interference by people. Nests also parasitized by cuckoos, including Great Spotted *Clamator glandarius*, Common *Cuculus canorus* and Channel-Billed *Scythrops novaehollandiae* Cuckoos, and Common Koel *Eudynamys scolopacea* (Rowley 1970, 1971, 1973a,b,c, 1974; Rowley *et al.* 1973; Goodwin 1986; BWP; see species accounts).

Some 14 species are considered globally threatened: Hawaiian Crow *Corvus hawaiiensis* is considered extinct in the wild (with last two individuals seen in wild in 1992); Banggai Crow *Corvus unicolor*, of Banggai Arch., Indonesia, is critically endangered; Ethiopian Bush-crow *Zavattariornis stresemanni*, Flores Crow *Corvus florensis*, Mariana Crow *C. kubaryi* and Cuban Palm Crow *C. minutus* are considered endangered; and eight species considered vulnerable. Many threatened species are endemic island forms. Captive breeding of Hawaiian Crow has been only partly successful, with the death of many released birds; its major threats are habitat loss, mainly clearing for agriculture, logging and fire. Virtually nothing is known of the Banggai Crow, but it is assumed to have a very small population. A further 11 species are considered near threatened (Stattersfield & Capper 2000; BirdLife International 2005a,b; BirdLife International Species Factsheets, available at http://www.birdlife.org/datazone/species/index.html [accessed Sept. 2005]). In the HANZAB region, two taxa considered near threatened: the n. subspecies *boreus* of the Forest Raven, of ne. NSW, owing to ongoing loss of habitat and possible historical declines in population; and the Aust. populations of subspecies *orru* of the Torresian Crow in Torres Str., which confined to several small islands with total population perhaps <1000 individuals (but subspecies only of least concern on a global basis) (Garnett & Crowley 2000).

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Corvus frugilegus Rook

COLOUR PLATE FACING PAGE 737

Corvus frugilegus Linnaeus, 1758, *Syst. Nat.* 10(1): 105 — Europa = Sweden.

The genus name is from the Latin *corvus*, a raven. The specific name refers to the habit of flocks feeding in fields, from Latin *frugilegus*, crop-picking, from *frux*, *frugis*, fruit, and *legere*, to gather (Mediaeval Latin *frigella*, the Rook).

OTHER ENGLISH NAMES Crow.

POLYTYPIC Nominate *frugilegus*, introduced to e. NI and SI, NZ; indigenous to w. Eurasia from British Isles and Iberian Pen. E to central Siberia, nw. Mongolia, Tien Shan and Iran; winter S to n. Africa, Saudi Arabia and nw. India; *pastinator* Gould, 1845, central-e. Asia, from central-e. Siberia and central Mongolia to central China (e. Xinjiang to Yangtze R.) and Korean Pen.; winter in Japan S to se. China.

FIELD IDENTIFICATION Length 44–46 cm; wingspan 81–99 cm; weight 435 g (all BWP). Small gregarious crow, with: long and very pointed bill, length of which accentuated by bare whitish face; small head with steep high forehead (also emphasized by bare face); moderately long tail with wedge-shaped tip; and long strong legs with fairly long toes and hooked claws, and heavily feathered thighs giving strongly trousered appearance. In flight, bill and bare face give long pointed front end; wings long and broad with prominent fingers at tips; and tail broad and fan-shaped when spread. Larger and more slender than Australian Magpie *Gymnorhina tibicen*. Adults glossy black, with conspicuous pale face. Sexes identical. Slight seasonal variation with wear of plumage. Juvenile and first immature like adult but have fully feathered face, lacking bare skin; first immature plumage glossier than juvenile. Second immature also distinguishable but very like adult. No geographical variation in NZ. **Adult** Entirely black, with glossy violet, purple, blue or green sheen depending on angle of light, brightest on crown, rear of cheeks and mantle; no glossy sheen to undertail and underwing. Plumage becomes duller with wear in summer. Plumage contrasts with bare whitish-grey face, which is rough and warty and extends from base of bill through lores to eyes, fore-cheeks, malar area, chin, and at most times of year, throat. In fresh plumage, in autumn, throat lightly feathered with black but feathers lost with wear by spring. Bill mostly greyish black or brownish black. Iris, dark brown. Orbital ring, dark grey. Legs and feet, black. **Juvenile** Similar to adult but: head fully feathered, with small black feathers over most of area of facial patch, and varying white feathering on chin and upper throat; sides of chin and throat and gape bare, dark brown; and rest of plumage much less glossy than in adult, mostly brownish black with only slight gloss to upperparts, tail, and upperwing and somewhat mottled, dark-grey and brownish-black underbody. Rectrices and primaries narrower and more pointed than in adult. Bill, greyish black, lacking paler base and not contrasting with blackish plumage. Iris, light grey-blue. Legs and feet, greyish black. **First immature** Similar to adult but, like juvenile, head fully feathered with short black feathers over most of area of facial patch, apart from bare sides of chin and throat; and plumage slightly less glossy than adult, with sheen of head mainly green or blue, contrasting with mainly violet sheen of rest of plumage; most secondary coverts new and adult-like, glossy violet, contrasting strongly with retained brown juvenile outer greater secondary coverts, primary coverts and remiges; also retain narrower and more pointed juvenile remiges and rectrices (latter also much browner and less glossy than in adult). With age, lose most feathering of face but tend not to have large white face of adult. Iris darkens to dark brown of adult after few months. **Second immature** Retain some trace of feathering on face till 2 years old; and bare skin smooth, not warty; otherwise indistinguishable from adult.

Similar species None in introduced range in NZ.

Highly sociable; usually occur in large flocks, of hundreds, and congregate in rookeries in which they nest or roost, in tall trees overlooking open pasture. Often involved in aerial squabbles, in which flocks wheel about, calling and squawking to each other. Flight varies: when flying some distance in direct flight, have fast, flapping and fairly regular wing-beats and little gliding, with wings swept back; also perform highly manoeuvrable flights, in which very agile when wheeling and chasing one another, mostly at or over rookeries. In good light, wing-beats have flickering aspect, with contrast between glossy upperwing and black underwing. Mostly forage on ground, eating insects, earthworms, carrion, grain, nuts and other vegetable matter. On ground, move with sedate rolling walk, but also make heavy hopping and sidling movements; hold head high and look tall when searching for food; jump and run energetically over the ground chasing insects; when probing, hold head close to ground, pushing bill deep into soil after grain and worms. Common call a harsh *kaah* or *caw*, unlike calls of any other NZ bird.

HABITAT In NZ, mainly inhabit farmland with stands of trees for roosting and nesting (see below). Occur from coast to 610 m asl, with rainfall of 762–1651 mm pa, though mostly <1015 mm (Bull & Porter 1975; CSN 42; see Distribution). In natural range, require fairly tall trees, either on edges of forests or woodlands or preferably in clumps, groves or along watercourses bordering open grasslands or croplands in which forage; breed in trees only where adjacent countryside readily accessible (BWP).

In NZ, preferred habitat is farmland with stands of trees for rookeries, especially eucalypts and pines, in shelterbelts, plantations or homestead gardens, and often with a good view of surrounding country; avoid dense woodland (Bull 1957; Criglington 1969; Douglas 1970; Bull & Porter 1975; Oliver; NZRD; CSN 31; see Breeding [Site]). At Hawkes Bay, and in Canterbury, rookeries in stands of pines *Pinus*, such as Monterey Pine or Monterey Cypress *Cupressus macrocarpa*, or eucalypts, including Tasmanian Blue Gum *Eucalyptus globulus* (Purchas 1979; Langham & Porter 1991; CSN 25; see Breeding [Site]). Primarily forage in farmland, mainly pastureland and crops, such as cereals, Peas *Pisum sativum*, Pumpkins *Cucurbita moschata*, Maize, stubble and Walnuts (Bull 1966a,b; Purchas 1979; Pierce 1980; CSN 4, 22, 24, 32, 39, 45); also forage in other open areas, such as golf courses (Oliver), showgrounds (CSN 42) and racecourses (CSN 41), and in orchards (Owen & Sell 1985; CSN 41). Rarely, forage on beaches (CSN 41), e.g. single juvenile seen in tidal zone at low tide, stripping bark from log (Owen & Sell 1985). In Miranda seen foraging over seaside pasture which a few years earlier had been intertidal flats with mangroves (CSN 25).

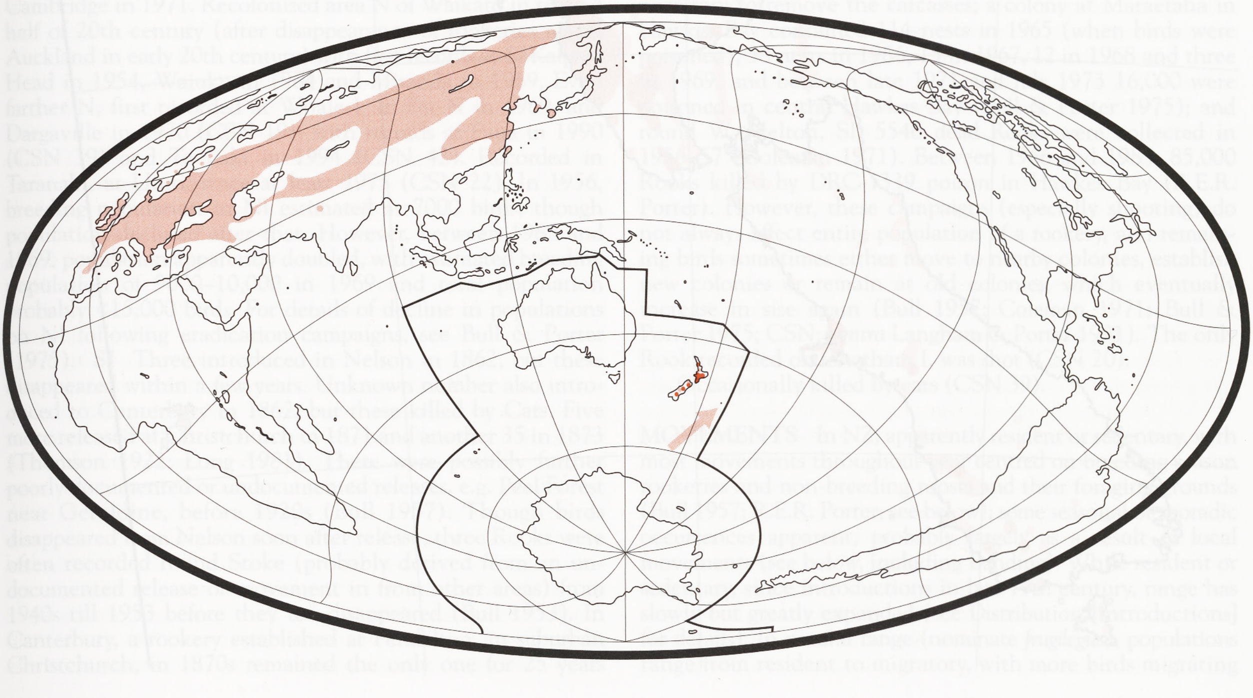
DISTRIBUTION AND POPULATION In natural range, widespread in Eurasia: breed from Iberian Pen. and British

Isles, E through much of Europe, to s. Siberia and n. and central China. Winter throughout much of breeding range except Russia, and S of breeding range in s. Europe, n. Africa, Middle East, Afghanistan and Indian Subcontinent, se. China and Japan (Étchécopar & Hüe 1983; Flint *et al.* 1984; Sibley & Monroe 1990; BWP). Introduced to NZ.

NZ NI Recorded at scattered sites N of 39°S, and more widespread farther S. In NORTHLAND, recorded at Te Paki, Paua, Whale I. and Matauri Bay in Far N, and near Whangarei and at Dargaville; in AUCKLAND, at S. Kaipara Head and Helensville, and at various sites in suburban Auckland. In S. AUCKLAND, from near Kohekohe S to near Limestone Downs, and farther E, Hunua Ras, S to Hauraki Plains, and on Coromandel Pen. at Te Maata and Papaaroa. In WAIKATO, in area centred on Hamilton, and at Tihiroa. In BAY OF PLENTY, at scattered sites from Hinuera, N to Tauranga and E to Maketu, with isolated record on Motuhora I. Recorded at a few sparsely scattered places in coastal EAST COAST, including Hicks Bay, Ruatoria, Tolaga Bay and Gisborne, and a few sites farther inland, but more widespread in coastal areas of S, between Mahia and Raupunga. Widespread in much of HAWKES BAY, from Kotemaori and Putorino, W to line joining Patoka and Dannevirke, and S to Porangahau; also farther S in area from Weber, E to mouth of Tautane Stream (near C. Turnagain) and S to Owahanga R.; and inland to se. edge of Ruahine Ra. Scattered in WAIRARAPA, mostly along e. edge of Tararua Ra., S of Woodville, with isolated coastal or near-coastal records near Tunui and Uruti, and, farther S, near lower reaches of Awhea R., and slightly more widespread elsewhere in S, largely between Huamahanga R. and L. Wairarapa, S to Pirinoa. Scattered in WELLINGTON, from Baring Head N to Waikanae Beach. Recorded at scattered sites in w. MANAWATU and s. WANGANUI, from Levin N to Apiti and W to Waitotara. In Taranaki, recorded at Inglewood, New Plymouth, Waitara and Uruti. Recorded at a few sites in Volcanic Plateau, from Waitahanui and Poronui, N to Tarukenga and L. Rotoiti (Douglas 1970; Bull & Porter 1975; Edgar 1978; McKenzie 1979; NZ Atlas; CSN; R.E.R. Porter). **SI** In NELSON, vagrants recorded in NW near Kahurangi Pt and at Puponga and Farewell Spit; also very occasionally recorded at Tapawera, Appleby, round Waimea Inlet and near Delaware Bay. In MARLBOROUGH, isolated record on Stephens I., but recorded at scattered sites farther S, from n. Cloudy Bay S to Ward, and also occur farther S round Kaikoura. In CANTERBURY, isolated n. record at Motunau, but widespread on Banks Pen., extending W to Sheffield and Hororata; also occur at scattered sites from near L. Heron S to Timaru, with isolated s. record at L. Wainono. Widespread but scattered in OTAGO, from Kakanui SW to Clinton and Wairuna, and inland to line from Mare Burn and Hyde, through Lammermoor Ra., to Wairuna; also much farther inland, at scattered sites from near Tarras and Earnscleugh W to Kinloch. Sparsely scattered in SOUTHLAND, with coastal records from Catlins and Fortrose, at various sites on Stewart I., and at a few inland locations, including Pebbly Hill, Orawia, Blackmount and Lumsden. Recorded at scattered sites in n. WEST COAST, from Hokitika N to Westport, and inland to Rotomanu; also much farther N at Karamea (Coleman 1971; Dennison & Robertson 1979; Pierce 1980; Owen & Sell 1985; NZ Atlas; CSN).

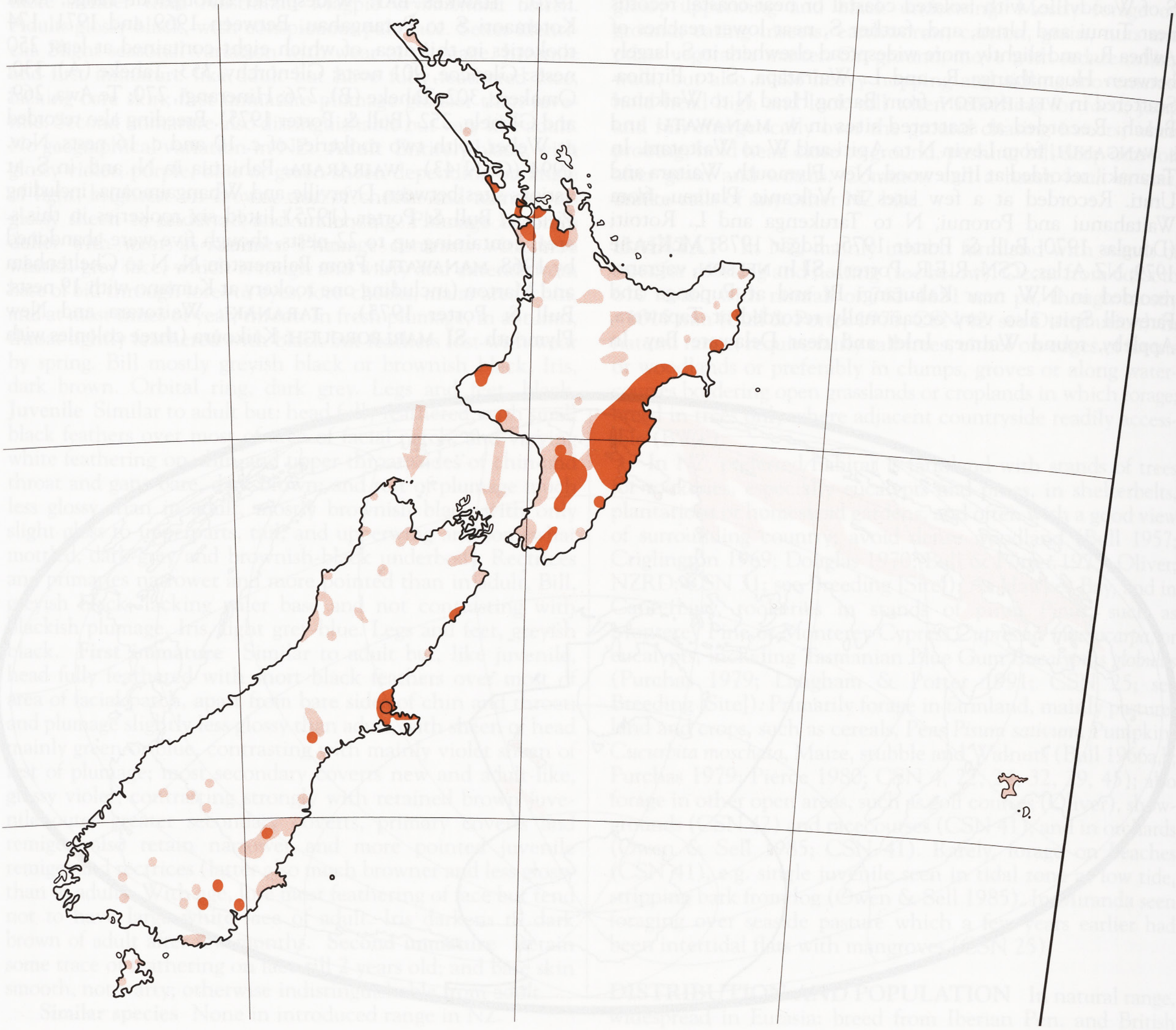
Chatham Is One record: single, Owenga, Chatham I., 17 Apr. 1973 (Freeman 1994; CSN 20).

Breeding Rookeries recorded at scattered sites throughout much of range, though many isolated or ephemeral (NZCL). **NI** AUCKLAND: S. Kaipara Head and Auckland. S. AUCKLAND: Waiuku Pen. and round sw. Firth of Thames, centred on Miranda. WAIKATO: Morrinsville and Cambridge. EAST COAST: Tolaga Bay and Gisborne; single nest recorded at Wairoa in 1970. HAWKES BAY: Widespread throughout range, from Kotemaori S to Porangahau. Between 1969 and 1971, 174 rookeries in this area, of which eight contained at least 250 nests: Glencoe, 901 nests; Glenorchy, 353; Taheke (A), 330; Omakere, 302; Taheke (B), 276; Hinerangi, 270; Te Awa, 269; and Glenelg, 252 (Bull & Porter 1975). Breeding also recorded at Weber, with two rookeries of *c.* 10 and *c.* 16 nests, Nov. 1994 (CSN 43). WAIRARAPA: Pahiatua in N; and, in S, at various sites between Dyerville and Whangaimoana, including Pirinoa; Bull & Porter (1975) listed six rookeries in this s. area, containing up to 22 nests, though five were abandoned by 1968. MANAWATU: From Palmerston N, N to Cheltenham and Marton (including one rookery at Kumano with 19 nests; Bull & Porter 1975). TARANAKI: Waitotara and New Plymouth. **SI** MARLBOROUGH: Kaikoura (three colonies with



85 nests in Nov. 1983; CSN 34). CANTERBURY: On n. Banks Pen. and suburban Christchurch, extending W to W. Melton and S to L. Ellesmere; Coleman (1971) listed ten rookeries in this area, 1967–69, with two >50 nests: 'Robinson's Rookery', 92 nests; and Long Look Out Pt, Banks Pen., 83. Breeding also recorded round Geraldine, including Cloverlea. OTAGO: Recorded at Middlemarch (55 nests in Mar. 1990; CSN 38) and Sutton; and farther S, at scattered sites from Balclutha (just two nests in new rookery, Sept. 1978; CSN 26) NW to Clydevale and W to Wairuna. (References for all of above: Dear 1951; Bull 1957; Douglas 1970; Coleman 1971, 1972; Bull & Porter 1975; Falla *et al.* 1981; CSN.)

Introductions, and subsequent change in range and populations First introduced in SI, in Nelson and Canterbury, in 1862, and in NI, round Auckland, in 1869–70 (see below). In general, rate of expansion of range from sites of introduction has been slow (Bull 1957; see below), with s. expansion from Napier, NI, estimated at 1.3–3.1 km/year, and movement N even slower, e.g. c. 35 years elapsed between release near Napier and arrival at Tutira, 27 km N (Bull & Porter 1975). Suggested dispersal rather slow because birds strongly attached to breeding and roosting sites once they are established. Vagrants occasionally recorded well away from known populations, e.g. unknown number recorded at Hicks Bay in East Coast before 1922, but did not persist, and not recorded there again till 1966; also recorded at L. Taupo before 1922 but not again till 1971 (Bull 1957; Bull & Porter 1975). Some populations have also increased with greater availability of food as agricultural areas have expanded, though numbers have declined locally after periodic campaigns of eradication (Porter & Bull 1975; see Threats). **NI** Two introduced round Auckland in 1869, and 64 more in 1870 (Thomson 1922; Long 1981); hundreds of nests recorded in colony in late 1880s to early 1890s, but not recorded after 1905 (Bull & Porter 1975). In HAWKES BAY, a few pairs released at Meeanee, between Hastings and Napier, in 1872 and again at Meeanee in 1873; in Oct. 1874, a further 72 arrived by ship at Napier. Another 11 said to have been released at Clive in early 1870s. There were possibly other undocumented liberations, e.g. Spring Bush and Omakere in 1930s or early 1940s (Thomson 1922; Bull & Porter 1975; Long 1981). Following summarized from Bull (1957) and Bull & Porter (1975). After first releases between Hastings and Napier in 1872–73, populations increased greatly but spread of population was slow. Quickly moved to Puketapu and began to increase; a second rookery was subsequently established at Fernhill and though both rookeries flourished (see below), these remained the only two rookeries in Hawkes Bay till at least 1915; by late 1890s or early 1900s, these two were large, and by 1917, the one at Fernhill contained thousands of birds, possibly 5000–10,000,



but declined in 1920s after shooting drives and trees chopped down. After rookery at Fernhill eradicated in 1920s, surviving birds probably moved to Sherenden and Pakipaki, and not recorded breeding at Fernhill again till 1957. First recorded at Tutira, 27 km N of Napier, in 1907, and at Havelock N., *c.* 15 km S of Meeanee, by 1914; colonies were established at Petane (E of Eskdale), Rissington and Waikonini (*c.* 32 km NW of Napier) before 1922 and near Maraekakaho in *c.* 1927. In 1930s, slowly spread S and SW, with rookeries established at Raukawa in *c.* 1935, and Glencoe before 1940. By 1940s, range extended N to Patoka and Tikokino in SW and also farther S, remote from main breeding range, in area from Mangakuri and Spring Bush (SE and S of Elsthorpe, respectively) to site NE of Porangahau. In 1950s, range spread slightly W, to include rookeries at Glenross (*c.* 1950) and Waihau (*c.* 1955), but spread was mostly colonizing previously uninhabited areas between main distribution (centred on Napier) and those s. areas colonized in 1940s, though range also extended W or SW to Hinerangi. In addition, populations increased in this period, e.g. at Tikokino, where first rookery recorded before 1950, two more rookeries by mid-1950s. In 1960s, range slowly expanded farther W, to Whanawhana and Kereru (rookeries established at both in 1961), and S and SW, with rookeries established at Flemington in 1960 and site *c.* 5 km SW of Takapau in 1963. Range expanded rapidly after 1964, with rookeries recorded in N at Tareha and Matahoura in 1967, in NW at Puketitiri in 1970, and in SW at Oringi (between Dannevirke and Woodville) in 1966, Woodville in 1968 and Palmerston N in 1969. Between 1939 and 1969, the breeding range in Hawkes Bay experienced a fourfold increase in area. ELSEWHERE IN NI: All birds recorded in NI today thought to have originated from Hawkes Bay releases. Nesting first recorded in s. Wairarapa, at Pirinoa, in 1930 when three recorded in Whakatomotomo Valley; numbers had increased to 40–50 by 1943 and >200 in early 1950s. First observed near Porirua, Wellington, in 1939. Other areas N of Hawkes Bay were apparently colonized in second half of 20th century. In East Coast, first recorded at Tolaga Bay in 1958, Hicks Bay in 1966 (though a stray recorded here early in 20th century; Thomson 1922) and Ruatoria in 1971, with first breeding records at Kaiti, Gisborne, in 1966, and Wairoa in 1970. In Waikato, first recorded near Morrinsville in 1964 and at Cambridge in 1971. Recolonized area N of Waikato in second half of 20th century (after disappearance of rookeries round Auckland in early 20th century) with first records at S. Kaipara Head in 1954, Waiuku in 1964 and Miranda in 1969. Even farther N, first recorded at Whale I. in Far N in 1969, and Dargaville in 1970 (CSN 19), with records at Paua in 1990 (CSN 39) and Te Paki in 1994 (CSN 42). Recorded in Taranaki, at Uruti, since at least 1975 (CSN 22). In 1956, breeding population in NI estimated at 7000 birds, though population declined after that. However, between 1965 and 1969, population apparently doubled, with estimated breeding population of 9000–10,000 in 1969 and total population probably <15,000 birds. For details of decline in populations on NI following eradication campaigns, see Bull & Porter (1975). **SI** Three introduced in Nelson in 1862, but these disappeared within a few years. Unknown number also introduced to Canterbury in 1862, but these killed by Cats. Five more released at Christchurch in 1871 and another 35 in 1873 (Thomson 1922; Long 1981). There were possibly further poorly documented or undocumented releases, e.g. Peel Forest near Geraldine, before 1920s (Bull 1957). Though birds disappeared from Nelson soon after release, three Rooks were often recorded round Stoke (probably derived from an undocumented release or movement in from other areas) from 1940s till 1953 before they too disappeared (Bull 1953). In Canterbury, a rookery established at Fendalton, in suburban Christchurch, in 1870s remained the only one for 25 years (Bull 1957; Bull & Porter 1975). First recorded round Okains Bay, Banks Pen., in 1925 (Bull 1957). Since 1925, range near Christchurch has expanded W, with rookeries at Islington in 1930, Paparua in *c.* 1935 and W. Melton by early 1950s (Bull 1957). In Canterbury, from original release of *c.* 40 birds in 1870s, population had increased to *c.* 1000 by *c.* 1925 and 7000–10,000 by 1947, with populations increasing dramatically in 1950s (Bull 1957; Coleman 1971). For details of decline in Canterbury after eradication campaigns, see Coleman (1971).

Populations Total population in 1978 estimated to be *c.* 30,000 birds (NZCL), of which *c.* 25,000 were in Hawkes Bay and 2500 in Canterbury (Heather & Robertson 2000), but numbers subsequently reduced after poisoning campaign. In 1965, total population in Hawkes Bay estimated at 15,000 birds, with 9000–10,000 breeding birds (Bull & Porter 1975); and in 1950s in Canterbury, >10,000 (Coleman 1971).

THREATS AND HUMAN INTERACTIONS Originally introduced to control insects (Bull & Porter 1975). However, now considered a pest in some agricultural areas, particularly of crops and nut-groves, and sometimes causing minor damage in orchards (Thomson 1922; Bull 1957, 1966a; Coleman 1971; Bull & Porter 1975; Porter 1979; Purchas 1980; Langham & Porter 1991; Oliver; R.E.R. Porter). Generally valued in grazing areas (Coleman 1971, 1972; Porter 1979; Oliver), though once blamed for attacks on sheep (Thomson 1922). At Islington, SI, disliked round the freezing works, as they drove away the gulls which had been useful in removing pieces of offal from drainage ponds (Bull 1957). Legally protected in Hawkes Bay till 1915, when 3-month open season granted; all protection was removed in 1919; and declared a Pest of Local Importance in 1971, which allowed local rating money to be used for their control (Bull & Porter 1975; J.D. Coleman). Periodically there are campaigns to reduce or eradicate populations by poisoning, shooting and removal of nest-trees, with bounties placed on birds; these were sporadic before 1945, but more co-ordinated and vigorous thereafter (Falla 1947; Bull 1957; Coleman 1971; Purchas 1973; Bull & Porter 1975; Langham & Porter 1991; CSN), e.g. in 1920s, at one rookery at Fernhill in Hawkes Bay, 4000–5000 birds were poisoned, and a horse and dray were necessary to remove the carcasses; a colony at Maraetaha in Hawkes Bay contained 114 nests in 1965 (when birds were poisoned), 38 nests in 1966, 15 in 1967, 12 in 1968 and three in 1969, and between late 1971 and July 1973 16,000 were poisoned in central Hawkes Bay (Bull & Porter 1975); and round W. Melton, SI, 5546 dead Rooks were collected in 1956–57 (Coleman 1971). Between 1966 and 1985, 85,000 Rooks killed by DRC-1339 poison in Hawkes Bay (R.E.R. Porter). However, these campaigns (especially shooting) do not always affect entire population of a rookery, and remaining birds sometimes either move to nearby colonies, establish new colonies or remain at old colonies, which eventually increase in size again (Bull 1957; Coleman 1971; Bull & Porter 1975; CSN; *contra* Langham & Porter 1991). The only Rook recorded on Chatham I. was shot (CSN 20).

Occasionally killed by cars (CSN 39).

MOVEMENTS In NZ, apparently resident or sedentary, with most movements throughout year centred on breeding season rookeries and non-breeding roosts and their foraging grounds (Bull 1957; R.E.R. Porter; see below); some seasonal or sporadic occurrences apparent, probably largely as a result of local movements (see below, including Banding). While resident or sedentary, since introductions in late 19th century, range has slowly but greatly expanded (see Distribution [Introductions] for details). In natural range (nominate *frugilegus*), populations range from resident to migratory, with more birds migrating in cold winters (Heather & Robertson 2000; BWP). Suggested that warmer winter climate in NZ precludes necessity for winter migration (Bull 1957).

Gregarious year-round (see Social Organization). Breed colonially, in traditional rookeries and, during breeding season, appear to forage within a few kilometres of them (Bull 1957; Coleman 1972). Mean distance from four Canterbury rookeries to foraging sites in spring, 0.6 km (Coleman 1971). Most rookeries deserted at end of breeding season (Bull 1957). After leaving rookeries, mainly roost communally through winter at permanent roosting sites close to rookeries, and from which birds leave for foraging sites each morning; usually also visit rookeries once or twice a day (Coleman 1971; Heather & Robertson 2000). On Canterbury Plains, at end of breeding season, rookery populations split into small mobile groups (sometimes described as nomadic), which change roosting sites often, occupying a series of temporary roosts, which are roosting sites used briefly by adults and newly fledged young before establishment of permanent winter roosts, in mid-Feb. (Coleman 1971). During late 1930s–1950s, a large proportion of Christchurch population congregated at permanent winter roost at Paparua about end of Mar. (Bull 1957). Where known, winter roosts and rookeries close to each other, e.g. at Geraldine, 300 m apart in 1967, and one communal roost at Long Look Out Pt, Banks Pen., comprised birds from rookeries at Long Look Out Pt, *c.* 3 km away, and Okains Bay, *c.* 6 km distant (Coleman 1971). Winter feeding areas usually within 16 km of roosts (Bull 1957); and, at W. Melton, mean distance travelled <2.5 km, with mean foraging range greatest in Apr, 3.5 km, and lowest in Oct., 0.53 km (Coleman 1971). Stay in winter roosts till late Aug., when winter flock breaks up into breeding flocks (Bull 1957; Coleman 1971), e.g. round Christchurch, moved from winter roost to rookery on 31 Aug. 1971 (Coleman 1972). Winter roosts occasionally used by non-breeding birds during breeding season, e.g. 13 birds at W. Melton during 1996.

While able to disperse over long distances (see BWP for movements in natural range), suggested that rarely do so in NZ (Bull 1957; Heather & Robertson 2000). Long-distance dispersal of small numbers may occasionally be responsible for establishment of new rookeries in remote locations. Suggested establishment of new rookeries may be presaged by autumn arrival of small numbers that forage through winter for 3–4 years, then eventually stay to breed, as described for rookeries near Hawkes Bay at Otane, Takapau, Porangahau and Whanawhana (Bull & Porter 1975). Much movement between rookeries indicated by rapid increase in size of new rookeries, and changes in size of older rookeries (Bull & Porter 1975).

Show some seasonal or sporadic occurrences, which probably mostly a result of local movements. In suburban garden at Palmerston N., 1987–92, only observed during winter (Guest & Guest 1993). In contrast, flock of *c.* 500 seen feeding on Barley *Hordeum vulgare* stubble NE of Palmerston N in big influx in Jan. 1975; flock later disappearing from district (CSN 22). Appeared periodically round Fielding, and suggested that birds either crossed Ruahine Ra. from Hawkes Bay or came from an unknown local rookery (Dear 1951; Bull & Porter 1975). Occasionally reported in small numbers long distances from known rookeries. To 1957, longest distance moved was an individual recorded at Maungaturoto, N. Auckland, *c.* 480 km from nearest rookery in Hawkes Bay (Bull 1957). Also observed at Hicks Bay before 1922, *c.* 245 km from nearest rookery in Hawkes Bay (Bull 1957); and first observed at Tolaga Bay, 145 km from nearest Hawkes Bay rookery, 1 Oct. 1958 (Bull & Porter 1975). Dead birds twice found on road near Hinds, *c.* 82 km from nearest rookery at W. Melton; and live birds observed at Homebush, *c.* 30 km distant (Bull 1957). An immature observed foraging and roosting with Australian Magpies at Kaikoura, Dec. 1968–Mar. 1969, may have been blown there by strong nw. winds (Criglington 1969).

Banding Of 1070 banded 1950–96 (none since 1989), no recoveries recorded 1988–93; no information on recoveries 1993–96 (Cossee 1989, 1991, 1993, 1995, 1997, 1998a,b; Cossee & Wakelin 1991). One that escaped captivity at Wallaceville, Hutt Valley, recovered several months later in flock of Rooks near Dyerville, 32 km distant across mountain range 610 m asl (Bull & Porter 1975). In s. Hawkes Bay, most mobile of ten marked and radio-tagged birds was a 1-year-old male that moved at least 45 km between 18 Nov. 1988 and 19 May 1989, within an area *c.* 8.5 km × 9 km (Langham & Porter 1991). No other data.

FOOD Omnivorous and opportunistic. Three main types of food: (1) invertebrates, especially flies, beetles and earthworms; (2) seeds, particularly commercial cereals, such as Wheat, Corn, Barley *Hordeum vulgare* and Rye *Secale cereale* and lentils; and (3) nuts, mainly Walnuts *Juglans nigra* and acorns *Quercus*. Also take carrion (Purchas 1973, 1980; Porter 1979; Heather & Robertson 2000; Oliver; see below). Wheat, Walnuts, Corn, grass-grubs and earthworms preferred foods, varying with season (Purchas 1973; Porter 1979). **Behaviour** Some aspects well known in NZ, though much poorly known. For comprehensive summaries of extralimital information, see BWP, Glutz von Blotzheim & Bauer (1993) and Dement'ev & Gladkov (1954). Opportunistic, changing from one major food source to another during year depending on availability, with most abundant foods usually the most important items in diet; seeds eaten throughout year but more often in summer when invertebrates scarcer (Coleman 1971; Purchas 1973, 1980; Porter 1979; Heather & Robertson 2000; Oliver). Forage mainly on ground, particularly in agricultural land; mainly by gleaning and probing for invertebrates and seeds, as well as digging, scratching and turning surface material, and by jumping and running after active insects; and take nuts from trees and ground (Purchas 1973, 1980; Porter 1979; Heather & Robertson 2000). DETAILED STUDIES: On Heretaunga Plains, Hawkes Bay, e. NI, 1969–70 (Purchas 1973, 1980); throughout Hawkes Bay, July 1965–June 1966 (Porter 1979); and on Canterbury Plains, SI (Coleman 1971, 1972). FORAGING ASSOCIATIONS: Varies greatly. Seen foraging: singly or in small groups of <10 (CSN 24, 31, 41); in flocks of 10–60 (CSN 1, 4, 22, 23, 24, 35, 37, 38, 39, 41, 60); in large flocks, of up to or more than 100 (CSN 45), often of several hundred (Purchas 1973, 1980; CSN 22); sometimes, in late summer, of 2000–3000 (Purchas 1973) and, in midsummer, up to 6000 during control operations in early 1970s (R.E.R. Porter). On Heretaunga Plains, show distinct seasonal changes in size of flocks and foraging site linked to availability of three main foods (invertebrates, seeds, nuts): occur in small flocks, dispersed over a wide area, when favoured food plentiful in autumn, winter and spring; flocks largest in summer, when food scarce. In late summer, very large flocks, usually of 400+ and sometimes of 2000–3000, congregate to forage on invertebrates and seeds, mainly cereals in stubble-fields; in autumn, flocks disperse to groves of Walnut, usually in flocks of <50 birds, and spend much time eating and storing Walnuts; in winter, birds usually dispersed into still smaller flocks to eat grass-grubs or Walnuts; in spring, when earthworms plentiful, birds foraged singly or in very small flocks; in summer, once again begin to form large flocks (Purchas 1973, 1980). Occasionally forage with Masked Lapwings *Vanellus miles*, e.g. five seen foraging in Oat paddock with *c.* 200 Masked Lapwings (CSN 31, 41). Once, lone immature accompanied flock of Australian Magpies for over 4 months, and foraged with them in sheep pasture (Criglington 1969). FORAGING SITES, HEIGHTS: Forage mainly on ground; predominantly in agricultural and grazing land, including pastures, paddocks, ploughed fields and cereal crops (Criglington 1969; Purchas 1973, 1980; Porter 1979; Oliver; CSN; see Habitat); and take nuts and acorns from trees, or from ground below trees (Purchas 1980; Heather & Robertson 2000). Occasionally forage in other habitats, such as on beaches (Owen & Sell 1985; CSN 25, 31, 41; J.D. Coleman), and orchards (CSN 45); see Habitat. **FORAGING METHODS**: On Heretaunga Plains, used six methods to catch invertebrates (figures are proportion of time spent foraging by the six methods described below; figures approximate, estimated from graph; late summer = Jan.–Feb.; autumn = Mar.–May; winter = June to mid-Aug.; spring = mid-Aug. to Oct.; early summer = Nov.–Dec.): (1) *GLEAN* invertebrates from surface of ground; most often used method in all seasons (*c.* 38% of time spent foraging in late summer, *c.* 41% in autumn, *c.* 48% in winter, *c.* 97% in spring, and *c.* 53% in early summer); (2) *DIG* into and loosen pasture, mainly in small patches where grass-grubs abundant (*c.* 4%, *c.* 12%, *c.* 18%, –, *c.* 4%); (3) *PROBE* soil with bill for earthworms, in locally damp areas (*c.* 6%, *c.* 5%, *c.* 14%, –, *c.* 12%); (4) *TURN OVER SURFACE MATERIAL* such as loose dung or vegetation with bill, to expose invertebrates (*c.* 10%, *c.* 7%, *c.* 11%, –, *c.* 3%); (5) *TEAR OPEN DUNG* with bill to obtain larvae of Striped Dung-Fly (*c.* 17%, *c.* 15%, *c.* 5%, –, *c.* 10%); and (6) *JUMP AND RUN* (*LUNGE*) to catch active insects, most often in summer and autumn (*c.* 25%, *c.* 25%, *c.* 4%, *c.* 3%, *c.* 18%) (Purchas 1980). Availability of some foods depends on climate in any given year: in summer, on dry ground, invertebrates collected mainly by gleaning from on or just above ground, while in damper areas, invertebrates collected by probing and turning surface material. In cooler winter months, soil invertebrates, such as earthworms, easily obtained by probing soft soil when it is not frozen (Purchas 1980). Can only dig with bill to a depth of 7 cm (Lockie 1956); when earthworms or other soil invertebrates deeper in soil than this, alternative food must be found (Purchas 1980). Take Walnuts and acorns from trees and ground below trees, and carry them singly in bill to open ground 25–300 m away from tree; nuts hammered open with tip of bill and eaten (Purchas 1980). When feeding on newly sown crops, work methodically along rows searching for seeds and extracting each in turn (Heather & Robertson 2000). One seen stripping bark from log on beach at low tide, searching for food (Owen & Sell 1985). **CACHING**: When Walnuts and acorns available in autumn, some cached for winter (Purchas 1973, 1980; Porter 1979; Heather & Robertson 2000; see Seasonal variation below). Nuts that are not eaten immediately are hidden singly, using bill, in tufts of grass, in crevices between clods of ploughed soil, or in holes in soil dug with bill, with nuts placed on ground while bird probes or digs hole, then inserted in hole and covered with piece of dry dung, uprooted turf or soil. Nuts sometimes moved to four or five different places before being finally buried, especially if other Rooks nearby. Throughout winter, Rooks scratch for and retrieve cached nuts, which either eaten or moved elsewhere. Average rate at which nuts were found was 5.8 min/nut (Purchas 1980; Heather & Robertson 2000). **SEASONAL VARIATION IN DIET**: Diet varies over year with changing availability of different items, with most abundant food at any given time usually most important item in diet (Porter 1979; Purchas 1980). Over year, 40% of total foraging time spent foraging for invertebrates, with maxi-mum, of 75–80% of time, during Aug.–Oct., and minimum, of 30–40%, during Feb.–Apr.; seeds taken throughout year, with proportion of foraging time varying from low of 10–15% during Mar.–Oct. to maximum of 45% during Dec.–Jan.; 30–60% of foraging time spent collecting and eating nuts from Mar.–July (Purchas 1980). Following based on Porter (1979) and Purchas (1973, 1980). In *LATE SUMMER TO AUTUMN* (months as in Foraging methods), eat many insects, particularly Striped Dung-Fly larvae (*c.* 80% of insects eaten at this time) with most Dung-Fly larvae eaten in Jan. and numbers declining Feb.–Mar., and increasing slightly in Apr. As numbers of Dung-Flies decreased in Feb., seeds from cereal stubbles eaten as they became available, with 31% of foraging time spent on cereals (22% on Wheat stubble and 9% on stock feed). Earthworms scarce in top 7 cm of soil at this time, because conditions hot and dry. By *AUTUMN*, Walnuts and acorns available and preferred food. By late Apr., most nuts either harvested or have fallen to ground. Above-ground insects, such as Dung-Flies, less abundant by this time, though some soil insects, such as grass-grubs and weevils, increased in number and were eaten. Seeds from Barley crops readily available and eaten much. In *WINTER*, food quite scarce, with few invertebrates other than earthworms available, and by July, most cached nuts eaten. Feed mainly on grain, especially Corn from stubbles and stock-feed. Large numbers of earthworms eaten in Aug., possibly because they come closer to surface because conditions wet; click beetles (mainly *Agrypnus variabilis*) make up *c.* 50% of insects eaten in Aug. In *SPRING*, eat many earthworms, blowflies, and much carrion. Blowfly larvae make up *c.* 78% of insects eaten. In *EARLY SUMMER*, above-ground invertebrates, especially grass-grubs, dung-flies, spiders and moths, eaten in large quantities; and also eat large numbers of Peas *Pisum sativum* and Broad Beans *Vicia faba*. Foraging methods also vary seasonally (see above). **DIURNAL VARIATION**: Diet can vary throughout day. In winter 1968, in hour after sunrise, large numbers congregated in Corn stubbles; by mid-morning, birds were foraging in areas containing grass-grubs within 1 km of Corn stubbles; later in day, birds dispersed into smaller flocks to eat or transplant Walnuts stored during autumn (Purchas 1980). **PEST STATUS**: Regarded as significant pest in agricultural areas, causing damage to cereal crops and nut-groves, especially to crops of Corn, Peas, Pumpkins *Cucurbita moschata* and Walnuts, and regarded as a minor pest in orchards. Pull out germinating crops to extract seeds, systematically working over fields, so that considerable areas can be ruined in a day (Thomson 1922; Bull 1957, 1966a,c; Coleman 1971, 1972; Bull & Porter 1975; Porter 1979; Purchas 1980; Langham & Porter 1991; Heather & Robertson 2000; Oliver; R.E.R. Porter). Both newly sown seeds of cereals, Peas and Pumpkins and maturing crops of grain and Peas are often eaten (Bull 1966c). Conversely, many of the insects eaten, such as grass-grubs *Costelytra zealandica*, are pests of pasture and livestock, and Rooks generally considered useful in grazing areas, though blamed for opening up pastures for weed invasion while searching for grass-grubs (Coleman 1971, 1972; Porter 1979; Oliver; R.E.R. Porter). Also damage golf courses when probing for grass-grubs (Oliver). Eradication campaigns conducted throughout range, resulting in shooting or poisoning of thousands (see Threats and Human Interactions). **DRINKING**: Seen to drink water from troughs (CSN 35). **TIME-BUDGET**: Proportion of time spent foraging highest in autumn and lowest between late winter and late spring: in summer, 50–60%; in autumn, 65%; in winter, 40–45%; and in spring, 25–30% (but double this rate towards end of season) (Purchas 1973, 1980). Proportion of time spent foraging lower in late summer mornings than winter mornings (Purchas 1973, 1980). Also see Seasonal variation in diet (above).

Detailed studies In **HAWKES BAY, NI**, July 1965 to June 1966 (stomach contents of 160 birds [mainly adults but including some free-flying juveniles that had left rookery]; see Table 1 for subset of these data Oct.–Dec. 1965, as well as % vol. and mean number of items per gizzard; Porter 1979): **Plants** Unident. vegetable matter 21.9% freq.; other vegetable matter 11.3; grass (Poaceae) and clover *Trifolium* (Fabaceae) combined 71.2. **MONOCOTYLEDONS**: Cereal sds 40.6. **DICOTYLEDONS**: Cucurbitaceae: Pumpkin *Cucurbita moschata* sds 4.4; Fabaceae: Peas *Pisum sativum* 5.6; Walnuts

Juglans nigra (Juglandaceae) and acorns *Quercus* (Fagaceae) combined 30.0; Rosaceae: Apple *Malus sylvestris* skin and flesh 0.6; Cherry Plum *Prunus cerasifera* 1.3; Solanaceae: Potato *Solanum tuberosum* 0.6. **Animals** Unident. carrion 50.0. ANNELIDS: Oligochaetes 75.0. MOLLUSCS: Gastropods 1.3. SPIDERS: Unident. 10.0: Agelenidae: Agelenids 0.6; Lycosidae 3.8; Salticidae 0.6. OPILIONES 1.3. MITES: Acarina: Acaridae 2.5. DIPLOPODS 4.4. COLLEMBOLA 3.1. INSECTS: Coleoptera: Unident. beetles 21.3: Carabidae ads 1.3; Common Tiger Beetle *Neocicindela tuberculata* ads 1.3; Cerambycidae: Lemon-tree Borer *Oemona hirta* ads 0.6; Chrysomelidae: Eucalyptus Tortoise Beetle *Paropsis charybdis* ads 1.9; Cryptophagidae: Fungus-feeding Beetle *Cryptophagus pilesus* ads 0.6; Curculionidae: White-fringed Weevil *Graphognathus leucoloma* ads 16.3; Subterranean Clover Weevil *Listroderes delaiguei* 5.6; Elateridae ads 0.6; Variable Click Beetle *Agrypnus variabilis* ads 55.0, larv. 15.0; Scarabaeidae *Costelytra zealandica* larv. 11.3; Staphylinidae larv. 3.8; Dermaptera: unident. earwigs 11.9; Forficulidae: European Earwig *Forficula auricularia* 0.6; Labiduridae: earwig *Labidura riparia* 0.6; Diptera: unident. flies: ads 21.9, larv. 10.6: Agromyzidae larv. 0.6; Calliphoridae (Eastern Golden-haired Blowfly *Calliphora stygia*, New Zealand Blue Blowfly *C. quadrimaculata*, European Bluebottle Blowfly *C. vicina*, Hairy Maggot Blowfly *Chrysomya rufifacies*, blowfly *Lucilia*): ads 8.1, larv. 22.5; Dolichopodidae ads 0.6; Sarcophagidae: Striped Dung-Fly *Hybopygia varia* ads 20.0, larv. 34.4; Syrphidae ads 0.6, larv. 2.5; Tipulidae ads 8.8, larv. 0.6; Hemiptera: unident. bugs 2.5; Nabidae 0.6; Pentatomidae 11.3; Hymenoptera: unident. ads 1.9; Apidae: Honey Bee *Apis mellifera* ads 34.4; Braconidae ads 0.6; Chalcidoidae ads 0.6; Formicidae: Southern Ant *Chelaner antarcticus* ads 0.6; Ichneumonidae ads 19.4; Lepidoptera ads 8.8, larv. 6.3; Coleophoridae *Coleophora* larv. 2.5; Hepialidae: Porina Moth *Wiseana cervinata* ads 0.6; Noctuidae larv. 16.9; Pyralidae: Crambinae ads 1.9, larv. 0.6; Odonata 0.6; Orthoptera: unident. grasshoppers 1.3; Acrididae 2.5; Gryllidae: Black Field Cricket *Teleogryllus commodus* 4.4; Tettigoniidae 0.6; Phthiraptera 1.3; Thysanoptera 0.6. **Other matter** Stones and grit 98.1.

Other records **Plants** Seeds[3,5,6,7]; unident. fruit and vegetables[7]. MONOCOTYLEDONS: Poaceae: Oats *Avena sativa* sds[8]; Barley *Hordeum vulgare* sds[5,6,9]; Rye *Secale cereale* sds[5]; Wheat *Triticum aestivum* sds[4]; Corn *Zea mays* sds[4,5]; grass lvs[6]. DICOTYLEDONS: Cucurbitaceae: Pumpkins *Cucurbita moschata*[2,6]; Fabaceae: Peas *Pisum sativum*[2,4,5,6]; Broad Beans *Vicia faba*[5,6]; clover *Trifolium* lvs[6]; Fagaceae: acorns *Quercus* nuts[4,5,6]; Juglandaceae: Walnuts *Juglans nigra* nuts[2,4,5,6,7]; Solanaceae: Potatoes *Solanum tuberosum*[7]. **Animals** Unident. carrion[8]. ANNELIDS: Oligochaetes: earthworms[1,4,5,6,7]. SPIDERS[4,6]. INSECTS[4,5,7]: Coleoptera: Scarabaeidae: *Costelytra zealandica* larv.[3,4,5,6]; Diptera: ads[6], larv.[1,3]: Sarcophagidae: *Hybopygia varia* ads, larv.[4,5]; Hymenoptera: wasps[6]; Lepidoptera: larv.[1,6]: Hepialidae: *Wiseana* ads[6], larv.[3]. BIRDS: Unident. young birds and eggs[7]: sparrows *Passer*[7].

REFERENCES: Bull [1] 1957, [2] 1966c; [3] Coleman 1971; Purchas [4] 1973, [5] 1980; [6] Heather & Robertson 2000; [7] Oliver; CSN [8] 5, [9] 22.

Young For first 20 days or so, nestling fed only by male (male also fed brooding female, who stayed on nest). From c. 20 days, combined food requirements of young and female too great for male alone and female also forages and feeds nestlings (Coleman 1972). On Canterbury Plains: overall rate of feeding of nestlings 2.4 visits/h (0.64; 1.4–3.3; n=19 broods); when 1–7 days old, fed at mean rate of 2.07 visits/h (n=50 obs. [10 × 5-h periods], 7 broods); when 10–30 days old, fed at mean rate of 2.28 visits/h (n=50 obs. [10 × 5-h periods], 7 broods). Frequency of feeding did not vary with size of brood. Weight of food/feed 0.02 to 9.4 g (n=16 feeds of nestlings), and increased with age of nestling: between 5 and 11 days old, mean 0.97 g (0.38; 10 meals); 17 and 23 days old, 3.4 g (2.60; 6) (Coleman 1972). Fledgelings dependent on parents for some time (Coleman 1971); extralimitally for roughly 6–8.5 weeks (Wilmore 1977; BWP). Fledgelings spend first 7–10 days roosting in rookery or nearby temporary roosts, then accompany parents to forage in fields (Coleman 1971). Diet of fledgelings still in rookery as adult, with all items except Diptera occurring at similar frequency, volume and number per gizzard, though fledgelings fed significantly more Striped Dung-Fly larvae than were eaten by adults (Porter 1979). Analysis of 48 regurgitations of indigestible food remains near nest by adults and nestlings throughout breeding season, showed cereal residues more common than invertebrate remains; and, of invertebrates, Lepidoptera (*Wiseana*), Diptera larvae and adult grass-grubs (Coleoptera) most common (Coleman 1971). When young can fly, accompany parents in searches for bird nests, mainly of sparrows, whose nests they tear to pieces, eating eggs and young (Oliver).

Detailed studies At HAWKES BAY, NI, Oct.–Dec. 1965 (contents of stomachs of 105 fledged juveniles that had not left rookery; see Table 1 for summary of these data, as well as % vol. and mean number of items per gizzard; Porter 1979): **Plants** Unident. vegetable matter 43.8% freq.; other vegetable matter 40.0; Grass (Poaceae) and clover (Fabaceae: *Trifolium*) 87.6. MONOCOTYLEDONS: Cereal sds 23.8. **Animals** Unident. carrion 47.6. ANNELIDS: Oligochaetes 84.8. SPIDERS: Unident. 13.3; Lycosidae 4.8; Salticidae 1.0. DIPLOPODS 3.8. COLLEMBOLA 1.0. INSECTS: Coleoptera: unident. beetles 9.5; Carabidae ads 4.7; Curculionidae: Compressed Weevil *Irenimus compressus* ads 1.0; Subterranean Clover Weevil *Listroderes delaiguei* 10.5; Elateridae larv. 12.4; Variable Click Beetle *Agrypnus variabilis* ads 75.2, larv. 3.8; Scarabaeidae: Grass-grub *Costelytra zealandica* ads 1.0; Staphylinidae larv. 2.9; Metallic Green Rove Beetle *Thyreocephalus chloropterus* ads 1.9; Tenebrionidae: False Wireworm Beetle *Mimopeus opaculus* ads 1.0; Dermaptera: unident. earwigs 1.9; Labiduridae: earwig *Labidura riparia* 1.0; Diptera: unident. flies ads 9.5, larv. 5.7; Calliphoridae (including species as in adults): ads 26.6, larv. 27.6; Drosophilidae ads 1.9; Sarcophagidae: Striped Dung-Fly *Hybopygia varia* ads 18.1, larv. 41.9; Stratiomyidae larv. 1.0; Syrphidae ads 1.0, larv. 1.0; Tachinidae ads 1.0; Tipulidae ads 21.9, larv. 2.9; *Holorusia* ads 1.9; Hemiptera: Aphididae 1.0; Pentatomidae 10.5; Brown Shield Bug *Dictyotis caenosus* ads 2.9; Hymenoptera: Apidae: Honey Bee *Apis mellifera* ads 25.7; Ichneumonidae ads 1.0; Lepidoptera: Ads 2.9, larv. 5.7: Coleophoridae *Coleophora* larv. 2.9; Hepialidae *Wiseana* larv. 1.0. **Other matter** Stones and grit 100.

On CANTERBURY PLAINS, SI (food items collected by use of neck-collar from 14 nestlings; Coleman 1971): **Animals** Unident. meat 18.7% freq., 19.0% wt. ANNELIDS: Oligochaetes: Lumbricidae: earthworms 50.0, 16.9. SPIDERS: Lycosidae: wolf spiders 18.7, 2.9. INSECTS: Lepidoptera: Hepialidae: porina moth *Wiseana* 62.5, 41.4; Diptera: Sarcophagidae: Striped Dung-Fly *Hybopygia varia* 12.5, 2.8; Hemiptera: Pentatomidae: Brown Shield Bug *Dictyotis caenosus* 6.3, 0.4; Orthoptera: Curculionidae: weevils 6.3, 0.7; Elateridae: click beetle *Lacon variabilis* 12.5, 0.6; Scarabaeidae: grass-grub *Costelytra zealandica* 12.5, 3.2; Tenebrionidae: false wireworm *Celibe* 12.5, 3.2.

Intake SIZE OF FOOD: Invertebrates eaten >4 mm long (Porter 1979). ENERGY REQUIREMENTS: Estimated energy expenditure 18–20 kJ/h/bird throughout year, though expenditure varies seasonally with changing temperature and length of day. Increases steadily from c. 30 kJ/daylight h/bird in early summer to almost double that in winter (Purchas 1980). Individuals eat 56–128 g, and 140 ml, of food per day (Roebuck 1938), and thought easily able to digest enough of main food items to meet daily energy requirements (Purchas 1980). Of

Table 1. Contents of stomachs of 160 birds (45 adults and 105 free-flying juveniles that had left rookery) and 105 juveniles (large young that had not left nest) in Hawkes Bay, NI, July 1965 to June 1966 (Porter 1979).

	ADULTS & FREE-FLYING JUVENILES			JUVENILES IN ROOKERY		
Items	% Freq.	% Vol.	Mean no./gizzard	% Freq.	% Vol.	Mean no./gizzard
Unident. residual matter	–	14	–	13	–	–
Plants						
Unident. vegetable matter	48	6	–	63	4	–
Unident. seeds	36	–	–	17	–	–
Grass (Poaceae) and clover *Trifolium* (Fabaceae)	93	20	–	88	14	–
MONOCOTYLEDONS:						
Cereal seeds	31	13	–	24	13	–
Animals						
Unident. carrion	67	19	–	48	15	–
ANNELIDS:						
Earthworms	86	4	–	85	4	–
SPIDERS AND OPILIONES:						
Spiders and harvestmen	24	–	–	19	–	–
INSECTS:						
Unident. insects	52	4	3	34	6	1
Coleoptera: Beetles	29	7	–	21	8	–
Curculionidae: Weevils	29	–	–	23	–	–
Elateridae: Click beetles	57	–	1	75	–	2
Diptera: Flies	48	1	1	35	–	1
Calliphoridae: Blowflies	52	–	28	66	–	5
Sarcophagidae: *Hybopygia varia*	43	4	5	44	18	16
Hymenoptera: Bees and wasps	31	–	–	26	–	–
Lepidoptera: Moths	29	–	1	12	–	–

Table 2. Estimated numbers of each food item needed per daylight hour per bird in May–June and Dec., assuming no other food eaten and that energy is only requirement (after Purchas 1980).

Food	21 May–17 June	3–31 Dec.
# daylight hours	9	15
kJ/daylight h needed	54	29
Walnuts	0.6	0.3
Acorns	1.7	0.9
Corn	13	7.0
Wheat	130	70
Peas	44	23
Earthworms	41	22
Mixed insects[1]	67	36
Grass-grubs	139	75

[1] Comprising 40.5% caterpillars, 17.5% weevils, 10% nabid bugs, 7% mixed bugs, and 25% spiders.

food eaten, Walnuts most nutritious and best source of energy (28 kJ/g dry weight, and metabolizable energy 20 kJ/g dry weight), followed by insects (mixed invertebrates [see Table 2], 24, 16; grass-grubs *Costelytra zealandica* larvae 22, 14), Corn (18, 14), earthworms (19, 13), Wheat (18, 12) and Peas (16, 11) (Purchas 1973, which see for further details of energy content of food items). Based on metabolizable energy content of main foods and average weight of item, estimated numbers of each food item needed per daylight hour summarized in Table 2. STONES AND GRIT: Limestone most commonly found matter in gizzards, followed by pumice, greywacke, soil concretions, quartz, brick and glass. More stones and grit present in winter (mean 2 cm^2/gizzard) than in summer (0.2). All fledgelings still in rookery had some stones and grit in gizzard (mean 0.95 cm^2/gizzard), mostly limestone (Porter 1979).

SOCIAL ORGANIZATION

Poorly known in HANZAB region but very well known extralimitally. Some information on breeding dispersion and roosting for NZ from surveys during 1955 and 1956 breeding seasons in Canterbury and Hawkes Bay (Bull 1957), and on Heretaunga Plains, Hawkes Bay, 1968–70 (Purchas 1973). For summaries of extralimital studies of nominate *frugilegus* (which introduced to NZ), see Witherby *et al.* (1938), Dement'ev & Gladkov (1954), Wilmore (1977), Goodwin (1986), Glutz von Blotzheim & Bauer (1993), and BWP and references therein; extralimital comments below from BWP unless stated. Gregarious throughout year, when breeding, foraging and roosting, though size of flocks varies seasonally and during day (see below). Forage singly or in small groups of <10, in flocks of 10–60, and in large flocks of 100 to several hundreds of birds, and occasionally in thousands; sizes of flocks linked with availability of food (see Food, and below). Breed colonially, in traditional rookeries during spring–summer (see Breeding dispersion, below); after breeding, populations from local rookeries coalesce to form communal roosts and foraging flocks, of up to several hundred birds; at end of winter, during Aug., flocks break up into breeding flocks and return to rookeries (Bull 1957; Purchas 1973, 1980; Moeed 1976; CSN 48). On Heretaunga Plains, patterns of flocking varied seasonally and through day: during summer, in large flocks throughout the day, usually of 400+ birds, though a few in flocks <50; in autumn, c. 60% of all birds in flocks of <50 during morning and middle of day, though flocks larger by last hour of day as birds congregated in flocks of up to several hundred birds before roosting; in winter, flocks early in day larger than at other times of year with >50% of flocks >200, but in middle of day at least 75% in flocks of <50, and flocks larger again late in day; in spring, most flocks were small throughout day with 50% or more in flocks of <50, and none in flocks of >200; in early summer, most birds were in flocks of >50 throughout day. Flocks in late summer and winter significantly larger in first hour of day than during middle of day. In last hour before sunset, most flocks near rookeries; in autumn and winter, flocks spent most of that time congregating before roosting, and in spring and early summer spent most of that time foraging (Purchas 1973). Large foraging flocks occur during late summer, with small flocks dispersed over a larger area in autumn, winter and spring (Purchas 1973; see Food). Since control programs started in 1970s, fewer large flocks seen as fewer birds present (R.E.R. Porter). ASSOCIATIONS WITH OTHER SPECIES: Immature Rook observed to accompany a flock of Australian Magpies over 4 months, roosting and feeding with them (Criglington 1969). Individuals also seen in regular company with flocks of Magpies (Bull & Porter 1975). Occasionally forage with Masked Lapwings (see Food).

Bonds In NZ, apparently monogamous; and nest in simple territorial pairs, within colonies (Coleman 1972; see below). Extralimitally, essentially monogamous, and pair-bond maintained throughout year, from year to year, and possibly lifelong in established breeding pairs. Inexperienced pairs may divorce after nesting failure. Within colonies, trios of a male and two females observed occasionally, though no evidence of male mating with extra female. Extra-pair copulations occur often. Pair is main constituent social unit throughout year, even within communal roosts. AGE OF FIRST BREEDING: Usually reach sexual maturity and breed in second year (Bull 1957; Coleman 1972). However, may breed in first year if populations decline and there is a subsequent increase in availability of food, or if there is an absence of interference by older birds (Coleman 1972). Extralimitally, age of first breeding usually 2 years, occasionally 1. **Parental care** Only female incubates and broods nestlings; males bring food for nestlings and female for first 20 days of nestling period; female also feeds nestlings thereafter. Fledgelings fed by both parents (see Breeding).

Breeding dispersion Colonial, nesting in rookeries with nests rather densely clustered (Bull 1957; Sibson 1963; Coleman 1972; Bull & Porter 1975; Oliver). In NI, mean 58.7 nests/rookery (65.04; 5–310; 31) in 1965; 78.3 (93.71; 6–466; 31) in 1966; 69.8 (83.26; 4–430; 31) in 1967; 84.7 (84.7; 111.69; 4–584; 31) in 1968; and 114.4 (169.67; 3–901; 30) in 1969 (Bull & Porter 1975). In NI, in 1969, areas occupied for <10 years (*c*. 1850 km^2) contained 1.0 rookery/100 km^2 with mean 47 nests/rookery (n=19); areas occupied for 10–20 years (*c*. 1627 km^2) contained 1.5 rookeries/100 km^2 with mean 96 nests/rookery (n=25); areas occupied for 20–30 years (*c*. 1111 km^2) contained 2.4 rookeries/100 km^2 with mean 102 nests/rookery (n=27); areas occupied for >30 years (*c*. 1362 km^2) contained 2.6 rookeries/100 km^2 with mean 102 nests/rookery (n=36) (Bull & Porter 1975). On Canterbury Plains, in 1967, mean 50.2 nests/rookery (28.55; 26–90; 6) (Coleman 1972). In Hawkes Bay, 1955–56, area of *c*. 777 km^2 contained 22 rookeries, with 6–314 nests per rookery, and density of *c*. 1.6 nests/km^2 (Bull 1957). One rookery at Napier in row of Norfolk Island Pines comprised 19 nests with one or two nests per tree over distance of *c*. 1.6 km; said to be unusual (Bull & Porter 1975). Several nesting attempts of individual pairs found nesting away from rookeries in S. Auckland failed, probably because they lacked protection from predation by Australian Magpies or Common Mynas *Acridotheres tristis*, which do not approach rookeries (Douglas 1970). In Canterbury and Hawkes Bay, rookeries apparently need to attain a certain minimum size to become established; smaller colonies appear to die out or rejoin larger colonies (Bull 1957). If rookeries disturbed, birds move locally and establish new rookeries. Groups may split up after being disturbed but will also merge again, abandoning less favourable sites (Bull 1957). Extralimitally, typically nest colonially, with apparently solitary nests usually colony outliers. However, genuine solitary nesting recorded after colonies were incessantly disturbed for several years. **Territories** While breeding colonially, strongly territorial, defending nests and their contents (Coleman 1972; J.D. Coleman). Extralimitally: territory confined to small area round nest, of 0.5–3 m radius, though distance reduced when additional pairs squeeze into tree; usually several nests per tree. When fledgelings disperse into trees of rookery, defence extends to area occupied by brood and overlapping such territories of other pairs and their young. Old, experienced and successful pairs have strong bond to nest-site and usually retain it; inexperienced birds abandon sites after breeding failure. All pairs that breed successfully return to same sites in following year, and fidelity to rookery continues even if nests removed. **Home-range** In Christchurch area, appear to forage within *c*. 5 km of rookeries during breeding season, and within 16 km of roosting sites during non-breeding season, with occasional birds and flocks seen farther afield (Bull 1957; see Food).

Roosting During winter, form large communal roosts, of hundreds or thousands of birds, close to but separate from rookeries, though will visit rookeries during day through winter (Bull 1957; Coleman 1971). Winter roost-sites established mid-Feb. and retained till late Aug. (Coleman 1971). Flocks leave roosts at or soon after dawn, in small parties that travel via habitual flight-paths and disperse to nearby foraging sites, sometimes visiting birds left at rookeries on the way. Pattern reversed at dusk (Bull 1957; Coleman 1971). During breeding season, most birds roost in or alongside nests, but some non-breeding birds occasionally use communal roost-sites that were used in winter. After fledging, young spent first 7–10 days roosting in rookery or in nearby temporary roost-sites. Temporary roost-sites that changed often were used by non-breeding adults and newly fledged young during breeding season, until communal winter roosts established (Coleman 1971). Extralimitally, members of pairs perch together even within communal roosts. When breeding, female roosts on nest and male on nearby branch.

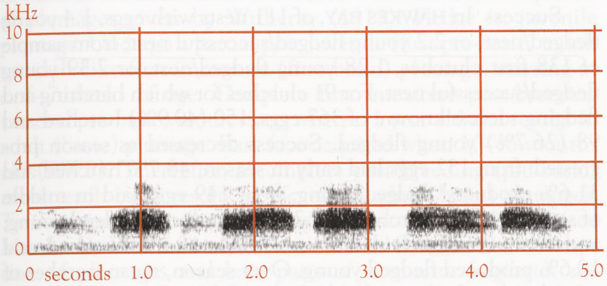
SOCIAL BEHAVIOUR Poorly known in HANZAB region but very well known extralimitally. Some information for NZ from study on Canterbury Plains during 1967 (Coleman 1972). For summaries of extralimital studies of nominate *frugilegus* (which introduced to NZ), see Witherby *et al*. (1938), Dement'ev & Gladkov (1954), Wilmore (1977), Goodwin (1986), Glutz von Blotzheim & Bauer (1993), BWP and references therein; extralimital comments below from BWP unless stated. **Flock behaviour** No information for NZ. Extralimitally: When flying to roosts in non-breeding season, flocks often perform towering tumbling flights (sometimes called crows, weddings or parliaments) and same displays sometimes performed on approach to rookeries or foraging sites. Flock behaviour at rookeries also includes DREADS, in which sudden bout of Caw Calls precedes silent mass departure from all or part of rookery and which sometimes only attributable to obvious disturbance or alarm.

Agonistic behaviour Little information for NZ. At Hawkes Bay in Sept. and Oct., male spent much time guarding territory from intruders. When male absent, female often subject to forced copulations from males (see Sexual behaviour), and attempts to repel these males often became quite violent (Purchas 1979). Extralimitally, both members of pair share defence of nest, though most by female. Defence strongest during breeding season, especially during nest-building. **Interactions with other species** Once, five Rooks chased other unidentified birds (CSN 41). Not usually harassed by other birds, though on appearance in a new locality in small numbers, sometimes chased by Australian Magpies (Douglas 1970; Oliver). Rooks easily scared from food by Magpies and Kelp Gulls *Larus dominicanus*; flocks of 20–30 Rooks seen to be scared off food by single Magpie (R.E.R. Porter).

Sexual behaviour Little information for NZ. Sexual activity said to decrease during late incubation period and hatching (Coleman 1972). Extralimitally, sexual cycle begins and pair-bonds established in autumn, enabling early spring nesting. **Courtship feeding** Once nest finished, female rarely leaves it, and is fed by male throughout laying, incubation period and first 20 days or so of nestling period (Coleman 1972; see Breeding). Extralimitally, courtship feeding plays important role in pair-formation. **Forced copulation** At time when most young of colony hatching, females often subjected to violent matings and mobbing by males that were not partner. In Hawkes Bay, rate of successful or attempted forced copulation of females occurred at 0.3 attempts/h in early Sept. (14.7 h obs.), 0.7 attempts/h in late Sept. (20.4 h obs.), 0.6 attempts/h in early Oct. (8.9 h obs.), and none in late Oct. (1.5 h obs.) (Purchas 1979).

Relations within family group Nestlings fed by male for first 20 days or so, and then fed by female and male, when demands of nestlings and female apparently beyond foraging capabilities of male. Nestlings within individual broods develop at different rates as hatching asynchronous. Usually, all nestlings fed on each parental feeding visit, though amount of food probably differs slightly. As nestlings grow, differences in amount each received increase as older nestlings beg more strongly and obtain more food and grow more rapidly. Parents noted killing smallest nestling before it died of starvation. All nestlings fledge at same time (Coleman 1972; see Breeding).

VOICE Well known within natural range (e.g. Roskaft & Espmark 1982; Glutz von Blotzheim & Bauer 1993; BWP, all of which contain sonagrams); also see Goodwin (1976). The little information from NZ is consistent with these descriptions, e.g. main call a distinctive *kaah* (Criglington 1969) and cawing, which draws attention to a rookery (Sibson 1963). Sonagram **A** shows caws from more than one bird at a rookery. Many calls are noisy and raucous, and complexity of repertoire best appreciated through sonagrams (BWP); Roskaft & Espmark (1982) distinguished over 20 calls, some of which were similar in structure but uttered in different circumstances. The most common call is a harsh flat *caw* or *kaah!*, given, with minor variations, in many situations that involve some social or sexual excitement; it accompanies some displays and is used as a greeting between mates when one returns after a short absence; it varies both in timbre and pitch, both between individuals and in different contexts, and that of the female is longer and of higher pitch than that of the male. The alarm call, used when mobbing a predator, differs only in being louder, more vehement and perhaps a little harsher (Goodwin 1976; BWP).



A L.B. McPherson; Lismore, SI, Sept. 1987; P107

BREEDING Well known. Many studies of breeding round Hawkes Bay in NI (Bull 1957; Bull & Porter 1975; Purchas 1979), and Canterbury Plains, SI (Bull 1957; Coleman 1972). Well known extralimitally, with data for nominate *frugilegus* (which introduced to NZ) in Witherby *et al.* (1938), Dement'ev & Gladkov (1954), Wilmore (1977), Goodwin (1986), Glutz von Blotzheim & Bauer (1993) and BWP, and references therein. Nest colonially, in often large, closely packed rookeries (see Social Organization: Breeding dispersion).

Season NI: In Hawkes Bay: clutches start late Aug. to late Oct., with 93% of first clutches started by mid-Sept., and 83% replacement clutches started after mid-Sept. (Purchas 1979); by mid-Oct., most eggs hatched and some young had fledged (Bull 1957). Numbers of nests increased from late Aug., reached maximum in early Oct., then declined (Bull & Porter 1975). At Pirinoa, hatching from mid-Oct. (Bull 1957). Otherwise, breed early Sept. to late Nov. (Sibson 1963; CSN 42, 43). SI: On Canterbury Plains: laying recorded 30 Aug. to 6 Nov., with peak mid-Sept. to early Oct. (Coleman 1972); eggs and newly hatched young recorded early Oct., which indicates laying from mid-Sept.; most nests with large young, early Nov., with some fledging from late Oct. (Bull 1957). Otherwise, breeding, late Aug. and in Sept. (CSN 37, 42).

Site Usually in fork in top branches of live trees, mostly eucalypts and exotic pines *Pinus*, but occasionally in other species or in dead trees (Bull 1957; Sibson 1963; Coleman 1972; Bull & Porter 1975; Oliver; see below). Of 20 rookeries in Hawkes Bay in 1956: 12 (60%) were in eucalypts, four (20%) in mixed eucalypts and pines, two (10%) in mix of poplars and pines, one (5%) in Norfolk Island Pines, and one in mix of eucalypts and poplars (Bull 1957). Of 108 rookeries in Hawkes Bay in 1969: 35 (32%) in eucalypts, 28 (26%) in pines (mainly Monterey Pine), 36 (33%) in plantations of both eucalypts and pines, and ten (9%) in other plants, usually mixes including Norfolk Island Pines, Lombardy *Populus nigra* and Silver *P. alba* Poplars, elms *Ulmus*, oaks *Quercus*, acacias, walnuts *Juglans* and willows *Salix* (Bull & Porter 1975). Nest-plants used can change as rookeries develop and age: of 1515 nests in 1965, 36% were in pines and 64% in eucalypts; of 3661 nests in 1969, 52% were in pines and 48% in eucalypts. Shift from eucalypts to pines, when both present, probably results from lack of sufficient sites in eucalypts as rookery grows; eucalypts often become spindly or die with increasing age whereas pines provide secure nest-sites, so shift probably reflects availability of suitable sites rather than a preference for a tree species (Bull & Porter 1975). Situation of nest more important in selection of site than nest-plant species (Bull 1957). On Canterbury Plains, formerly, nested almost exclusively in stands of Tasmanian Blue Gum *Eucalyptus globulus*, preferring forks of thick branches; as Gums started dying, started nesting in other trees, mostly pines. Of 28 rookeries in 1955–56: 20 (71.4%) in pines (mostly Monterey Pine), five in eucalypts (mostly Tasmanian Blue Gum), two (7.1%) in mixed plantations of pine and cypress *Cupressus*, and one (3.6%) in mixed plantation of pines and eucalypts (Bull 1957). In 1967, all rookeries were in stands dominated by Monterey Pines, some in pure stands, others in mixed stands with eucalypts and Monterey Cypress *Cupressus macrocarpa*; nests in eucalypts were always in crotch of branches below crown (Coleman 1972). Same site can be used for more than one season (Oliver). MEASUREMENTS (m): Height of nest: On Canterbury Plains, early nests were built higher than later nests, despite availability of high sites in trees peripheral to rookery; at Robinson's rookery, mean height of nests 25–31 Aug., 17.9 (1.20; 14.2–19.6; 18); 1–12 Sept., 17.1 (1.36; 13.7– 19.5; 44); 13–24 Sept., 16.4 (1.60; 13.4–19.0; 23); after 24 Sept., 16.6 (1.48; 14.9–19.2; 7) (Coleman 1972). Two nests in dead trees, 18.3 and 21.4 (Sibson 1963).

Nest, Materials Build large, untidy nest of sticks, twigs, leaves and mud, and lined with grass; nests can be refurbished year after year and can become quite bulky (Coleman 1972; Bull & Porter 1975; Oliver). Extralimitally, both sexes build; male probably brings most material, particularly lining, and female builds more (BWP). First build a rough, cup-shaped base of sticks of eucalypts or pines, each c. 60 cm long and 1 cm thick; then place freshly picked foliage round base to form a deep cup, which is then lined with pine needles, eucalypt bark, tufts of grass with roots and sometimes wool (Purchas 1979). Up to c. 30 twigs placed on first day of construction. Mean time taken to build nest, 7.5 days (2.66; 5–20; 56), with later nests built more rapidly than earlier ones (Coleman 1972). Extralimitally, most material broken from trees, some gathered from ground; will steal material from neighbouring nests (BWP). Partly collapsed nests containing eggs or young not rebuilt, but building will occur after loss of clutch or brood (Coleman 1972). MEASUREMENTS (cm): No data for NZ. In Europe (50 nests): external diameter, 42 (27–85); external height, 31 (17–60); internal diameter, 20 (16–31); internal depth, 12 (7–19) (BWP).

Eggs Oval; pale green, closely spotted and blotched all over with dark and light brown (Oliver). Extralimitally, sub-elliptical; smooth, faintly glossy; light blue to dull green, with specks, blotches and hair-streaks of olive-buff to blackish olive, sometimes forming a cap at large end; sometimes unmarked (BWP). MEASUREMENTS: Three eggs, 33 × 26, 34.8 × 26.4, 35.5 × 26.5 (Oliver). Extralimitally, 39.8 (36.6– 47.4; 1050) × 29.9 (25.2–32.0) (BWP). WEIGHT: 16.0 (no N) (BWP). VOLUME: Mean volume during one season ranged from 13.7 to 15.5 ml, with no significant difference over season (Coleman 1972).

Clutch-size One to seven but mostly 3–5 (Coleman 1972; Purchas 1979; Oliver), as in natural range (BWP). In Hawkes Bay: first clutches (figures from bar graph), 4.28 (1.04; 1–7; 164): C/1 × 1, C/2 × 5, C/3 × 30, C/4 × 58, C/5 × 53, C/6 × 15, C/7 × 2; second clutches, 3.74 (1.23; 1–6; 42); mean clutch-size decreased significantly from 4.8 at start of season to 2.9 towards end of season (Purchas 1979, which see for variation between colonies and season). On Canterbury Plains: 3.38 (0.84; 2–5; 40): C/2 × 8, C/3 × 10, C/4 × 21, C/5 × 1 (Bull 1957); first clutches (excluding seven clutches of one considered incomplete), 3.49 (1.04; 2–6; 208): C/2 × 38, C/3 × 72, C/4 × 64, C/5 × 27, C/6 × 7; between rookeries, mean first clutch-size varied from 2.94 to 3.85; differences between some rookeries significant. Clutch-size decreased significantly during season; for one colony, mean size of clutches laid up to 5 Sept., 3.5 (n=4 clutches); 6–10 Sept., 4.59 (n=17); 11–15 Sept., 4.33 (n=18); 16–20 Sept., 3.64 (n=22); 21–25 Sept., 2.50 (n=8); 26–30 Sept., 3.33 (n=12); 1–5 Oct., 3.0 (n=5); after 5 Oct., 2.75 (n=4); C/6 recorded only during first 2 weeks of laying season, C/5 more common in first half of season, C/3 and C/4 laid throughout season but most frequent early and at end of season, and C/1 and C/2 laid only late in season. In general, replacement clutches (2.92) smaller than preceding first clutches (3.36) but larger than other first clutches laid at same time (Coleman 1972).

Laying Usually on consecutive days; of 183 eggs, 157 (86%) laid on consecutive days; some eggs laid after intervals of up to 5 days, with longer intervals more common between eggs laid later in clutch than between first eggs; of 26 eggs laid after intervals of >1 day, 11 were between final eggs of clutch; six eggs were laid after intervals of 3 or more days. Eggs laid between 07:00 and 10:00 (Coleman 1972). Will re-lay after loss of eggs of nestlings (Coleman 1972; Purchas 1979). Of 21 clutches or broods that failed, 16 replacement clutches laid (Purchas 1979). Interval between first and replacement clutches, 30.8 days (12.64; 12–51; 11 clutches) (Coleman 1972). Usually do not lay second clutches (Coleman 1972; Purchas 1979), though Coleman (1972) records one second clutch, laid 46 days after first.

Incubation By female only (Purchas 1979). Extralimitally, also by female only, starting with first egg (Wilmore 1977) or probably starting with second or third egg, or last egg (BWP). Male feeds female at nest during incubation (Wilmore 1977; Goodwin 1986). Eggs hatch asynchronously, in order laid (Coleman 1972). Nestlings take *c.* 24 h from first pipping to being free of eggshell (Coleman 1972). Cracked and addled eggs sometimes eaten by adults (Coleman 1972). INCUBATION PERIOD: 17.4 days (1.31; 14–22); for individual eggs within a clutch, incubation period decreased for each successive egg, with shorter periods for later eggs resulting from increased intensity of incubation during laying (Coleman 1972); 17.7 (0.2 [SE]; 17–18) (Purchas 1979).

Young Altricial, nidicolous. Extralimitally, largely naked at hatching, with sparse, short dark-grey down on upperparts, upperwing and thighs (Wilmore 1977; BWP; J.D. Coleman). **Growth** WEIGHT: At hatching, 13 g (n=8) (Purchas 1979); usually 12–15 g (Coleman 1972). In Hawkes Bay, mean weight of nestlings (figures from growth curve): at 5 days, 45 g; at 10 days, 175; 15 days, 295; 19 days, 360 (maximum weight); and 20 days, 350; mean gain in weight in first 5 days, 7.3 g/day; from 5 to 20 days, 20.3 g/day (Purchas 1979). On Canterbury Plains, weight of nestlings in B/3 (n=13) from one rookery (estimated from growth-curve): at 2 days, 25 g (10–45); at 5 days, 60 (25–100); 8 days, 165 (80–250); 11 days, 245 (170–310); 14 days, 330 (270–310); 17 days, 390 (350–450); 20 days, 410 (360–450); 23 days, 430 (380–490); 26 days, 430 (365–490); and 29 days, 420 (375–480). Chicks in large broods grew more slowly and were lighter at fledging than those in small broods, and fewer fledged. Gain 30–40 g/day between 6 and 18 days old; and reach maximum weight, of 380–440 g by 23 days old (Coleman 1972, which see for details of growth-rates in broods of one, two, four and five, and comparative growth-rates within broods, between broods of first and replacement clutches, and between early and late broods). **Parental care** Female stays at nest and broods young for first 20 days, and is fed by male; nestlings fed only by male during this time. Thereafter, female also forages and feeds young (Coleman 1972; see Food). Extralimitally, for first 2–4 weeks, nestlings brooded by female and nestlings and female fed by male; thereafter, both sexes feed nestlings (Goodwin 1986; BWP). For details of feeding of young, see Food. Extralimitally, eggshells usually eaten by female but some females eject them from nest (BWP); and faecal sacs removed and dropped away from nest (Goodwin 1986).

Fledging to independence All nestlings fledge at same time (Coleman 1972). FLEDGING PERIOD: From hatching to fledging of first-hatched nestling, 33 days (1.25; 47); length of period varies with size of brood, with period for B/4 (36.4 days) significantly longer than B/3 (33.6 days), B/2 (31.7 days) and B/1 (31.9 days). Extralimitally, 30–36 days (BWP). Fledgelings fed by adults after fledging, for *c.* 6 weeks (BWP) or for 60 days (Wilmore 1977). Extralimitally, fully independent at 5 months old (Wilmore 1977).

Success In HAWKES BAY, of 111 nests with eggs, 1.4 young fledged/nest, or 2.2 young fledged/successful nest; from sample of 138 first clutches, 1.28 young fledged/nest, or 2.39 young fledged/successful nest. For 91 clutches for which hatching and fledging success known: of 367 eggs, 150 (40.9%) hatched and 98 (26.7%) young fledged. Success decreased as season progressed: from 152 eggs laid early in season, 48.7% hatched and 31.6% produced fledged young; from 149 eggs laid in middle of season, 43.0% hatched and 28.9% produced fledged young; and from 66 eggs laid late in season, 18.2% hatched and 10.6% produced fledged young. Over season, mean number of eggs that hatched per clutch declined from 2.05 to 0.63, and mean number of young that fledged per clutch declined from 1.33 to 0.37. However, these declines probably largely a result of decline in clutch-size over season. Fledgeling production increased with clutch-size, from 1.25 fledgelings/nest for C/2 (n=4), to 2.45 fledgelings/nest for C/6 (n=11). In Hawkes Bay, *c.* 40% of eggs or young were lost round time of hatching; *c.* 20% incubated eggs failed to hatch; *c.* 10% of nestlings <10 days old failed; and all nestlings >10 days old survived to at least 20 days old (Purchas 1979). For further details of fledging success against clutch-size, and for comparison of success between sites within Hawkes Bay, see Purchas (1979). In CANTERBURY, for four rookeries: from 557 eggs, in 162 first clutches, 290 (52.1%) hatched, and 185 (33.2%) young fledged (excludes eggs broken by observer) (Coleman 1972, which see for further details of success, and of hatching and fledging success against clutch-size). At Robinson's rookery, fledging success greater for clutches laid early in season, when food abundant, than for those laid later; fledging success decreased from 55.8% for eggs laid up to 11 Sept. (n=26), to 8.3% for eggs laid between 6 and 10 Oct. (n=12), and 15.4% for eggs laid after 10 Oct. (n=13). Success also higher in first clutches (36.5%) than in replacement clutches (6.4%). Successful nests fledged 1–4 young; and 53% of successful nests lost one or more nestlings before rest fledged (Coleman 1972). On Canterbury Plains, from 135 eggs, in 40 nests, 114 (84.4%) hatched (Bull 1957). CAUSES OF FAILURE: From three rookeries on Canterbury Plains: of 379 eggs that failed to hatch: 263 (69.4%) disappeared from nest; 47 (12.4%) showed no sign of development; 28 (7.4%) broken by observer; 21 (5.5%) lost when nest collapsed; seven (1.8%) embryos died at hatching; six (1.6%) eggs eaten by parent; four (1.1%) embryos were dead; two (0.5%) eggs buried in nest; and one (0.3%) egg cracked by parent. At Robinson's rookery, of 76 nestlings that failed to fledge, 27 (35.5%) were killed by parent; 14 (18.4%) died after nest collapsed; 12 (15.8%) were deserted; 12 (15.8%) starved; five (6.6%) killed by observer; two (2.6%) died when nest destroyed; one (1.3%) fell from nest; and three (3.9%) lost for unknown reasons (Coleman 1972, which see for causes of failure in relation to age and position of nestling within brood). Some parents ate cracked and addled eggs (Coleman 1972). In Hawkes Bay, some clutches lost after nests fell from trees; at one site, loss of nest-contents occurred more from nests in two trees that had many twigs on trunk affording good footholds for mammalian predators than in a tree with smooth trunk and branches (Purchas 1979). Nests in thin outer foliage of trees liable to failure through dislodgment by strong winds; once, 500 young found on ground under rookery after strong winds (Bull 1957). MORTALITY: Adults and fledgelings shot and poisoned as part of Rook control programs (Bull & Porter 1975); rookeries have been destroyed by cutting down of nest-trees (Bull 1957); also see Threats & Human Interactions. CUCKOOS: No information.

PLUMAGES Prepared by J.S. Matthew. Following partial account based mostly on published literature (Witherby 1913; Goodwin 1986; Svensson *et al.* 1999; BWP) and examination of skins of ten adult males in NMNZ. Full account of sequence of plumages given by Witherby (1913): Fledge in juvenile plumage. Undergo a partial post-juvenile (first pre-basic) moult to adult-like first immature (first basic) plumage, starting at *c.* 6–7 weeks of age. Complete first immature post-breeding (second pre-basic) moult starts when *c.* 1 year old and results in adult (basic) plumage. Bare face acquired when 10–15 months old (BWP). Thereafter, a complete post-breeding (pre-basic) moult each cycle results in successive adult (basic) plumages. Two subspecies: nominate *frugilegus* introduced to NZ (see Masthead, Distribution). Sexes similar. For detailed description of plumages and bare parts of nominate *frugilegus*, see Witherby (1913) and BWP; see Field Identi-fication (q.v.) for general descriptions and ageing.

MOULTS Following summarized from Witherby (1913) and BWP, with information on timing of moult in NZ based on examination of skins of ten adults (NMNZ). **Adult post-breeding** (Third and subsequent pre-basic). Complete. Primaries outward. Following from BWP unless stated otherwise. In Britain and Europe, starts about May or early June, and finishes about Sept. or early Oct.; in some areas at least, males tend to start moult of primaries slightly earlier than females; individual duration of moult of primaries *c.* 107 days. Secondaries moult inward; start at s1, when PMS 15–25 or slightly later; individual duration of moult of secondaries *c.* 105 days. Moult of tail centrifugal, starting at t1 when PMS 15–30; individual duration of moult of tail *c.* 92 days. Little information on timing of moult in NZ; on NI, active moult of primaries recorded Nov. (4 of 6; mean PMS 11.3 [2.36; 11–13]) and Jan. (1 of 1; PMS 24), latter with following unconventional pattern of primary-moult, of $N^{3}O^{4}N^{1}4^{1}O^{1}$. Two skins from NI in July have all primaries slightly worn, and another two skins in Nov. have all primaries worn. These few data suggest post-breeding moult occurs in summer in NZ. **Post-juvenile** (First pre-basic). Partial. Involves all feathers of head and body, usually all marginal upperwing-coverts, varying number of, or no, median upperwing-coverts, and sometimes a few inner greater secondary upperwing-coverts; some birds also replace one or more feathers of alula, some primaries or some rectrices. In Britain and Europe, moult starts when 6–7 weeks old, usually from late June to early Sept., and finished from early Aug. on (BWP). No information on timing of post-juvenile moult in NZ, but probably starts late spring or early summer. **First immature post-breeding** (Second pre-basic). Complete. In Britain, moult of primaries starts, on average, 1 week earlier than adult post-breeding. No information for NZ.

MEASUREMENTS NOMINATE *FRUGILEGUS*: (1–3) NI and SI, NZ, skins: (1) Adult males (NMNZ); (2) Adults (CM, NMNZ), probably including some from sample (1) (Niethammer 1971). (3–5) SI, carcasses, sexed by examination of gonads; Bill S and Tarsus measured to nearest 5 mm (R.E.R. Porter & P.C. Bull): (3) Adults; (4) First immatures, *c.* 1 year old; (5) Juveniles. (6) Scotland, live or freshly dead, adults (BWP). (7) W. Europe (Netherlands, Belgium, Germany), adults, skins (BWP). (8) Germany, adults, skins (Niethammer 1971). (9) Great Britain, adults, skins (Witherby 1913).

		MALES	FEMALES	
WING	(1)	318.8 (10.74; 297–333; 10)	–	
	(2)	317.6 (11.40; 300–339; 14)	298.0 (3.76; 292–305; 11)	**
	(3)	317.3 (8.33; 303–335; 41)	300.3 (8.75; 284–333; 35)	**
	(4)	299.3 (8.38; 289–316; 13)	283.9 (5.60; 275–309; 12)	**
	(5)	294.4 (17.08; 258–315; 17)	279.9 (19.05; 258–303; 10)	*
	(6)	321.6 (6.70; 305–338; 102)	300.8 (7.70; 280–314; 54)	**
	(7)	322.9 (6.00; 311–335; 47)	306.6 (5.62; 297–320; 54)	**
	(8)	314.9 (292–332; 10)	303.9 (287–321; 10)	
	(9)	315.4 (305–330; 12)	301.9 (290–311; 10)	
TAIL	(1)	174.1 (15.79; 162–210; 10)	–	
	(3)	168.4 (35.22; 158–189; 42)	160.9 (26.17; 155–173; 35)	ns
	(4)	166.1 (7.12; 147–178; 13)	157.4 (5.70; 150–167; 12)	**
	(5)	166.6 (9.98; 144–181; 17)	159.1 (12.92; 131–171; 10)	ns
	(7)	176.8 (4.57; 170–186; 23)	165.1 (5.30; 154–176; 27)	**
BILL S	(1)	61.2 (2.53; 55.9–64.7; 10)	–	
	(3)	59.0 (2.07; 56–63; 41)	54.9 (2.17; 52–61; 35)	**
	(4)	56.4 (2.51; 54.5–60; 12)	53.5 (2.87; 48.5–57.5; 12)	**
	(5)	53.5 (2.64; 47–57; 17)	48.7 (2.25; 43.5–51.5; 10)	**
	(7)	61.7 (2.81; 57.5–66.5; 44)	57.6 (1.49; 55.0–66.0; 36)	**
TARSUS	(1)	54.5 (2.34; 51.6–59.2; 9)	–	
	(3)	55.1 (1.59; 52–58.5; 41)	52.6 (1.66; 50–56; 35)	**
	(4)	54.7 (2.11; 51–57.5; 13)	51.0 (2.08; 48–54; 12)	**
	(5)	55.4 (1.94; 51.5–58.5; 17)	52.7 (0.91; 51–54; 10)	**
	(7)	56.9 (1.69; 54.0–59.5; 31)	54.1 (1.49; 51.0–56.5; 30)	**

WEIGHTS NOMINATE *FRUGILEGUS*: (1) NI and SI, NZ, adult males, from museum labels (NMNZ). (2–4) SI, carcasses (killed by poison), sexed by examination of gonads (R.E.R. Porter & P.C. Bull): (2) Adults; (3) First immatures, *c.* 1 year old; (4) Juveniles. (5) Scotland, adults and first immatures (BWP).

	MALES	FEMALES	
(1)	412.1 (53.91; 298–480; 13)	–	
(2)	428.0 (40.34; 245–543; 227)	373.8 (37.99; 295–524; 222)	**

(3)	398.3 (39.77; 315–519; 52)	344.1 (35.32; 244–440; 70)	**
(4)	367.4 (36.83; 300–445; 17)	329.8 (37.72; 253–385; 10)	**
(5)	489.0 (30.24; 405–560; 162)	418.0 (34.52; 325–525; 126)	**

Data from birds poisoned on SI indicate that juveniles weigh less than adults (P<0.01, sexes separate), and juvenile males weigh less than first immature males (P<0.01). First immatures weigh less than adults (P<0.01, sexes separate).

STRUCTURE See BWP for full details; see Field Identification for summary.

GEOGRAPHICAL VARIATION Nominate *frugilegus* the only subspecies known to have been introduced to NZ (NZRD). Skins (NMNZ) of ten adult males, all collected NI, all have bare skin on anterior facial area (upper chin, lores and area around base of bill), which characteristic of nominate (cf. subspecies *pastinator* from e. Asia, which have mostly feathered lores and chin).

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Volume 7 (Part A), Plate 22

Rook *Corvus frugilegus* (page 678)
NOMINATE *FRUGILEGUS*: **1** Adult; **2** Juvenile; **3** First immature; **4** Adult

Little Crow *Corvus bennetti* (page 745)
5 Adult; **6** Juvenile; **7** Adult

Torresian Crow *Corvus orru* (page 757)
SUBSPECIES *CECILAE*: **8** Adult; **9** First immature; **10** Adult

House Crow *Corvus splendens* (page 770)
11, 12 Adult