

Order ANSERIFORMES

Medium-sized to large aquatic, marine and terrestrial birds. Three families: (1) Anhimidae (screamers), (2) Anseranatidae (Magpie Goose) and (3) Anatidae (true wildfowl); Screamers confined to South America, Magpie Goose confined to Aust. and New Guinea, and rest cosmopolitan. Suggestion that the order is distantly related to Phoenicopteriformes and Ciconiiformes (see Sibley & Ahlquist 1972) now seems unlikely. Claims for some anatomical similarities with gamebirds such as Cracidae, suggesting distant affinity with Galliformes via Anhimidae and Anseranatidae (Simonetta 1963; Johnsgard 1968; Bock 1969), strongly rejected by Olson & Feduccia (1980).

All members of the Anseriformes are web-footed (in some semi-palmate) swimming (some now almost terrestrial) and diving birds that are filter-feeders or are derived from aquatic filter-feeders. They differ from Galliformes in almost every anatomical feature (see Olson & Feduccia 1980). The unique filter-feeding mechanism is diagnostic of the order. Two groups of filter-feeding birds probably evolved from some charadriiform origin; in one, the specialized mechanisms for filtering evolved in the lower mandible (flamingoes); in the other, the upper mandible housed the specialized tongue used to provide the pump-action for filtering. The complex structure of the bill and its operation during filter-feeding in a typical duck has been investigated recently (Zweers 1974; Zweers *et al.* 1977; Kooloos 1986; Kooloos & Zweers 1989; Kooloos *et al.* 1989). Sensory apparatus of the bill associated with this filtering function is likewise complex (Berkhoudt 1980). The typical bill, representing the fundamental apparatus unique to the order, acts as a double-action suction-pump in which fluid is drawn in at the tip and expelled past filter plates at the sides and rear. The tongue and internal shape of the bill provide the elaborate piston effects and the lamellae or fine plates, common to all members of the order, act as the sieves. Lamellae trap the food, which is then brushed free and swallowed by the combined actions of tongue and lamellae. Vestigial lamellae occur in screamers (Olson & Feduccia 1980). Filtering is the original feeding method and departures from it towards adaptations for grazing in geese, serrated edges for catching fish in 'saw-billed' ducks (mergansers and allies) or superficially fowl-like bill of screamers, are all derived features (Olson & Feduccia 1980). Anhimidae, however, being extralimital, are not considered further.

The innovative modern classification of the ducks, geese and swans, and the systematic order proposed by Delacour & Mayr (1945, 1946) and Delacour (1954-64), was modified by Johnsgard (e.g. 1965a, 1968) in the light of further studies, particularly on behaviour and social signals, and new information on little known species. Woolfenden (1961) and Livezey (1986) have prepared phylogenetic analyses of the order based on morphological characters, and the classification by Livezey has been followed by some recent works (e.g. Madge & Burn 1988). Madsen *et al.* (1988) provide important additional information from DNA studies and give a partial classification of the order. We have adopted the classification of Johnsgard in Peters with some modification concerning only those species within our area. Our reasons for these changes are as follows but the arrangement of species fits closely the proposed classification of the order given by Sibley *et al.* (1988) and Madsen *et al.* (1988). The arrangement is consistent with the persuasive argument presented by Olson & Feduccia (1980) concerning the origin and evolution of the order. The fossil *Presbyornis* (Eocene; North America) and the endemic *Stictonetta* (Freckled Duck) and *Malacorhynchus* (Pink-eared Duck) of Aust. have special significance in this respect (see Olson & Feduccia 1980).

Special features of *Stictonetta* are: reticulated anterior face of tarsus; lack of a syringeal bulla; no speculum; unpatterned downy young (see Frith 1964a,b). Structure of the trachea and syrinx described by Ramsey (1878) and in more detail by Campbell (1889) and in Campbell demonstrate the lack of any development of a swollen bulla in drake. Claim by Frith (1964a, 1965, 1967, 1982) that tracheal loop occurs in mature drake is unconfirmed in many hundreds of birds examined (G.F. van Tets). Long neck. Uropygeal wax esters like those of some swans (Edkins & Hansen 1972) but chemotaxonomy difficult to interpret because similarities also shown with *Cereopsis*, *Branta*, *Cairina*, *Tadorna*, *Mergus* and *Melanitta* (Jacob & Glaser 1975). Brush (1976) has shown that the feather-proteins are unique. Verheyen (1953) on skeletal characters (cranial & post-cranial) concluded that it was sufficiently distinct to be separated from other waterfowl. Clearly it shows a large number of 'primitive' characters. Olson & Feduccia (1980) emphasize several features of the cranium that are unique in living ducks: the markedly recurved rostrum and mandible and the expanded lachrymal. Livezey (1986), largely from osteological characters, supports traditional conclusions that it is the last branch of the waterfowl with reticulate tarsi and places it after the geese and swans. Faith (1989) has shown that many of these skeletal characters might be explained on divergence between diving, dabbling and grazing adaptations. Recent DNA studies (Madsen *et al.* 1988) lend some support to an earlier suggestion, based on behaviour and some morphological features, of possible similarity with Oxyurinae (Johnsgard 1965b). Fullagar *et al.* (in press) add support to idea that *Stictonetta* has several behavioural similarities with stiff-tails. The uniqueness of this species has been widely supported, but in the past the absence of information about its behaviour and ecology ensured that it remained doubtful to which other group of

wildfowl it was most closely related. Many of these deficiencies have now been resolved (see text elsewhere) and the argument for a link with stiff-tails has become more compelling. Plumages, social signals and vocalizations are all in some way most readily comparable to *Oxyura* and *Biziura* but specially to *Heteronetta*. A seasonally colourful bill in the male most closely matches the condition found in *Heteronetta* but also in most stiff-tails; sequence of moults follow unusual pattern found in at least some, if not all, stiff-tails but not known in other wildfowl, notably the presence of a post-juvenile moult including wings. Many characteristics of breeding biology (nest-construction and choice of site; small clutch-size; predisposition to dump laying; appearance and quantity of down used in lining nest; unpatterned ducklings) are features shared with most stiff-tails. In particular the unusual copulation involving greatly elongated pseudopenis is most closely comparable with features shown only by stiff-tails.

Major recommended works of reference are: **Comprehensive accounts:** Delacour (1954–64); Todd (1979); Phillips (1922–26) [ducks]; Scott (1972) [swans]; Owen (1980) [geese]. **Regional accounts:** Palmer (1976) [Nearctic]; BWP [w. Palaearctic]; Bauer & Glutz von Blotzheim (1968–69) [Europe]; Frith (1982) [Aust.]. **Field guides:** Scott (1988); Madge & Burn (1988). **Special studies:** Hochbaum (1955, 1973) and Sowls (1955) [migration and habits]; Johnsgard (1965a) [complete review of behaviour]; Hochbaum (1944); Driver (1974) and Kear & Berger (1980) [species monographs].

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Family ANATIDAE wildfowl

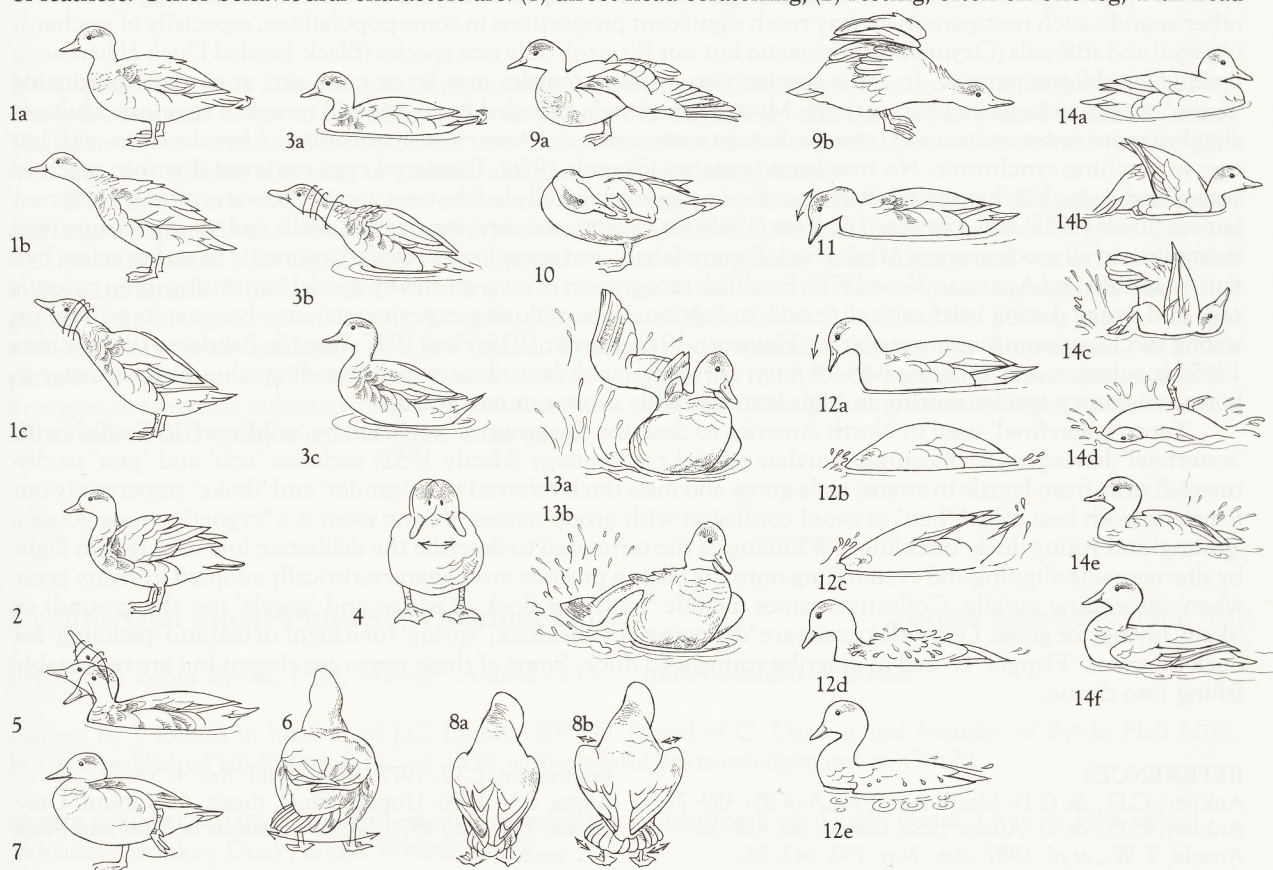
Waterbirds (some more or less terrestrial) with rather short legs and front toes connected by webs; hallux elevated and reduced. Though considerable adaptive diversity in outward appearance, size, colours of plumage, behaviour, and ecology, homogeneous in many characters, as attested by numerous, often fertile, interspecific hybrids reported, chiefly in captivity (see Gray 1958). About 160 species in six sub-families: (1) Dendrocygnae (whistling-ducks); (2) Oxyurinae (stiff-tails and Freckled Duck); (3) Anserinae (swans and geese); (4) Tadorninae (shelducks, sheldgeese and steamer-ducks); (5) Anatinae (dabbling ducks and allies); (6) Merginae (eiders, scoters, mergansers and allies).

Body, broad and rather elongated in many, though more rotund in some, especially diving species. Plumage, thick and waterproof; contour-feathers distributed over distinct feather-tracts with underlying coat of down. Neck, medium to long. Wings generally rather small; mostly pointed, fairly broad in many, but narrower in some highly migratory species. Small claws on first and second digits occur in most. Spurs—horny sheathed bones—occur in several species as projections near carpal joint; attached either to radial carpal or the metacarpal. Wing-spurs are found in the Tadorninae and *Sarkidiornis*, *Plectopterus* and *Merganetta* in the Anatinae. Eleven primaries; p9 nearly always longest, p11 minute. Wide range in number of secondaries, from 12 to 24, innermost (tertials) often long and brightly coloured; diastatic. Many species, particularly in Tadorninae, Anatinae and Merginae have a specialized, contrastingly coloured patch (speculum) on upper surface of inner wing, important for sexual and social signalling. Most fly fast and have large, high-keeled sternum. Tail, short and square or slightly rounded in most; long in some diving species (serving as rudder), pointed or with elongated central feathers in some others. Tail-feathers, 14–24 but varying even in single species. Bills show much adaptive variation but typically of medium length, broad, often flattened centrally and distally but high at base, and rounded at tip with horny nail at tip, producing slight terminal hook; covered with soft skin. Edges of mandibles with rows of lamellae, showing different development in various ecological types and taxonomic groups; most highly specialized in surface plankton-feeders, least so in species (such as scoters *Melanitta*) that swallow molluscs whole. Tongue, thick and fleshy; epithelium covered with papillae and horny spines. Lower part of tibia and tarsus bare; front toes connected by webs (reduced in a few species), hind toe elevated. Gait, striding or waddling. Oil gland, feathered. Aftershaft, reduced or absent. Special intromittent copulatory organ present in males; vascularized sac everted from wall of cloaca, protruded by muscular action; facilitates sexing by examination (Hochbaum 1942), even of small young. Salt-secreting nasal glands subject to adaptive variation in size, even in same species; enlarged in forms inhabiting saltwater or brackish habitats, modifying profile of head considerably. In many species, males have remarkably lengthened, bent, or locally widened trachea forming resonating tubes; also syngo-bronchial sound-boxes (bullae), either fully ossified or with membranous fenestrae. These vocal structures highly characteristic of species or larger taxonomic units (see Eyton 1838 and, especially, Johnsgard 1961, 1971). Considerable diversity in types of plumage: male and female similar, nearly similar, or show extreme sexual dimorphism. In all species, except some sheldgeese, flight-feathers moulted simultaneously, producing period of flightlessness lasting 3–4 weeks. Two body-moult per cycle. Young precocial and nidifugous, covered with thick down; pattern often cryptic and characteristic of taxonomic groups within sub-families. Able to swim soon after hatching.

Cosmopolitan, but absent from continental Antarctica and some islands. Usually on or close to water. Highly vulnerable to human pressures on habitats. Labrador duck *Camptorhynchus labradorius* extinct during last century, and three more (Crested Shelduck *Tadorna cristata*, Pink-headed Duck *Rhodonessa caryophyllacea*, Auckland Merganser *Mergus australis*) probably so this century. A few species domesticated: Swan Goose *Anser cygnoides*, Greylag Goose *A. anser*, Muscovy Duck *Cairina moschata*, and Mallard *Anas platyrhynchos* (Goodwin 1965); some populations of a few more (Mute Swan *Cygnus olor*, Canada Goose *Branta canadensis*, Egyptian Goose *Alopochen aegyptiacus*) kept in semi-domesticated or feral conditions.

N. forms often highly migratory and tied to Arctic or high latitudes for breeding, exploiting brief but productive period each year to raise young; for many of these species autumn movements preceded by marked moult-migrations by males to special areas for period of flightlessness. More sedentary in warmer latitudes, specially in equatorial regions. The term 'boreal' for these n. wildfowl is useful to draw attention to the marked differences between the breeding ecology of n. high-latitude wildfowl compared with many s. hemisphere species for which the term 'austral' has been used (Fullagar *et al.* 1988). In general, most austral species are more sedentary and certainly lack spectacular migrations. Regular movements in most s. hemisphere species are at best only local. Occasional much wider dispersal is often initiated by factors such as flooding rains and drought (specially in Aust.). Many austral ducks exploit seasonally persistent or occasional, extremely propitious conditions by responding with an extended breeding season. In reality, most are seasonal breeders but productivity of some will vary greatly according to rainfall and flooding; most notable with many species in Aust. For further details see Fullagar *et al.* (1988).

Wide range in diet, from totally vegetable to totally animal, and in feeding habits, from terrestrial grazing to bottom diving; correlated with conspicuous adaptations in structure of bill, musculature of head, length of neck, and in general proportions of body. Terminology of feeding methods in species accounts mainly after Szijj (1965) and Bauer & Glutz (1968, 1969); see also Olney (1963). Typical filtering action of most members of the order, described earlier, best termed 'suzzling'. Most species gregarious, feeding, loafing, roosting, and travelling in cohesive flocks, integrated by calls and special pre-flight signals. Generally solitary breeders nesting in concealed sites, though some species colonial, either habitually or, more often, as alternative to dispersed nesting, usually in protected areas such as islands. Degree of territorialism when breeding and relation between territory and nest-site vary between species and larger taxa; some strictly territorial; others occupy wholly or largely undefended home-ranges. Monogamous pair-bond in most species but much variation between taxonomic groups in duration of bond and degree of male promiscuity (if any). Social systems and displays correlated with formation and maintenance of pairs; complex (see classic work of Lorenz 1951-53) and largely dissimilar in six sub-families (see below). Copulation on water in all species (except some Anserinae and Tadorninae), typically with male grasping female's nape in bill. Vocalizations varied but generally simple (mainly honks, grunts, quacks, coos, and whistles); often different between sexes when linked with anatomical differences in vocal apparatuses (syringeal bullae). Non-vocal sound-signals produced in some species. Calls of downy young are: (1) Contact or Greeting Call (also termed Pleasure and Contentment Call) and (2) Distress Call (see Kear 1968). Comfort-behaviour well known. Bathing frequent and elaborate. Typically performed while swimming in water too deep for standing; involves head-dipping, wing-thrashing, somersaulting, and diving. Followed by oiling (with use of bill and head) and preening. Full description of comfort movements, the behaviour patterns of shaking, stretching, preening, bathing and related activities given by McKinney (1965). The diagrams (Figs 1 to 14) based on those from McKinney illustrate most of these actions, all of which are common to all wildfowl. Some essentially aquatic species (genera *Thalassornis*, *Oxyura* and *Biziura*) have other, slightly specialized, preening and shaking actions peculiar to them because they are performed on water. No elaborate thermoregulatory responses except erection of feathers. Other behavioural characters are: (1) direct head-scratching; (2) resting, often on one leg, with head



Figs 1-14. Comfort movements of Anatidae (based on Grey Teal): (1a-c) Body-shake; (2) Wing-shake; (3a-c) Swimming-shake; (4) Head-shake; (5) Head-flick; (6) Tail-wag; (7) Foot-shake; (8a,b) Wing-shuffle and tail-fan; (9a) Wing-and-leg Stretch; (9b) Both-wing Stretch; (10) Foot-pecking; (11) Bill-cleaning; (12a-e) Head-dipping; (13a,b) Wing-thrashing (14a-f) Somersaulting.

turned back and bill inserted in scapulars on same side as lifted leg (Heinroth & Heinroth 1954), latter being characteristically stowed away in waterproof flank 'pocket'.

Breeding strictly seasonal in boreal, migratory species and populations; less so or opportunistic at warmer latitudes. For most wildfowl, censuses of breeding numbers extremely difficult. Although breeding habitat and nest-sites show considerable diversity, nests usually placed over water or on or near ground. Well hidden in vegetation or sometimes concealed in other dark places such as burrows and tree holes (or nest-boxes); some species also use old nests of other birds or cliff ledges. Often near water but some species may at times nest far away from it. Nests made only of vegetation, or other materials, within reach of sitting bird, using side-building method (see Harrison 1967). In spite of limited scope of this method materials are often collected from large area by repeated movements of this form. Nest usually lined with down plucked from female's belly (often cryptic and grown specially for this purpose). Value of down for insulation and for concealing nest examined for arctic geese by Thompson & Raveling (1988). Eggs, large, immaculate; surfaces greasy. Clutches often large. Regulation of clutch-size in Anatidae has been the subject of much investigation in n. hemisphere (Rohwer 1984, 1988), but has received little attention in s. Proximate (physiological and psychological [Lack 1974]) factors that may regulate clutch-size include availability of food, condition of birds, weather, age or experience of the breeding birds, ability to incubate, and, of the female, to acquire resources for production of eggs, time of breeding, hormonal levels and interactions between two or more of these (Bengston 1971; Johnsgard 1973; Braithwaite 1977; Ankney & MacInnes 1978; Drent & Daan 1980; Duncan 1987; Ankney & Afton 1988; Kingsford 1989; Briggs 1990). Ultimate (evolutionary [Lack 1974]) factors that may regulate clutch-size are availability of food, condition of birds, length of breeding season, weather, predation and viability of eggs, ability to incubate and rear brood, time of breeding, trade-offs between annual reproductive effort and residual reproductive value, and interactions between two or more of these (Williams 1966; Lack 1967; Ryder 1970; Johnsgard 1973; Braithwaite 1977; Pellis & Pellis 1982; Toft *et al.* 1984; Lessells 1986; Arnold *et al.* 1987; Briggs 1990). Both proximate and ultimate factors can act together to influence clutch-size. Eggs laid at intervals of 24 h in most species but longer in some. Clutch covered by down in most species during recess of adult. Some species may lay some or all of their eggs in nests of other anatids; such nest-parasitism may reach significant proportions in some populations, especially of pochards (*Aythya*) and stiff-tails (*Oxyura* and *Stictonetta* but not *Biziura*); only one species (Black-headed Duck *Heteronetta atricapilla*) obligate parasite. In some species, two or more females may lay at same site, at extreme producing 'dump' of eggs without incubating them. Most species single-brooded but many will re-nest if eggs lost. Multiple clutches more common in austral species. Except some species of Anserinae, incubation by female; starts with last egg; so hatching synchronic. No true brood-patches (Skutch 1976). Displaced eggs retrieved if within reach of sitting bird, using bill. Eggshells left in nest. Downy young typically led, but not carried, to water after leaving nest but see SOWLS (1955) and Johnsgard & Kear (1968) for exceptional carrying of eggs, shells and young. Young feed themselves in all species except Musk Duck *Biziura lobata*, but some food provided indirectly in earlier stages by a few Anserinae and Anatinae (Kear 1970). Establish recognition of own species by special imprinting upon parent's calls and image during brief critical period; exceptionally (e.g. during experiments) may become imprinted on wrong species or even inanimate objects (Heinroth 1911; Lorenz 1935; Hess 1957; Boyd & Fabricius 1965; Schutz 1965). Incubation and fledgling periods vary, correlated with latitude at which breeding takes place; shorter in boreal migratory species nesting in high latitudes with short summer season.

Term 'waterfowl' used in North America to describe the group is restricted by 'wildfowl' in English with 'waterfowl' having wider meaning. Further special terminology (Hardy 1952) includes 'cob' and 'pen' to distinguish male from female in swans; male goose and male duck referred to as 'gander' and 'drake' respectively but female in both best called 'hen' to avoid confusion with group names. Young swan is a 'cygnet'; young goose a 'gosling' and young duck 'duckling'. 'Whiffling' is the term used to describe the deliberate loss of height in flight by alternate side-slipping and even rolling onto the back; a practice most characteristically adopted by many geese when descending rapidly. Collective names include 'herd' for flock of swans and 'gaggle' (on the ground) or 'skein' (flying) for geese. Less well known are 'dropping' for shelduck; 'spring' for a flight of teal and 'padding' for duck on water. 'Flapper' is used to describe young wild duck. Some of these terms are elegant but are regrettably falling into disuse.

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Sub-family ANATINAE ducks

Small to fairly large wildfowl. Tarsi scutellate in front. Marked sexual dimorphism in plumage and structure of syrinx in most species; correlated with sexual differences in visual displays and voice. About 70 species, composing four main groups: (1) so called 'perching ducks' and allies; (2) Torrent Duck (polytypic species in genus *Merganetta*, South America); (3) typical dabbling ducks (very large genus *Anas* and monotypic *Marmaronetta*) and (4) pochards (*Netta*, *Aythya* and extinct *Rhodonessa*).

Trachea of male usually with bony, asymmetrical bulla on left side of syrinx. Double annual moult in both sexes, resulting in two recognizable plumages. These usually closely similar and cryptic in females, though non-breeding plumage usually duller. Breeding plumage of male of many species in temperate regions elaborate and colourful ('bright'), contrasting with sombre and cryptic non-breeding plumage (eclipse) usually worn for short period in boreal species, during and following flightless period and post-breeding moult and resembling plumages of females and juveniles. Loss of bright plumage in some austral species much more complex. Wing typically brightly coloured in both sexes, often with metallic speculum on greater coverts and secondaries, which contrasts with colourful median and lesser wing-coverts or tertials; this pattern maintained all year, wing being moulted only once. As a rule, juvenile plumage resembles female plumage, but juveniles separable by tail-feathers (notched tip with bare shaft protruding) and by narrower, shorter, and more pointed body-feathers and wing coverts. Juvenile body-plumage moulted within a few months of hatching (3–4 months). In some species breeding in first year, this plumage involves growth of only a few new feathers and is quickly replaced by breeding plumage; in others that defer breeding until second year, immature plumage more complete and retained longer, being only gradually replaced by breeding plumage during whole first year of life. In all, juvenile wing retained until first complete moult in summer of second calendar year, although tertials often and some wing-coverts sometimes replaced earlier.

TERMINOLOGY OF PLUMAGES. Bright (breeding) male plumage of most duck species (often termed 'nuptial' in ornithological literature and more accurately 'alternate'; see Humphrey & Parkes 1959; Humphrey & Clark 1964) usually worn for much of year when birds not actually breeding, including autumn and winter when pair-bonds initiated and maintained until nesting in spring (see below). Thus, males often attain non-breeding plumage (basic) soon after start of nesting when their reproductive activities (but not those of females) are over. In females, though timing of both moults tends to correspond roughly with those of males, also subject to adaptive variation. In many species, post-breeding moult of females more protracted, with greater individual variation in timing, particularly in successfully breeding females; moult usually inhibited during nesting, starting 1–2 months later than in males. Females of some species (e.g. some dabbling ducks) start moult shortly before nesting and therefore incubate and rear young in basic plumage. Although such females in fact nest in 'non-breeding' plumage, terminology sometimes maintained for reasons of homology.

Perching ducks and aberrant species

Small to fairly large wildfowl, usually living in well-wooded areas, most freely perch in trees, and often nest in holes high above ground. Some semi-terrestrial. Highly diversified group of 19 species in 15 mainly monotypic genera, often showing striking convergences with other Anatidae and some regarded now as more properly assigned to other sub-families, specially Tadorninae. Most are here retained in Anatinae following Johnsgard (1965) and Peters. Two groups: (1) more generalized genera *Plectropterus* (Spur-winged Goose in Ethiopian Africa), *Cairina* (Muscovy Duck of neotropical America; White-winged Wood Duck of se. Asia), *Pteronetta* (Hartlaub's Duck of Africa), and *Sarkidiornis* (Comb Duck of South America, Ethiopian Africa, s. Asia); (2) more specialized genera *Nettapus* (three pygmy-geese of central Africa, India to Aust.), *Callonetta* (Ringed Teal of South America), *Aix* (Carolina Duck *A. sponsa* of North America and Mandarin *A. galericulata* of e. Asia), *Chenonetta* (Maned Duck of Aust.), and *Amazonetta* (Brazilian Teal of South America). Also considered here are two very specialized A'sian genera *Malacorhynchus* (Pink-eared Duck of Aust.) and *Hymenolaimus* (Blue Duck of NZ) and *Merganetta* (Torrent Duck of South America) and *Salvadorina* (Salvadori's Duck of New Guinea). Five species in our region.

Wings, often wide and rounded; bony, spur-like knob on metacarpal joint in some. Tails, fairly broad and elongated; slightly graduated but not pointed. Bill, rather thick and goose-like, not depressed, often heavy; large nail; highly specialized structures in *Malacorhynchus* and *Hymenolaimus*. Hind toe well developed, not lobed, and claws strong and sharp at all ages; legs set far forward, tarsus usually short (especially in *Nettapus*), but longer in some (especially semi-terrestrial *Plectropterus*). Usually do not dive, but *Hymenolaimus* specialized river duck. Male noticeably larger than female in some species. Sexes differ in tracheal structure to varying degrees; except in *Nettapus*, *Malacorhynchus* and *Hymenolaimus*, males with bony enlarged bullae; in *Aix*, rather large and rounded, somewhat resembling a dabbling duck. Plumage bright in many; often iridescent, especially in more

generalized genera. Patterns more complex in other genera, particularly *Aix*. No real speculum in most species but tertials and wing-coverts often bright and metallic. Sexual dimorphism slight in some, considerable in others, especially *Aix*. Eclipse plumage in *Aix*, *Nettapus* and *Chenonetta*. Juveniles, like adult females. Downy young, patterned dark brown and white or yellow, most like those of dabbling ducks; in some species remarkable for long stiff tails and capacity for climbing.

Cosmopolitan but most species tropical or subtropical. Most species surface-feeders, some very specialized, though others (notably *Plectropterus* and *Chenonetta*) terrestrial grazers. Often in flocks. **Pre-flight** signals diverse; include **Neck-craning**, **Chin-lifting**, and **Head-thrusting** movements, also lateral **Head-shaking**. Social patterns and behaviour of *Chenonetta* most like those of typical dabbling ducks. **Inciting** display of female also much as in *Anas*. In more generalized genera, however, pair-bonds weak or absent (Johnsgard 1965). Pre-copulatory behaviour varies; includes **Head-pumping** (as in *Anas*), **Head-dipping**, and **Bill-dipping**. Post-copulatory behaviour also varies, but little studied. Voice characteristics vary; sexually differentiated to greater or lesser extent. Male calls mostly whistles; female calls honking, quacking, or squeaking (characteristic **Decrescendo** calls of *Anas* lacking). Some species more or less silent. Torrent Ducks are specialized river-ducks inhabiting rapids and fast-flowing rivers of the Andes of South America; very noisy. *Salvadorina* is similarly specialized but is not necessarily closely allied to the Torrent Ducks. Little is known of its social behaviour and ecology.

Dabbling ducks (known also as surface-feeding, puddle, or river ducks)

Fairly small to medium-sized wildfowl. About 40 species in two genera, *Anas* and *Marmaronetta* (Marbled Teal of Mediterranean and w. Asia; has also been placed with pochards but not considered further here). More than 40 species in *Anas*, including following main species-groups, mostly in Holarctic, some or all formerly treated as separate genera: (1) wigeons, three species including *A. sibilatrix* vagrant to S. Georgia; (2) gadwalls, all Holarctic; (3) true teals, including several s. hemisphere species (about ten) typified by Grey Teal *A. gracilis* of Aust.; (4) pintails, including *A. eatoni* and *A. georgica* in our region; (5) mallards, including *A. superciliosa* of Aust. and NZ; and (6) blue-winged ducks, including Australasian Shoveler *A. rhynchotis*. Term 'teal' used loosely in ornithological literature to indicate small ducks generally, not only in different species-groups of *Anas*. Bodies fairly slender. No marked difference in size between sexes (males somewhat larger). Wings, long and pointed; in flight, wing-beats less rapid than in pochards and other diving ducks. Tails, usually fairly short, pointed; central feathers elongated in some species. Bills, fairly long in most species; flattened, with distinct lamellae. Legs, quite short and inserted centrally giving horizontal stance; hind toe much reduced, not lobed. Take-off from water and land with facility. Walk easily but with waddling gait; able to perch well, though only a few species regularly perch in trees. Dive rather poorly, submerging briefly with use of wings. Sexes differ in tracheal anatomy, males having enlarged rounded bony bullae on left side of syrinx. Plumage of both sexes usually with bright speculum. In many species, sexes alike also in other plumage characters; most of these rather sombre or wholly cryptic but some quite bright; in both types, non-breeding plumage differs little from breeding. In many species of *Anas*, particularly migrants within temperate parts of n. hemisphere, males only with bright plumage worn for much of year; alternates with eclipse plumage during flightless period at post-breeding moult. Females of these species highly cryptic at all times. Colour of bill or foot, or both, sometimes bright. Juveniles resemble adults in non-breeding plumage. Downy young, typically brown and buff or yellow, often with dark and light streaks on sides of head and light spot on each wing and on each side of back or rump.

Cosmopolitan and predominantly continental in distribution, though some island forms. Adapted for living in shallow, biologically productive waters. Many species prefer plenty of vegetation, marginal, submerged, and often emergent and floating. Range widely through mid-latitudes, penetrating into Arctic tundra or even taiga zones only slightly. Widespread and often the dominant genus in s. hemisphere. Faster streams and unsheltered or offshore marine waters normally avoided. Though some species enter wooded habitats (especially flooded or swamp forests) and others tolerate and even prefer wide-open spaces, most occupy sites with more or less dense fringing vegetation at chosen waters, latter being either standing or slow-flowing with ready access to secure and sheltered resting and breeding places. Need for concealment when breeding or in flightless stage of post-breeding moult may force them, more or less deeply, into dense marginal or emergent vegetation and swamps with little open water; some species nest, at least at times, far from water. As main habitats unstable in many areas, exceptional powers of flight enable reconnaissance of wide range of waters and rapid shift when necessary. Vulnerable to reclamation of wetlands, especially when these few and scattered, but readily accept artificially created waters if they provide suitable feeding areas. Little information on breeding numbers because accurate counts of nests impossible but large-scale ground and aerial counts now sufficiently comprehensive to provide reasonable estimates of wintering numbers and main locations, and, sometimes, tentative indication of trends. Some species migrate over considerable distances, especially in n. hemisphere. Males moult during late summer and early autumn on or near breeding grounds. All large-scale movements mainly nocturnal, sometimes at high altitudes, often in irregular wavy lines.

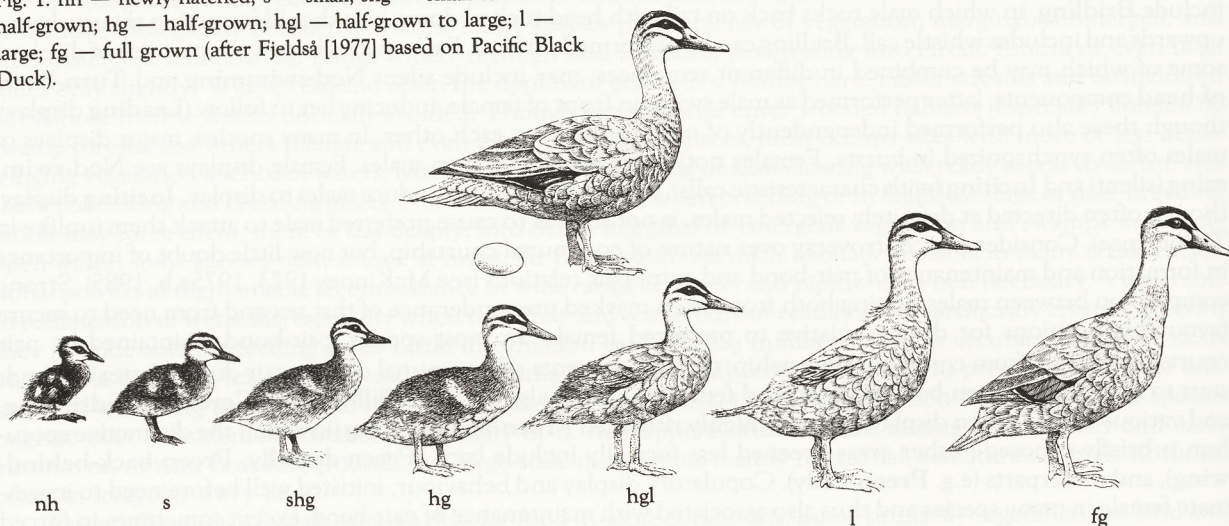
Essentially surface feeders, though dive for food in some conditions. Some primarily vegetarian, on land and

in shallow water. Many omnivorous, taking chiefly seeds and invertebrates mainly from shallow water by dabbling at surface at the same time pumping water and mud through bill, using lamellae to sieve out food (**Suzzling**). Also filter-feed by dipping head and neck below water, and up-ending; some highly specialized filter-feeders (shovelers), others also forage on land. Feed singly, but most often in pairs and flocks; otherwise usually gregarious when not nesting. Main pre-flight signals: lateral **Head-shaking** and repeated vertical **Head-thrusting**. Before and during initial stages of nesting, each pair typically occupies home-range which overlaps with those of other pairs. Within home-range, one or more small areas frequented for feeding, loafing, and preening; variously named 'core area', 'activity centre', 'waiting area' (where male stays while female at nest and where pair meet at times during laying and at times during incubation); defended as territories, to greater or lesser extent, in some species (mainly by male). Monogamous pair-bonds, long-term in monomorphic resident or nomadic, often tropical, species (see Siegfried 1974; Fullagar *et al.* 1988) but more usually of seasonal duration, especially in boreal migratory species. In latter, pair-formation typically starts in flock during autumn and winter after assumption of breeding ('nuptial') plumage, though initial pairings often temporary; final pair-bond ended at some stage during incubation when males again flock. In addition to maintaining firm bond with eventual mate, males of many species also show promiscuous tendencies, displaying to other females and also copulating with them, mainly by forced copulation. Extent of such promiscuity subject to ecological factors that affect intensity of defence of own mate and territory (McKinney *et al.* 1983; Birkhead 1988). Same factors also influence types and frequency of pursuit-flights of a female, which are of three main types: (1) courtship-flights: chase by several males originating from displaying party on water and initiated by female; (2) three-bird flights: chase of intruding pair by single male based on own activity centre; (3) forced copulation intent-flights: chase by several males often ending in attempts at forced copulation. Second and third types connected by intermediates; much controversy over details and interpretation, especially role of such pursuits in dispersing pairs. Courtship, typically on water but sometimes on land or even in flight (during pursuits), of two main types: (1) communal courtship (also termed 'social display') and (2) pair-courtship ('directed courtship' of von der Wall 1965). In communal courtship, often starting in autumn or winter, group of several males typically display to one or more females, both unpaired and (increasingly as season advances) paired birds of both sexes taking part. Courting party develops progressively in many species, as more and more males join in; in some, notably *A. superciliosa* in our region, group typically assembles before display starts. Male displays often elaborate, consisting of secondary and major forms, males tending first to assume special **Courtship-intent** posture, indicative of impending display. Marked tendency for each male to align body parallel to courted female before displaying; components of some displays also show marked directional bias towards female (McKinney 1975a,b). Secondary displays, mainly derived from comfort-behaviour and closely similar to latter in form, usually silent; often precede one or other of major displays. These are: **Upward-shake** and **Wing-flap** (both involving brief rise as bird treads water), lateral **Head-shake** (with bill inclined down), and **Head-flick** or **Head-roll** (with vertical component most marked). Major displays often more elaborate; usually with vocal components produced by contortion of tracheal tubes, which determines posture of neck. These are: **Grunt-whistle** (or **Water-flick**) and **Head-up Tail-up**; in both of which tail elevated and speculum momentarily exposed, specially in latter. **Grunt-whistle** has loud vocal component and deliberate action of spraying stream of water towards female using rapid flick of bill across the surface. **Burp** display, which is mainly a vocal signal, and **Down-up**, which also exposes speculum prominently and includes raising the tail and making contact with the water without directing it away. **Down-up** not usually addressed to female. Other displays include **Bridling**, in which male rocks back on tail with head tucked down into shoulders; action thrusts breast upwards and includes whistle call. Bridling can be performed on land. Each species has own repertoire of displays, some of which may be combined in different sequences; may include silent **Nod-swimming** and **Turn-back-of-head** components, latter performed as male swims in front of female, inducing her to follow (**Leading** display), though these also performed independently of other displays or each other. In many species, major displays of males often synchronized in bursts. Females noticeably less active than males. Female displays are **Nod-swimming** (silent) and **Inciting** (with characteristic calls), either of which may induce males to display. **Inciting** display, though often directed at definitely rejected males, is not such as to cause preferred male to attack them (unlike in Tadorninae). Considerable controversy over nature of communal courtship, but now little doubt of importance in formation and maintenance of pair-bond and extra-pair relations (see McKinney 1973, 1975a,b, 1985). Strong competition between males, arising both from often marked preponderance of that sex and from need to secure favourable positions for display relative to preferred female. In most species, pair-bond maintained by pair courtship distinct from communal courtship, though elements of communal often occur during latter as bonds start to form. Male **Turn-back-of-head** and female **Inciting**; also includes **Bill-dip**, full **Ceremonial-drinking**, and various **Mock-preen** displays, notably highly ritualized **Preen-behind-wing** (in which the distinctive speculum is briefly exposed); other areas preened less formally include back (**Preen-dorsally**, **Preen-back-behind-wing**), and underparts (e.g. **Preen-belly**). Copulatory display and behaviour, initiated well before need to inseminate female in many species and thus also associated with maintenance of pair-bond, except sometimes in forced

copulations. On water, pre-copulatory displays consist typically of mutual **Head-pumping**; post-copulatory displays of males vary more but include **Burp** display, **Bridling**, and **Nod-swimming**. Marked sexual differences in voice. Calls of males vary; often weak nasal, rasping, wheezing, clucking, or rattling sounds but also include penetrating whistles (sometimes followed by grunts) in many species; uttered chiefly during display, when disturbed, aggressive, or separated from mate or companions in flock. Calls of females typically louder and coarser, often quacking; most characteristic vocalizations: **Decrescendo** call (pattern of which tends to be constant individually, facilitating identification) and **Inciting** call. In some species, pair call simultaneously while posturing during and after antagonistic encounters (**Pair-palaver**); when mates separated, often call: **Decrescendo** calls from females; **Burp** calls from males. Non-vocal sound-signals produced in some species. Behaviour includes mass dashing-and-diving during bathing. Most complex repertoire of displays found in almost all teals, pintails and mallards but some of these do not have certain displays; e.g. most pintails and some teals do not have the **Down-up**; most mallards do not have the **Bridle**, except post-copulatory **bridling**. Gadwalls resemble mallards but never **bridle** and some also do not **Grunt-whistle**, **Head-up Tail-up**, and **Down-up**. All wigeons, the silver teals (*A. versicolor*; *A. punctata*) and the blue-winged ducks (typified by the shovelers) do not have any of these displays but all the last group have the added display of **Lateral Dabbling**, often use the **Jump-Flight** (less common in most other *Anas*); courtship pursuit-flights are particularly significant for shovelers. For details see McKinney (1978).

Breeding strictly seasonal in most species; short breeding periods in those forms nesting in Arctic, but more prolonged in others. Sites often on ground, concealed in thick cover, sometimes well away from water; less often in open but in our region commonly either above ground in cavities in trees (will use artificial nest-boxes) and old nests of other species or in vegetation, surrounded by water in most, and again often using old nest-sites of other species. Nests usually well dispersed but sometimes grouped even quite densely, at protected places. Shallow depressions with rim of vegetation, lined copiously with down plucked by female. Building by female only. Eggs oval, yellowish or pinkish-white, grey-green, buff, rarely bluish; smooth. Clutches usually 6–12, averaging smaller in forms on remote islands (see Lack 1968); multiple layings sometimes occur. Replacements laid after loss of eggs and several species normally double-brooded. Eggs laid at 24-h intervals. Incubation by female only, leaving nest two or more times per day when usually joins male (if still present). Incubation periods usually 21–28 days (Johnsgard 1968; Todd 1979). Young cared for only by female in some species in our region, and is typical pattern in boreal ducks but male parental activity common for many austral or tropical species with long-term pair-bonds; in them, male and female accompany young though only female broods them (see Kear 1970; Siegfried 1974; Fullagar *et al.* 1988). Young and parents, particularly the female, communicate and recognize each other by characteristic calls. Young aggressively defended by both sexes in species with dual parental care, but main anti-predator reaction otherwise distraction display of female in form of 'injury-feigning', parent flapping awkwardly over water or land with wings open, exposing speculum, and giving **Distraction** calls. In some species male also defensive but never as demonstrative as female. Young become independent just before or at fledging. Mature at 1 year old. Growth of ducklings can be described by reference to appearance that is usefully categorized in the sequence: newly-hatched (nh); small (s); small to half-grown (shg); half-grown (hg); half-grown to large (hgl); large (l) and full grown (fg) (Fig. 1 after Fjelds  [1977] based on Pacific Black Duck).

Fig. 1. nh — newly-hatched; s — small; shg — small to half-grown; hg — half-grown; hgl — half-grown to large; l — large; fg — full grown (after Fjelds  [1977] based on Pacific Black Duck).



Pochards

Medium-sized, mainly freshwater diving ducks. Designation 'diving duck' used not as taxonomic term but as ecological characterization for these and other ducks that plunge from the surface and swim underwater. Sixteen species in three genera: *Netta* (three species) and *Aythya* (12 species); monotypic *Rhodonessa* (Pink-headed Duck of India and Nepal) recently extinct. *Netta* intermediate in some characters between *Anas* and *Aythya*. Latter composed of three species-groups: (1) typical pochards, none in our region; (2) white-eyed pochards, including Hardhead *A. australis*; (3) scaups, including New Zealand Scaup *A. novaeseelandiae*.

In *Aythya*, body, short and heavy; head, big; wings, broader and less pointed than in typical Anatinae, necessitating faster wing-beats, often producing whistling sound; tail, short; bill, rather heavy (less so in white-eyed pochards), about as long as head, flattened and, in some, wider at tip; legs, short, with large toes and broadly lobed hind toe, and set well apart far back on body. *Netta* similar but body longer and narrower, bill narrower, legs longer and more slender. All take-off from water with some difficulty. *Aythya* clumsy on land; *Netta* much less awkward, with even more upright stance. Though *Netta* somewhat less well adapted for diving than *Aythya* (Delacour & Mayr 1945), all dive with considerable facility, typically without using wings. Sexes differ in tracheal anatomy; as well as showing 1-2 enlargements of tracheal tubes, males have large, rather angular bullae, with several fenestrae, not rounded and evenly ossified as in *Anas* males. Males, mainly patterned simply: black, brown, or chestnut and white; unstreaked females, varying shades of brown. Broad pale (often white) panel on rear half of upper wing; no metallic speculum. In most species, male eclipse. Females often nest in plumage homologous to non-breeding plumage. Bill, usually slate or bluish but red in two *Netta*; eyes, red (most pochards of both genera), white (males of white-eyed pochards), brown or yellow (females of scaup), or yellow (male scaup). Juveniles resemble females. Downy young mostly like other Anatinae but head-stripes faint or absent; young of scaups, dark.

Cosmopolitan, but most species Holarctic. Concentrated both as breeders and in winter on standing fresh water of moderate depth, usually 1-15 m; one Holarctic species (Greater Scaup *A. marila*) marine in winter, partial exception. Tolerate fairly restricted open waters with dense marginal vegetation, even in forest setting. In most areas, suitable sites are not plentiful and vulnerable to desiccation, drainage, and other adverse factors, leading to some instability in distribution and population. Some colonize modern artefacts such as reservoirs, gravel pits, and ornamental waters. All Holarctic species migratory to greater or lesser extent. Species in s. hemisphere have no migration but in Aust. *A. australis* has irregular and sometimes long dispersal movements with large congregations following rainfall and drought.

Range from chiefly vegetarian (e.g. *Netta*) to omnivorous; in some species (e.g. *A. australis*) animal food predominates. Food obtained in water, mainly by diving from surface to bottom. Usually submerge for shorter periods than Merginae. Difference between sexes in preferred depths of diving, and hence in mean duration of dives, recorded in some n. hemisphere species and probably widespread; may be contributory factors in partial winter segregation of sexes in those areas. Most species (especially in *Netta*) also dabble on surface at times, head-dip, and up-end. Feed mainly in pairs and flocks. Largely gregarious at most times. Repeated **Bill-lifting** main **Pre-flight** signal, but **Head-flicks** also frequent in some *Aythya*. Monogamous pair-bonds of short seasonal duration typical in Holarctic species. Promiscuous tendencies of males much less marked than in other Anatinae; except in *Netta*, attempts at forced copulation rare in Holarctic species, and pursuit-flights largely of courtship type. Communal courtship on water much as in other Anatinae though most major displays different. Often nocturnal as well as diurnal. Secondary displays of males are: **Head-flick** and **Upward-shake**, though latter infrequent in some species. Typical major displays, usually accompanied by calls, are: **Sneak** display, **Kinked-neck**, and **Head-throw**. Sneak takes two main forms: full version with head along water; incomplete version (or **Crouch** display) with head inclined forward. **Kinked-neck** involves sudden horizontal distortion of neck; **Head-throw**, the vertical posturing of head above centre of back with bill pointed upwards. Other displays include **Turn-back-of-head**, **Neck-stretch**, and **Coughing**, though some confusion in literature whether **Neck-stretch** and **Coughing** displays differ or are partly the same. In some species, females perform male-like major displays at times; **Inciting** display of same functional type as in other Anatinae but differs largely in form. In most species, some displays used by male in communal courtship also used in pair-courtship; others distinct, including unique **Courtship-feeding** of *N. rufina*. Displays performed by both male and female, sometimes mutually, include **Ceremonial-drinking** and **Mock-preening**. Copulation also part of pair-courtship. Pre-copulatory displays include **Bill-dipping** and **Preen-dorsally**; in *Netta*, also *Anas*-like **Head-pumping**. Prone-posture of female differs from that of *Anas* in that neck stretched diagonally forward not flat on water. Post-copulatory displays include characteristic **Bill-down** posture by male or both sexes. Calls of males often whirring or cooing and not far-carrying, but some (notably scaups) also whistle. Used chiefly in courtship, of two main types given (1) during **Head-throw** and **Kinked-neck** displays and (2) during **Coughing** display. Females usually not highly vocal; calls mostly growling and harsh, louder than those of males, include **Inciting** calls but **Decrescendo** calls lacking in most species. Non-vocal rattling sound produced in **Preen-behind-wing** display in all or most species.

Holarctic species strictly seasonal breeders; probably similar for species in our region. Nests sited over shallow water or on ground never far from water; usually in thick cover. Well dispersed or grouped, sometimes close together. Shallow depressions with rim of available material, lined with down plucked by female. Building by female only. Eggs oval, green-grey or pale buff; smooth. Clutches usually 5-12; multiple laying common in some species. Single-brooded; replacements laid after loss of eggs. Eggs laid at 24-h intervals. Incubation by female only. Incubation period 24-28 days (Kear 1970; Todd 1979). Young cared for by female only. **Distraction** display, in form of 'injury-feigning', occurs (at least in *Aythya*) but less common than in other Anatinae. No true crèching but broods sometimes amalgamated. Young independent at or before fledging in most species. Mature in first year.

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Hymenolaimus malacorhynchos Blue Duck

COLOUR PLATE FACING PAGE 1229

Anas malacorhynchos Gmelin, 1789, *Syst. Nat.* 1: 526; based on 'Soft-billed Duck' of Latham, 1785, *General Syn. Birds* 3: 522 — Dusky Sound, South Island, New Zealand.

Generic name compounded of Greek ὑμήν (skin, membrane) and λαιμός (throat, gullet), referring to bare inter-ramal skin; the specific, of μαλακός (soft) and ῥύγχος (beak) for characters of bill.

POLYTYPIC Nominate *malacorhynchos* SI, NZ; *hymenolaimus* Mathews, 1937, NI, NZ.

FIELD IDENTIFICATION Length 53 cm; weight 770–900 g. Slate or blue-grey duck with pale bill; similar size to Pacific Black Duck *Anas superciliosa*. Endemic to NZ; virtually restricted to white-water streams. Sexes similar but female smaller. No eclipse plumage. Juveniles darker on breast and lack glossy head.

DESCRIPTION **ADULT.** Upperparts, slate-blue with green gloss on crown; mantle and upperback, browner slate-blue appearing faintly spotted or blotched. Underparts, slate-blue; breast, heavily spotted chestnut. Wings, slate-blue above and below; outer secondaries often with white tips; inner secondaries and tertials, edged black. Bill, pink-white with black lip and flexible lobe on each side. Iris, yellow. Legs

and feet, pale grey; black at joints, webs black. **DOWNY YOUNG.** Face, white; dark stripe from bill through eye to nape and from eye to crown; upperparts, dark grey with green gloss; wing, black with white trailing-edge; underparts, white; dark stripe along back of thigh; prominent spot at base of tail, dark chestnut in male, fawn in female. Bill, grey-blue with rosy tip and black lobes. Iris, dark brown. Legs and feet, yellow-brown. **JUVENILE.** Like adults but spots on breast fewer and darker; no gloss on head. Bare parts, like adult but bill, pale grey. Iris, dark brown.

SIMILAR SPECIES Generally unmistakable; uniform blue-grey plumage, pale bill with black tip and specialized habitat distinctive.

In pairs or family groups throughout year on white water of fast-flowing rivers or mountain streams. On water, very skilled swimmer and diver. Feed mostly with head and neck submerged, or by upending, or taking insects from water surface; occasionally dive. Flight strong, direct. Move mainly using currents but fly reluctantly if disturbed. Most active dawn and dusk, sheltering by day out of sight. Males give a high-pitched wheezy whistle *whio* (from which Maori name derived) and short whistle-like *whee*; female, long low grating note and short staccato rasping note.

HABITAT Largely confined to turbulent watercourses in forested mountain ranges. Favoured habitats are rivers and creeks, as narrow as 0.3 m; always with steep gradients, partial shading by overhanging canopy and ground-cover to water's edge, which ensure that water fast-moving, cold, clear and highly oxygenated, and that channel free of silt, where caddisfly larvae, an important food, most common (Kear & Burton 1971). Stable watercourses preferred; small numbers of birds persist in some creeks subject to flooding (Hogarth 1971), but during floods rocks scoured of moss and algae which shelter aquatic larvae, and deposition of silt interferes with feeding (Williams 1958; Child 1980). Feed in shallow or deep water in rapids and pools, taking food from turbulent riffles, eddies downstream from rocks, and from rocky beds or shores (Kear & Burton 1971; Elderidge 1986). Occasionally observed on wide, slow-flowing rivers and edges of lakes, close to preferred river habitat; although found at heads of fiords, not usually in brackish or saline habitats, probably because birds have small salt glands and brackish-water caddisfly rare (Kear & Burton 1971).

Breed throughout range, nesting along banks of rivers in sites concealed by vegetation, rocks or overhangs, or in caves. Dive freely in pools to feed from bottom; observed diving repeatedly in water 3 m deep (Kear & Burton 1971). Fly when disturbed, usually keeping low.

Range and numbers decreased since European settlement. No longer occur in lowlands, where destruction of waterside vegetation by clearing and grazing by stock has increased flooding, scouring, deposition of silt, rise in nutrient levels and de-oxygenation of water in rivers. Introduced trout may compete for food, but not studied (Kear & Burton 1971).

DISTRIBUTION AND POPULATION Endemic to NZ. Formerly widespread NI and most of SI, now more restricted: w. SI and increasingly localized in central NI, rare or absent elsewhere on main islands (NZCL; NZ Atlas; M.J. Williams).

POPULATION Estimated 2000-4000 (M.J. Williams). Within its specialized habitat, highly territorial. Breeding success low and varying and only spasmodic recruitment into breeding population; changes in breeding density, slow (M.J. Williams).

MOVEMENTS Essentially sedentary, adults being strictly territorial (Elderidge 1986). In past, severe cold sometimes forced them to lower altitudes where occasionally gathered in small flocks (Potts 1871; Soper 1965) or moved to coast (Buller 1888), but this no longer occurs (M.J. Williams). Normally however, little movement of adults. Dispersive after fledging but with tendency to settle close to natal territory; occasionally more extensive movements but mostly confined to main channel. Movement between catchments, little

understood or studied (M.J. Williams).

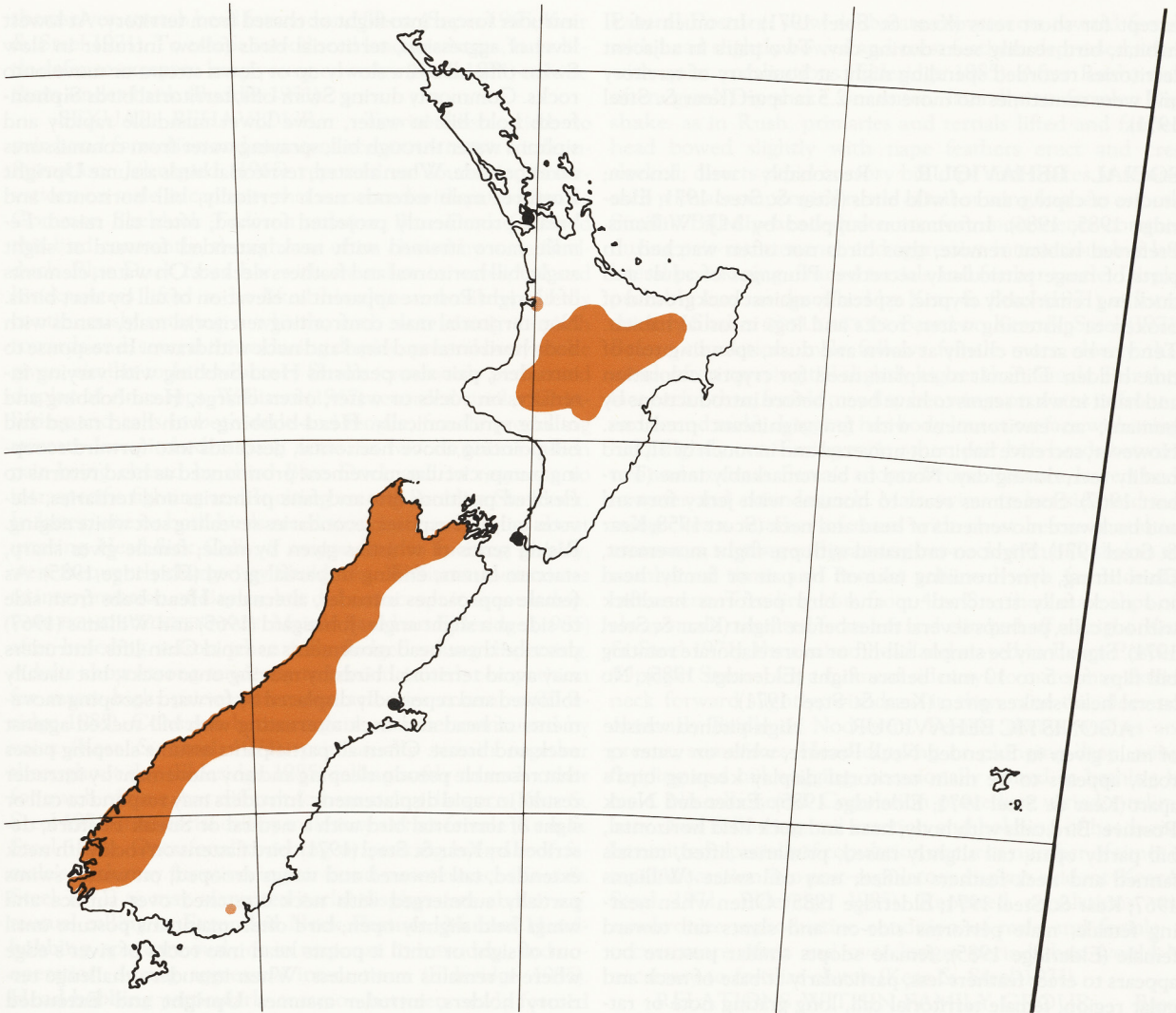
FOOD Mostly caddisfly larvae and other aquatic insects such as mayfly, stonefly and chironomid larvae, occasionally algae and berries. **BEHAVIOUR.** Food collected by searching among rocks on river bed or by scooping or filtering from surface of large boulders (Kear & Burton 1971; Williams 1980). To reach pebbles on stream bottom, either dabble from surface, up-end or dive for up to 20 s (Kear & Burton 1971). Adults and young sometimes catch small flies and other insects from water surface (Guthrie-Smith 1910; Oliver). Algae and diatoms scraped from sides of rocks using edge of bill. Bill quite unlike other dabbling ducks, culmen being straight and unflattened anteriorly. Marked constriction occurs in anterior half of upper jaw beyond which pair of flexible flaps hang down, overhanging lower jaw to considerable extent though this also emarginated. Flaps, in which there are few sensory glands, and narrow bill thought to protect edges of bill while exploring vigorously among pebbles (Kear & Burton 1971). Most feeding during day; timing of feeding apparently adjusted to take advantage of transient availability of food supplies (Elderidge 1986).

ADULT All samples (one stomach; six series of droppings; Kear & Burton 1971) dominated by caddisflies (both larvae and pupae of Sericostomatidae and Hydropsychidae), with smaller numbers of stonefly and mayfly nymphs, flies Chironomidae larvae and rarely beetle larvae and remains of crustaceans. Filamentous algae (incl. *Spirogyra*) and moss also occurred regularly but was little digested. Another set of dropping (500; M.J. Williams) confirmed dominance of caddisfly larvae Sericostomatidae *Beraeoptera* (>50% of identifiable remains in all months) with Chironomidae larvae of lesser importance; mayflies, stoneflies, alderflies, beetles, flies and spiders also recorded with a few fragments of algae and gastropods (*Potamopyrgus*). Rubiaceae *Coprosma* berries were taken Apr. and May. At another site, diet sometimes included large quantities of algae scraped from rocks in seasonally dry shallows.

YOUNG Droppings contained fragments of nymphs, fly larvae, one adult fly, one red mite and a few fragments of moss with fewer caddisfly cases than adults and no algae (Kear & Burton 1971).

SOCIAL ORGANIZATION Adults usually in pairs, maintaining territories throughout year; not gregarious except when in family groups (Kear & Steel 1971; Falla *et al.* 1981). In past, very occasionally congregated after flooding (Travers 1872) or in winter (Potts 1871; Soper 1965) when food shortage presumably drove them to leave their territories; does not occur in present times (M.J. Williams). Pair typically never moves beyond territory (Kear & Burton 1971). Broods disperse after breeding.

BONDS Monogamous, maintaining pair-bond year round (Pengelly & Kear 1970; Kear 1972; Elderidge 1985), and over several seasons (Buddle 1951); appear to be associated strongly with territories; pairs, once established, may live and breed together at same place for several years. If one member of pair dies, surviving bird attracts new partner to existing territory (M.J. Williams); loss of mate can also occur as result of supplanting by previously unestablished bird or neighbour who has lost mate. Possibly artificially skewed sex-ratio caused by female's vulnerability to introduced predators (Elderidge 1985). Pair-formation occurs within a month or two of fledging (M.J. Williams). Age of first breeding in wild varies. If



territory established during first year, birds can breed at end of year; five of ten females and three of five males bred in first year (M.J. Williams). One female in territory did not begin nesting until third year, and another with known breeding history, when paired with first-year bird, did not attempt nesting that year. Only female incubates. Both adults guard young throughout their development.

BREEDING DISPERSION Solitary, nesting in territories. Nest-sites along streams; may be used each year if successful (Guthrie-Smith 1910; M.J. Williams). **TERRITORIES.** Strongly territorial. Vary greatly in size. Douglas (in Pascoe 1957) in nineteenth century observed each pair kept 200–300 m of river to themselves; once found 13 pairs, each with young, on stretch of c. 6.5 km. Guthrie-Smith (1910) suggested stretch of 5–6.5 km needed to support one pair, though several pairs seen on shorter stretches (1.5–3.5 km). Kear & Steel (1971) record five pairs in c. 4 km whereas NZRD states each breeding pair needs on average about 1 km of river. Territory centred round feeding rapids (Elderidge 1986) and usually encompasses 5–6 pools and riffles, often with one pool and riffle between continuous territories; thus, territories in head waters tend to be shorter than those on less steep stretches of river; on lower reaches may have large sections of

unoccupied river between territories. Pair co-operates in defence of territory which they occupy all year (Elderidge 1986). Typically defend stretch of water into which only young allowed, provided they are not mature, i.e. when <5 months old and have not attained adult plumage (Kear & Burton 1971). Territorial behaviour and size, and density of territories appears related to abundance of food (Kear & Burton 1971; Elderidge 1985, 1986). To secure a territory, individuals try to establish themselves between existing territories or attempt to displace a resident adult; birds that fail to do so may live furtively within territories of two or three pairs for 1 or 2 years until successful. Newly-fledged juveniles try to establish territories either as individuals or with partners; one such juvenile pair, one having fledged only 6 weeks previously, tried to form territory between those of two adult pairs (M.J. Williams).

ROOSTING Within territory. Tend to be active chiefly at dawn and dusk (perhaps influenced by behaviour of prey), spending rest of time hidden beneath overhanging banks, vegetation and log-jams (Turbott 1967; Kear & Steel 1971; Kear & Burton 1971; Kear 1972; M.J. Williams) or resting and preening on rocks in middle of river (Guthrie-Smith 1910). When with young, adults do not retire during day

except for short rests (Kear & Steel 1971). In much of SI habitat, bird readily seen during day. Two pairs in adjacent territories recorded spending night at boundary of territory and were sometimes no more than 2.5 m apart (Kear & Steel 1971).

SOCIAL BEHAVIOUR Reasonably well known; studies of captive and of wild birds (Kear & Steel 1971; Elderidge 1985, 1986). Information supplied by M.J. Williams. Preferred habitat remote, thus birds not often watched. In parts of range particularly secretive. Plumages of adult and duckling remarkably cryptic, especially against background of broken or glistening water, rocks and logs in usual habitat. Tend to be active chiefly at dawn and dusk, spending rest of time hidden. Difficult to explain need for cryptic coloration and habit in what seems to have been, before introductions by humans, an environment with few significant predators. However, secretive habit not universal and in much of SI, bird readily seen during day. Noted to be remarkably tame (Turbott 1967). Sometimes react to humans with jerky forward and backward movements of head and neck (Scott 1958; Kear & Steel 1971). Flight co-ordinated with pre-flight movement, **Chin-lifting**, synchronizing take-off by pair or family: head and neck fully stretched up and bird performs headflick without calls, perhaps several times before flight (Kear & Steel 1971). Signal may be simple bill-lift or more elaborate rotating bill flips for 5 to 10 min before flight (Elderidge 1985). No lateral head-shakes given (Kear & Steel 1971).

AGONISTIC BEHAVIOUR High-pitched whistle of male given in Extended Neck Posture, while on water or rock, appears to be main territorial display keeping bird's apart (Kear & Steel 1971; Elderidge 1985). **Extended Neck Posture.** Bird calls with body, head and neck held horizontal, bill partly open, tail slightly raised, primaries lifted, tertials fanned and neck-feathers ruffled; may call twice (Williams 1967; Kear & Steel 1971; Elderidge 1985). Often when nearing female, male performs side-on and slants tail toward female (Elderidge 1985); female adopts similar posture but appears to erect feathers less, particularly at base of neck and gular region; female territorial call, long grating note or rattling growl. Female assumes posture only while calling but male often holds posture for long periods (Elderidge 1985). During Elderidge's study, in Jan. and Feb., male performed display more commonly than female. Pair often perform together when confronted by intruder or spontaneously, in vocal duets, at dawn and dusk when birds emerge to feed (Kear & Steel 1971; Elderidge 1985). Often at this time birds also fly whole length of territory (Kear & Steel 1971). Call, though not posture, develops in male when c. 14 weeks old (Pengelly & Kear 1970). During moult, flightless males have been seen to give call in response to flying juveniles and to chase intruders actively from territory. Territorial call by male may be uttered in flight; or from ground, when bird stretches forward fully with neck feathers raised. Interactions most common in morning; usually long and of low intensity in which pairs co-operate with Swim-offs, mutual displays and calls; least intense with juveniles which often involve Swim-offs by territorial female. When territorial male confronts intruding male, conflict can intensify; most intense between males over female and territory (Elderidge 1986). Throughout any interaction both territorial and intruding males call in clear-toned chirps. Intruders confronted with Swim-offs or more aggressively with Siphon-feeding, Upright, Head-bobbing, Head-low-flight and vocalizations. Can intensify until

intruder forced into flight or chased from territory. At lowest level of aggression, territorial birds follow intruder in slow **Swim-offs**: all swim slowly up or down stream or move onto rocks. Commonly during Swim-offs, territorial birds **Siphon-feed**: hold bill in water, move lower mandible rapidly and siphons water through bill, spraying water from commissures on either side. When alerted, territorial birds assume **Upright Posture**: male extends neck vertically, bill horizontal and breast prominently projected forward; often tail raised. Female more strained with neck extended forward at slight angle, bill horizontal and feathers sleeked. On water, elements of Upright Posture apparent in elevation of tail by alert birds. Non-territorial male confronting territorial male, stands with body horizontal and head and neck withdrawn. In response to intruders, pair also performs Head-bobbing with varying intensity, on rocks or water; often charge, Head-bobbing and calling synchronically. **Head-bobbing**: with head raised and bill pointing above horizontal, descends into forward scooping pump; circular movement pronounced as head returns to elevated position; lifts and fans primaries and tertials, elevates tail, and exposes secondaries revealing soft white edging. Rising series of whistles given by male; female gives sharp, staccato bursts, ending in partial growl (Elderidge 1985). As female approaches intruder, alternates **Head-bobs** from side to side at a slight angle. Johnsgard (1965) and Williams (1967) describe these head movements as rapid Chin-lifts. Intruders may avoid territorial birds by moving onto rocks, but usually followed and repeatedly displaced by forward scooping movements of head and neck alternating with bill tucked against neck and breast. Often all participants assume sleeping poses that resemble pseudo-sleeping and any movement by intruder results in rapid displacement. Intruders may respond to call or sight of territorial bird with a neutral or **Sneak Posture**, described by Kear & Steel (1971): bird flattens on rock with neck extended, tail lowered and wings drooped; on water, swims partially submerged with neck stretched over surface and wings held slightly open; bird often maintains posture until out of sight or until it points head into rocks of river's edge where it remains motionless. When intruders challenge territory holders, intruder assumes **Upright** and **Extended Neck** postures and calls. Territorial male responds by attacking in **Head-low-flight**: where feet spread to each side, scoops head and neck, and calls stridently; results in aerial chases or fights. **FIGHTS.** Can be vigorous, with birds striking each other with their wings using metacarpal wing-spur (Douglas in Pascoe 1957; Kear & Steel 1971). Kear & Steel (1971) suggested territory owners tolerate neighbours, thus avoiding full threats and attacks, though M.J. Williams reports this is not so during breeding season and Douglas (in Pascoe 1957) and Steel (1970) note fights may occur if individuals transgress each other's boundaries. Pair also very aggressive toward Pacific Black Ducks *Anas superciliosa* or Mallards *A. platyrhynchos* within territory. With neck extended, head low, bill open and scapular feathers raised, rush and finally fly over water at these species (Kear & Steel 1971). Tend to avoid Paradise Shelduck *Tadorna variegata*; threat from male Shelduck can cause Blue Duck to fly (Child 1961). On occasions, bill of Blue Duck reported to change colour from white to pink when bird disturbed (Blackburn 1963, 1967; Williams 1967; Elderidge 1985). Turbott (1967) claimed injury-feigning to protect young but Kear & Steel (1971) state not so; one report of male rushing over water at human intruder in posture similar to that used in chasing other birds (G.R. Williams). **ESCAPE.** To escape danger, pairs or families, if standing on rock, flatten

themselves, stretch head forward and freeze (Soper 1965; Kear & Steel 1971). To escape introduced land predators, have little defence except to keep young on water (Potts 1871) or hide them under bank (Buddle 1951).

SEXUAL BEHAVIOUR Territorialism tied to pair-bond formation and maintenance. **COURTSHIP.** Little information. Johnsgard (1965) reported as courtship, observations on male in captivity that associated with paired female Common Shelduck *Tadorna tadorna*. Blue Duck followed this bird constantly, though was often chased by male Shelduck. Blue Duck faced her with chest low in water, tail and hindquarters lifted as he lifted his chin and tail repeatedly continuously uttering a whistle, each note rising in pitch towards end; several times during display, general body shake given, similar to **Introductory Shake** (commonly performed display of *Anas* spp). Williams (1967) recorded similar **Chin-lifting** and calls in both male and female, female producing staccato low-pitched rasping notes, in two situations: when pair being chased by third Blue Duck and in response to intraspecific fighting and **Inciting** among Paradise Shelduck. In latter, one or both birds raced to vicinity and darted about uttering **Head-flick Calls**; if responding to **Inciting** display, were frequently charged by Shelducks. Williams uncertain as to interpretation of display, but did not accept it as courtship. **PAIR-BOND MAINTENANCE.** Mainly based on Elderidge (1985) after breeding season when fully fledged young dispersing. Adults show strong tendency to remain paired; competition for mates high; pair-maintenance activities common (Elderidge 1985). Cohesion between pairs may be maintained by voice (Kear & Steel 1971); pair usually remain together throughout day (Elderidge 1985) calling softly to each other for much of time, but difficult to hear at any distance (Kear & Steel 1971); territorial call by male may attract female (Kear & Steel 1971). Occasional touching or pecking by male of female's back may function in pair-bond maintenance (Kear & Steel 1971) as may many territorial displays (see above) e.g. mutual calling in **Extended Neck Posture**, **Mutual Head-bobbing**, spontaneously or in response to intruders, and co-operation during aggressive interactions (Elderidge 1985). **Head-bobbing** particularly common between newly formed pairs. Territorial male often initiates casual **Head-bobbing**, without vocalization, while feeding when female out of sight or absent; assumes elevated **Head-bobbing** stance without actual bobs and utters plaintive clear *whew*. Pre-copulatory interactions common, almost daily, between individuals of established pairs under stress and newly formed pairs. Involve three main displays, which male performs: **Head-low Rush**, **Lateral** and **Dip-shake**. **Head-low Rush.** Rushes over water with head and neck scooping forward, wings tucked, primaries lifted and tertiaries fanned to display feathers edged in black, performed by male more than by female, often repeatedly, and covering 1-10 m. Usually occurs when members reunite after separation or when intruding males present. Male also observed performing to female when Great Cormorant *Phalacrocorax carbo*, White-faced Heron *Ardea novae-hollandiae* and humans in territory (Elderidge 1985). Similar to swimming attacks of territorial males against intruders reported by Kear & Steel (1971), but lacks scooped head and neck and fanned tertiaries of this display. In stressed or new-formed pair, male occasionally rushes female and tries to copulate; female usually dives to escape. Female may solicit rush by dashing and diving near male and returning to surface in **Extended Sleek Posture**. If female stands on rock, male often rushes across and climbs onto rock beside her in subtle

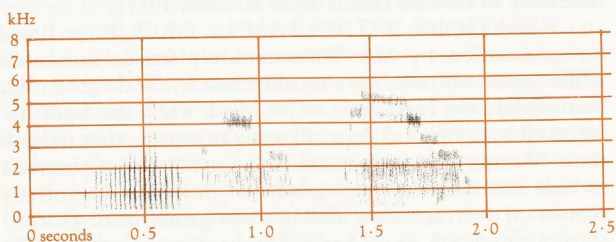
Lateral Posture: slow deliberate movements toward female with head slightly bowed and crest feathers depressed, often with quiet vocalizations (Elderidge 1985). After Rush, male often gives **Dip-shake** on water, laterally to female. **Dip-shake:** as in Rush, primaries and tertiaries lifted and fanned; head bowed slightly with nape feathers erect and crest sleeked; directs rapid cursory bill dips and shakes at female, each with accompanying rustle of tail or wing feathers or both. Similar **Bill-dip-head-shake** comfort movements common during pair-maintenance and aggressive interactions but lack lateral positioning, fanned tertiaries and feather rustle. Display probably same as described by Kear & Steel (1971) as **Introductory Shake**. **COPULATION.** Based on Kear & Steel (1971). Before copulation, male follows female more closely than usual, often carrying tail slightly higher than female. Pair then face each other; female may flap her wings on water in front of and round male, dragging her body low at surface with wings held slightly out. Facing each other, pair bob heads between two and six times. Female adopts **Prone Posture**, lowers body in water and extends neck. Male swims to her side and may nudge her a number of times with chest before mounting crossways, turning and grasping her neck with bill; shakes tail number of times and contact achieved with fast sideways movement. Treading lasts from 4 to 8 s, then male slips off; always male mounted from left and climbed off on right (Kear & Steel 1971), then raised head and stayed in **Erect Posture** (**Upright Stance**) for a moment sideways to mate; may extend neck forward slightly, withdraw it, then raise tail; does not obviously **Bridle** or **Nod-swim**. Female always washes and preens, sometimes **Head-dipping** or plunging deep, wings flapping and tail wagging; occasionally joined in bathing by male. No calls heard. Copulation procedure varied; preliminary close following, tail erection and bobbing of heads may be omitted, specially if copulation occurs a number of times in rapid succession. No post-copulatory displays evident (Kear & Steel 1971; Elderidge 1985). Repeated copulations may synchronize reproductive condition of male and female; it occurs more often and over longer period than would be necessary to fertilize clutch (Kear & Steel 1971).

RELATIONS WITHIN FAMILY GROUP Based on information by M.J. Williams. Only female incubates; while female on nest, mate usually close by. Male greets her immediately she leaves nest to feed and, while she feeds, remains close to her and alert; call softly to one another most of time. Waiting males very inconspicuous; have been observed to hide beneath overhanging bank or in hollow log; others remain on river, spending most of waiting time, resting inconspicuously among, or on, rocks. Favoured waiting site usually on edge of pool closest to nest-site. Male present when brood first enters water. Both parents care for young. Blackburn (1967) suggested that young taken to bank to be brooded; however, have also been seen under female on rocks in mid-stream (Kear & Steel 1971). Ducklings can swim against strong currents and jump onto rocks, logs or ledges immediately after hatching and have 2-3 syllable contact call and distress call. Adults guard ducklings very closely, female keeping close and feeding with them along river's edge. Role of male clearly protective; always extremely alert at rear of brood; moves from rock to rock, climbing up and standing upright, on constant guard for danger and closely watching any duckling that falls behind others; also ensures that fast current does not sweep ducklings out of contact with rest of brood; seldom feeds while ducklings active, only when they and female are resting. Ducklings quickly learn how to cope with white

water. Initially parents keep them close to edge of river; only small part of territory used as nursery and brood works up and down shoreline of this area. To cross river, brood bunches together, male behind, female in front and youngsters literally run across water. In order to go upstream, ducklings may have to go ashore and are led along bank by male or female perhaps with male in rear (Potts 1871; Buddle 1951). As ducklings become more adventurous, feed in swifter water, quickly learning their way about small eddies created as water flows round sides of rocks. They begin to feed by darting from downstream face of one rock to that of another, even diving for food in protective eddy at base of rocks. Fledging periods in wild 70–80 days but some broods have remained together for 90 days. Breakup of brood usually initiated by adults who begin to show less interest in ducklings, first evidenced by them resting apart from young. As adult begins to moult, when ducklings about two-thirds grown, appears to ignore young until finally becomes flightless and may spend some time hiding. Sometimes adult becomes flightless before young able to fly, however most successful breeding adults do not become flightless until 4–6 weeks after young have fledged. Members of pair tend to moult at about same time, maintaining close contact throughout period of flightlessness, hiding in caves or logs during most of day, but venturing out to feed together during evening and early mornings. Ducklings, then on their own, begin to disperse, flying beyond confines of parents' territory.

VOICE Only detailed studies by Elderidge (1985) and Pengelly & Kear (1970). Loud wheezy whistle of male well described by Maori name *whio*. Pair call softly to each other for much of the time, but difficult to hear at any distance (Kear & Steal 1971).

ADULT MALE Piercing whistle used as **Territorial (Advertising) Call** varies; consists of one or two syllables described as *whio*, *whio-whio* or *whi-whio*; high pitched (2–6 kHz) and above ambient frequencies of rapids and other water noises (second and third calls of sonagram A). Call



A K. & J. Bigwood; P102

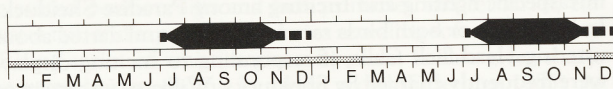
given: in Extended Neck posture on rocks or in water; often in vocal duet with female, commonly at dawn and dusk; with Head-bob display as a rising series of whistles; in Head-low-flight as strident *wi* before aerial chases or fights (see Social Behaviour). Throughout interactions, male gives clear toned *chirps* in groups of 3–4 with frequencies of 2.5–3 kHz. These hostile calls said to be similar to calls of downy ducklings.

ADULT FEMALE Prolonged, up to 2 s, low-frequency rattling growl stressing frequencies below 2 kHz (first call of sonagram A). Often a two part call with increasing emphasis on the second part *grrr* — *grrRRrr*. Given in Extended Neck and Head-bob postures when female calls in sharp, staccato burst with frequencies lower than 3 kHz ending in a partial growl *gak-gak-graak*.

YOUNG Information based on observations during captive rearing (Pengelly & Kear 1970). **Contact Call**: rapid 2–3 syllable sound. **Distress Call**: slower, resonating at higher pitch. Both calls typical of dabbling duck downies. No trills heard but slurred **Sleepy Call** given rarely when ducklings under bantam female. At 33 days, voice starts to change, that of female duckling becoming more guttural. Rasping call of adult female call obvious at 10 weeks, at a time when male duckling still Contact Calling. By 14 weeks male duckling gives clear whistle.

BREEDING Not well known. No detailed studies. Some information from captive reared brood at Slimbridge, UK, by Wildfowl and Wetlands Trust (Pengelly & Kear 1970). Information supplied by M.J. Williams and J.R. Starks. Breed in simple, probably long lasting pairs.

SEASON Laying may start as early as July and continue till Dec., peak usually Aug.–Oct., exceptional records of broods Mar.–Apr.



SITE In hollow logs, tree trunks, among tree roots, under flax bushes, *Carex* or grass clumps, holes in river bank, in clefts in rocks, on ledges in caves, under buildings. Usually sheltered from above and close to stream. Sites may be used from year to year, if successful.

NEST, MATERIALS Depression in ground, only a little down added (M.J. Williams); said to be made of grass and lined with down (Oliver). No information on building, site-selection.

EGGS Elliptical; glossy; creamy white.
MEASUREMENTS: 65.1 (2.6; 58.5–72.5; 18) x 45.1 (1.7; 43.0–50.0)

WEIGHTS: fresh, 70–73 (n=18).

CLUTCH-SIZE Reported to be 4–9. Of 20 nests, C/5 and C/6 commonest. Relaying after failure rare; three of 28 failed nests were replaced. No second broods.

LAYING Average 2 days between eggs.

INCUBATION By female only. Male usually nearby, greets her as soon as she leaves and remains close to her and very alert; while waiting, inconspicuous, may hide in holes, under overhang or rest quietly among or on rocks, usually on edge of pool closest to nest. **INCUBATION PERIOD**: in captivity, 31–32 days (Pengelly & Kear 1970). Males have been recorded as waiting alone for 35 days, supposedly while female incubates (M.J. Williams).

YOUNG Precocial, nidifugous. At hatching, downy, dark grey above with metallic green sheen; white below with chestnut under tail; bill, grey blue with rosy tip; iris, dark brown; legs, yellow brown. In captivity, develop first body feathers at 24 days, primaries emerge 36 days, fully feathered 56 days, wings developed enough for flight 70 days. As soon as leave nest can swim against strong current, jump on rocks, ledges. Guarded by both parents throughout development; female remains close to young, and feeds with them; male remains alert usually at rear of broods, seldom feeds while ducklings form brood, feeds only while female resting. Ducklings quickly become capable of coping with white water; at first kept close to edge of stream by parents, working up and down small part of territory; cross stream by bunching between adults and running across water; soon able to feed in

swift running water and from eddy to eddy. FLEDGING PERIOD: 70–80 days (M.J. Williams). Some broods recorded together for up to 90 days. Break up usually initiated by adults, showing gradually less interest in broods and then ignoring them as they go into moult and become flightless; ducklings then disperse, flying beyond parents' territory.

GROWTH Information on growth rates from tables in Pengelly & Kear (1970). Average weight at hatching: males 48 g., females 49 g. At 7 weeks: males 612 g, females 582 g. At 14 weeks: males 805 g, females 623 g. Tarsus length at hatching: 23.3 mm, at 1 week: 25.8 mm, at 14 weeks: males 50.7 mm, females 47.5 mm.

SUCCESS Probably poor and variable. During five seasons at Manganui-a-te-Ao R., six pairs reared 0–11 young/season, apparently at annual average of <1/pair. **PREDATORS.** Freshwater eels probably take chicks (Kear & Steel 1970).

PLUMAGES

ADULT Attained at c. 6 months in captive birds (Pengelly & Kear 1970); Kear (1972) states c. 5 months, with reference to wild birds. **HEAD AND NECK.** Crown, grey-brown (91), sometimes with light-grey (85) shade; in some lights, green (163) gloss on feathers. Lores and hindneck, grey-brown (91). Chin to base of neck, brown-grey (79). Interramal space, bare. **UPPERPARTS.** Mantle and upper back, dark brown (121), broadly fringed brown-grey (80) and basally brown-grey (79); feathers appear spotted. Back, rump and upper tail-coverts, brown-grey (79), fringed dark olive (48); fringes, narrower on upper tail-coverts; in some lights, fringes have green (163) gloss. Scapulars, varying marked; presumably in younger birds, dark brown (121) and fringed brown-grey (79); with age (or perhaps season), scapulars, dull dark-olive (48) with shaft streaks of dark brown (121) and fringed dark olive (48); in oldest birds presumably, scapulars similar but lack shaft streaks; in such birds, and those with shaft streaks, both webs of longest scapular, particularly on outer web, faintly edged black (89); in some lights, all fringes, glossy green (163). **TAIL,** brown (28). **UPPERWING.** All coverts, including alula, except lesser and median, brown-grey (79); lesser and median, olive-brown (29); all narrowly fringed brown-grey (80); in some lights, fringes, glossy green (163). Primaries, brown (28). Secondaries and tertiaries, similar, but with brown-grey (79) shade; secondaries, narrowly edged white distally on outer webs. Outermost secondary, s10, edged black (89) on outer web; tertiaries, s11–s14, similarly edged. **UNDERPARTS.** Breast-feathers, tipped brown (223A) centrally, bordered white laterally; basally, brown-grey (80); tips paler on outer breast; in older birds presumably, only mid and lower breast-feathers, tipped dark brown (221); tips on breast-feathers impart spotted appearance. Lower breast to vent, brown-grey (80); feathers tipped white; demarcation at lower breast and abdomen, moderately sharp. Flanks, brown-grey (79); thighs, similar and narrowly tipped white. Under tail-coverts, particularly longest, tipped brown (223A). **UNDERWING.** Greater and median primary coverts, light grey (85); innermost narrowly tipped white. Lesser, brown-grey (79) and narrowly tipped white. Marginal coverts, brown-grey (79). Outermost greater coverts, light grey (85); innermost narrowly tipped white; tips absent at extreme innermost. Median and lesser coverts, brown-grey (79), broadly tipped light brown (123A). Axillaries, pale brown-grey (79). Sequence of adult plumage in wild requires study; Pengelly & Kear (1970) provide some data for captive birds. Nominat *malacorhynchos*, similar to subspecies

hymenolaimus, but differs in lacking dark-brown (121) shaft streaks on scapulars; scapulars remain brown-grey (79) with some dull dark-olive (48), never all dark olive (48).

DOWNY YOUNG HEAD AND NECK. Broad, dark brown (119A) band of down, extends from frons, across crown, to base of hindneck. Narrow white supercilium, broken by narrow dark-brown (119A) line extending at 45° from eye to crown. Below supercilium, narrow dark-brown (119A) line extends through eye and meets hindcrown. Chin, throat and sides of head, white apart from small dark-brown (119A) auricular spot; lower neck, white. Down, short on head and neck, longer and hair-like on upperparts. **UPPERPARTS,** dark brown (119A); tips pale brown (223C); in some lights, tips glossy dark-green (262). Moderately large oval-shaped patch on either side of rump, light brown (39) in males; pink-buff (121D) in females; recognized as sexual dimorphic character and clearly visible when 7 days old (Pengelly & Kear 1970). **TAIL,** long, hair-like, dark brown (119A). **UPPERWING,** dark brown (119A) with narrow white posterior margin, restricted to radius and ulna. **UNDERPARTS,** entirely white; upper breast, duller. **UNDERWING,** white. Further description of downy young given in Potts (1870). Juvenile plumage attained at c. 8 weeks in captive birds; fledging at 70–77 days (Pengelly & Kear 1970). For full details of plumage acquisition to juvenile, see Pengelly & Kear (1970).

JUVENILE Similar to adult, only differences described. During post-juvenile moult, some feathers on cheeks tipped white. **HEAD AND NECK.** Feathers of head, duller; lack gloss on crown. **UPPERPARTS.** Dorsum, generally paler; spotting on mantle reduced. Scapulars, brown-grey (79), lacking dark brown (121) central portions or shaft streaks; brown-grey (80) fringes, narrower; impart slight gloss. **UNDERPARTS.** Breast-feathers have small subterminal spots of dark brown (121), bordered by brown (223A); feathers, broadly tipped white. Size of spotting on breast, smaller. Feathers on outer breast, brown-grey (79), narrowly tipped dark brown (121). Rest of underparts, pale brown-grey (79); few brown (223A) tips on under tail-coverts. Tips of rectrices, notched.

ABERRANT PLUMAGES Albinistic feathers observed on mantle (skin at NMNZ).

BARE PARTS Based on NZRD and photos captive birds Mt. Bruce Wildlife Reserve (R. O'Brien).

ADULT Iris, orange-yellow (18) usually, or yellow (55). Bill, pink (7) with white shade; black (89) membranous skin surrounds margins of upper mandible that is longest at tip, forming small flap on edges and covering nail; skin narrow, but moderately thick basally on bill, adjoining feather line; margins on distal half of lower mandible, and basal portion, also covered in black (89) skin; thickest at tip. Legs and feet, pale pink (7); joints and webs, dark grey (83); claws, grey-black (82).

DOWNY YOUNG Iris, dark brown (219). Bill, dark grey (83). NZRD states bill, grey-blue with rosy tip and black flap; legs and feet, yellow-brown. Oliver states bill, horn colour; membrane, black; feet, yellowish.

JUVENILE Iris, dark brown (Pengelly & Kear 1970). Bill, light blue-grey with dark-grey band from culmen to nail. Iris and bill respectively, turn yellow and white at c. 6 months. At 12 months, iris, golden; dark streak along culmen slightly visible. Legs and feet, no data.

MOULTS Largely undescribed.

ADULT POST-BREEDING Moult complete, with

adults flightless for c. 6 weeks, Dec.–May (M.J. Williams). Breeding birds rearing young begin to moult body-feathers when young about two-thirds grown; a few become flightless before young fledged but most do not become flightless until 4–6 weeks after young fledged (M.J. Williams). Unsuccessful breeders in captivity in NZ, in primary moult late Nov., flying by mid-Dec.; female of pair beginning moult before male. Also, in NZ captive female in full wing-moult in May, which may be abnormal (Kear 1972).

ADULT PRE-BREEDING Few data: adult male acquiring new contour feathers in Feb. (Kear 1972).

POST-JUVENILE In captivity in England, birds moulted remiges when c. 6–7 months old, in July; remiges moult when birds c. 12 months old, in NZ (Pengelly & Kear 1970).

MEASUREMENTS (1) Live adults; methods unknown (Pengelly & Kear 1970). (2) L. Manganui-a-te-Ao, NI, live adults; methods unknown (M.J. Williams). (3) NI, adults, skins (NMNZ).

	MALES	FEMALES
WING	(1) 233.0 (n=4) (2) 242,250 (3) 234.3 (9.68; 215–243; 6)	217.0 (n=3) 221.7 (12.96; 204–240; 4) 216,226
TAIL	(2) 107.0 (5.76; 99–115; 5) (3) 111.6 (6.82; 103–120; 5)	97.5 (7.5; 90–110; 4) 108,111
BILL	(2) 44.0 (42.3–45.1; 4) (2) 45.9 (0.97; 44.4–47.3; 5) (3) 45.4 (1.38; 43.6–46.9; 6)	40.8 (40.3–41.6; 6) 44.2 (0.83; 43.3–45.3; 4) 43,45
BD	(2) 20.2 (0.51; 19.8–21.1; 4)	19.4 (0.49; 18.7–19.8; 3)
BW	(2) 21.0 (0.73; 20.1–22; 5)	19.9 (0.46; 19.4–20.6; 4)
THL	(1) 91.7 (n=4)	86.2 (n=6)
TARSUS	(1) 49.8 (n=4) (2) 51.7 (0.91; 51–53.4; 5) (3) 50.7 (2.36; 46.4–54.3; 6)	47.0 (n=4) 47.3 (0.84; 46.8–48.8; 4) 46,48
TOE	(2) 67.3 (2.86; 64–71; 3) (3) 64.8 (1.52; 62.8–66.6; 6)	61.6 (1.24; 60–63; 3) 61,62

Males larger than females. Oliver (methods unknown), gives ranges: wing 220–240, bill 44–47; tarsus 45–52, tail 95–116 and toe 60–70. Delacour (1954–64; methods unknown), gives ranges: wing 235–249, bill 45–50, tarsus 48–51 and tail 125–135. Mathews (1937; methods unknown) states that nominate *malacorhynchos* has wing measurement of 236–240; in subspecies *hymenolaimus*, greater than 247. No measurements available for SI birds, and above measurements do not reflect Mathews (1937) findings for NI birds.

WEIGHTS Live adults (M.J. Williams; details as above): males 897.2 (48.63; 820–970; 11), females 767.8 (59.42; 680–870; 14). Kear (1972), gives weights of captive and wild birds in Feb., Apr., May, July and Dec.; means for captive and wild birds, given as: males 890, females 750. Pengelly & Kear (1970), give weights of adults, males 887. Males significantly heavier than females. Few data on seasonal weight changes. Full details of weight changes of downy young, given in Pengelly & Kear (1970) and Kear (1972).

STRUCTURE Wing, short and broad. Eleven pri-

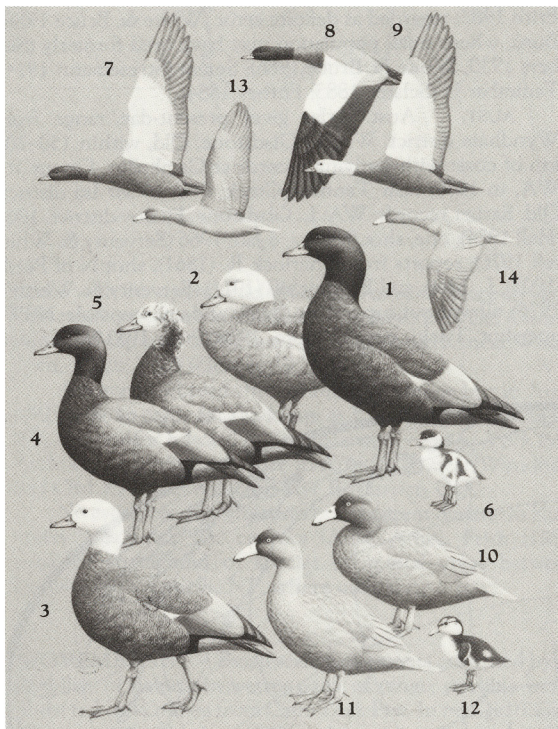
maries: p9 longest, p10 1.7 mm shorter, p8 1–3, p7 9–13, p6 20–26, p5 33–39, p4 46–52, p3 58–65, p2 67–76, p1 80–87, p11 minute. P10 emarginated on inner web; p9 slight on inner and outer webs. Fourteen secondaries, four of tertial form. Short, thick, exposed, rudimentary wing-spur at carpal joint. Twelve rectrices, sometimes 14, t1 longest, t6 25–31 mm shorter; when 14 rectrices, t7 27–37 mm shorter. Bill, almost straight, deep at base and tapering towards tip; at tip, flexible membranous skin that is well developed on lower mandible and lateral sides of upper mandible; short, coarse lamellae limited to posterior of upper mandible and posterior two-thirds of lower mandible; for further details of bill structure, see Food and Kear & Burton (1971). Legs, slender, tarsus short. Feet, webbed. Outer toe c. 96% of middle, inner c. 72%, hind c. 22%.

SEXING, AGEING Adults sexed on cloaca (M.J. Williams). Age categories on plumage. Downy young sexed by presence of bulla (Beer 1961–62).

GEOGRAPHICAL VARIATION Two subspecies; *malacorhynchos* restricted to SI and *hymenolaimus* to NI (Mathews 1937); *hymenolaimus* apparently overlooked by NZCL and warrants re-validation (R. O'Brien). Subspecies separated on colour of dorsum and degree of streaking and spotting on scapulars and mantle (Mathews 1937; R. O'Brien); Mathews (1937) also states that the two subspecies differ in measurements. Because no measurements for *malacorhynchos* (see Measurements), assessment of size difference remains undetermined. N nominate *malacorhynchos* paler on dorsum (see Plumages). RMO

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Volume 1 (Part B), Plate 88

Paradise Shelduck *Tadorna variegata*

1. Adult male
2. Adult female breeding
3. Adult female non-breeding
4. Juvenile male
5. Juvenile female
6. Downy young
7. Adult male, ventral
8. Adult male, dorsal
9. Adult female, ventral

Blue Duck *Hymenolaimus malacorhynchos*

10. Adult
11. Juvenile
12. Downy young, male
13. Adult, ventral
14. Adult, dorsal

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