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 feature 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

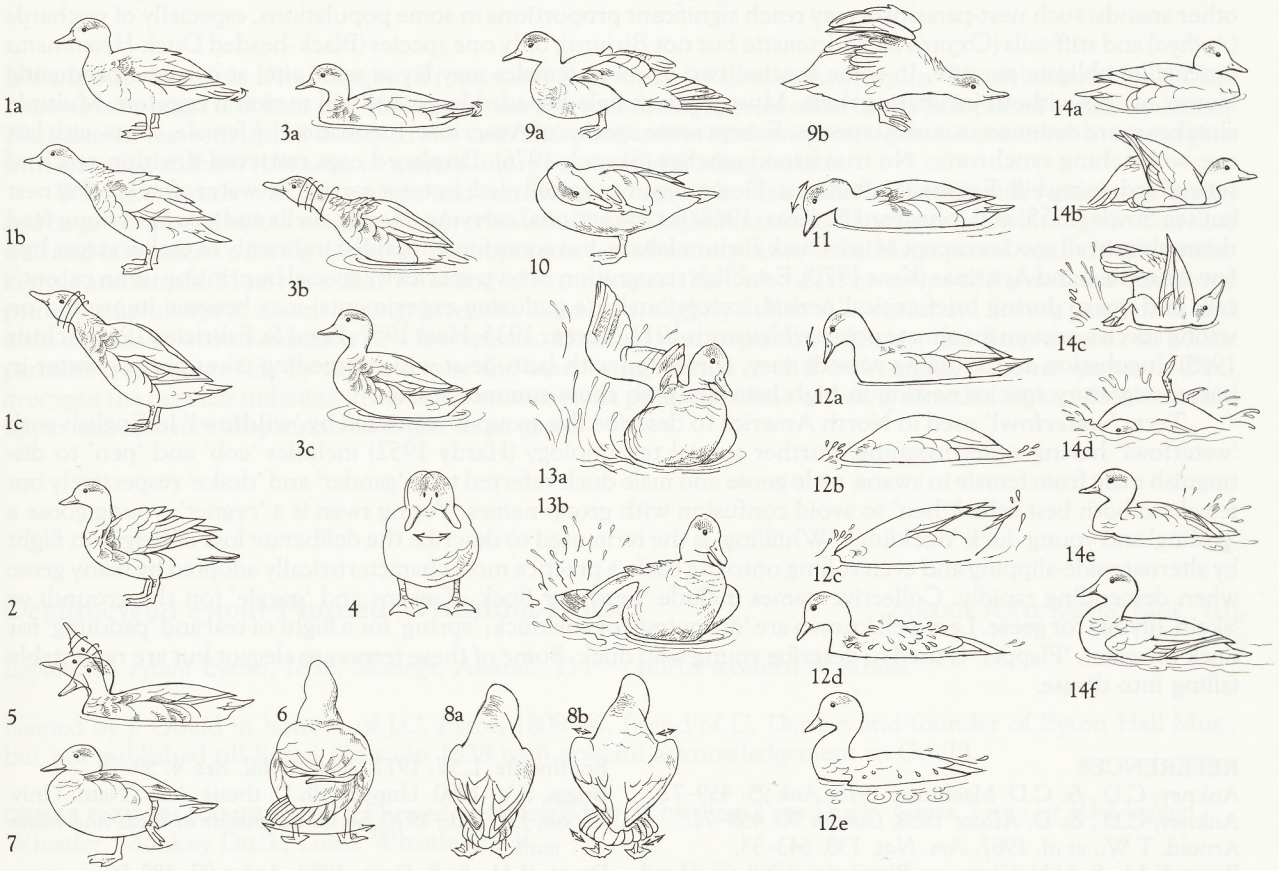
Waterbirds (some more or less terrestrial) with rather short legs and front toes connected by webs; hallux elevated and reduced. Though considerable adaptive diversity in outward appearance, size, colours of plumage, behaviour, and ecology, homogeneous in many characters, as attested by numerous, often fertile, interspecific hybrids reported, chiefly in captivity (see Gray 1958). About 160 species in six sub-families: (1) Dendrocygninae (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; diastataxic. 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 syringo-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-moults 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 'paddling' 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'asian 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 Fjeldså [1977] based on Pacific Black Duck).

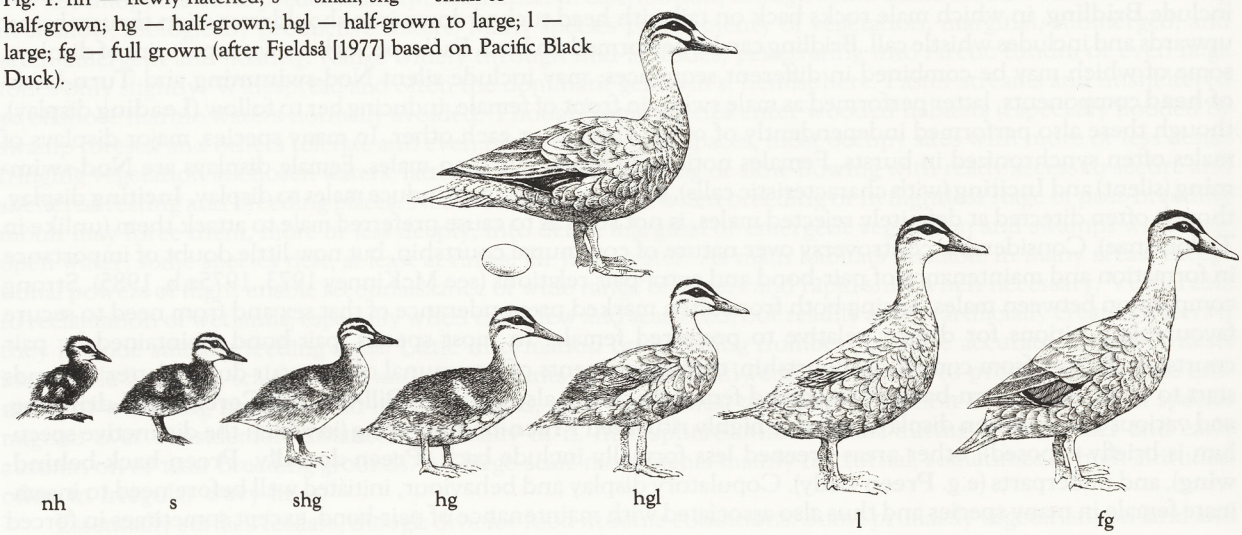

Fig. 1. nh — newly-hatched; s — small; shg — small to half-grown; hg — half-grown; hgl — half-grown to large; l — large; fg — full grown (after Fjeldså [1977] based on Pacific Black Duck).

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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Anas gracilis Grey Teal

COLOUR PLATE FACING PAGE 1252

Anas gracilis Buller, 1869, *Ibis* (2) 5: 41 — Manawatu, North Island, New Zealand.

The specific name indicates slender, lean or thin.

OTHER ENGLISH NAMES Slender, Gray, Wood, Oceanic, Mountain Teal; Australasian Grey Teal.

MONOTYPIC Here treated as full species separate from *Anas gibberifrons* Muller, 1842, of Indonesia (Parker *et al.* 1985).

FIELD IDENTIFICATION Length 42–44 cm; male averaging larger; wingspan 60–67 cm. Small drab-grey slender duck most likely to be confused with closely similar Chestnut Teal *A. castanea*. Head often held high on slender but short neck with prominent rising forehead and long nape-feathers that increase size of head when raised. Crown darker than chin, throat and upper foreneck, which off-white and distinctive; rest of body-plumage uniformly grey with indistinct scaly or mottled pattern formed by pale edging to most body-feathers. In flight shows prominent white patches centrally on upper and under wing; speculum black with glossy green sheen with broad white patch to fore and narrow white trailing-edge. Sexes similar, but easily distinguished by voice and behaviour. When in pairs, greater body-length and higher posture of head of male usually noticeable; but best distinction at all times is by voice and behaviour. Juveniles resemble adults except uniformly streaky breast pattern diagnostic. No seasonal differences in plumage except by wear. No eclipse plumage.

DESCRIPTION ADULT MALE. Crown, dark grey-brown, speckled with paler markings giving streaky appearance at close range. Hindneck, softly feathered and grey. Sides of face, chin and upper throat, pale, almost unspotted and in fresh plumage off-white. Most of rest of body, uniformly dark grey with each feather edged paler, giving scaled appearance; most noticeable on breast where prominently spotty. Surfaces of wings darker than body and lack scaly pattern. Back and rump, uniformly dark grey-brown; tail, dark grey-brown. Flight-feathers, dark grey. Speculum, mat black with oval patch on inner region shot with iridescent green and trailing-edge tipped white. Large wedge-shaped area of white on greater coverts narrowing inwards. Underwing, dark grey-brown with conspicuous white axillaries and area of white in centre-wing, narrowing outwards. Eyes, bright crimson. Bill, bluish-grey; nail, edges and often ridge, blacker. Legs, feet and webs, dull grey; toenails, dark grey. ADULT FEMALE. Like male with no distinguishing feature on plumage. Eyes often less intensely red than male, but not always. Moult wings after breeding, usually Jan. to Mar. in s. Aust. JUVENILE. Like adult but lower neck and breast heavily and uniformly streaked

longitudinally rather than spotted. Eyes, dull brown at least until completion of post-juvenile moult, often longer. Complete body-moult by juveniles, including tail (replacing characteristic notched juvenile rectrices) but not wings, occurs in first autumn or early winter after which plumage resembles adult (P.J. Fullagar). DOWNY YOUNG. Dull grey-brown above and off-white below. Chin, white but face showing warmer brown tones with dark stripe through eye and less distinct stripe below and behind eye, usually showing as small patch at ear. Trailing-edges of wings, off-white and small white patches each side of rump. Eyes, dark brown; bill, dark blue-grey; legs and feet, blue-grey; joints and webs, black.

SIMILAR SPECIES Closely similar to female **Chestnut Teal**, from which best distinguished by much paler chin and upper throat of Grey Teal of either sex; female Chestnut Teal appears warmer toned in general and looks darker; more streaked across sides of face and lacks clear white chin. Both species sometimes become heavily 'iron' stained on head, neck and underparts. Male Chestnut Teal characteristic except in eclipse when replacement of feathering can be almost complete, so that he closely resembles female. However, males usually show some residual alternate ('bright') feathering; dark crown with strong signs of green; occasional chestnut feathering on body and shadowy sign of pale thigh-patch at base of tail. No distinguishing features of behaviour or calls that can be used to separate the two species; however, knowledge of characteristic male behaviour and calls most certain method of recognizing male Grey Teal (see elsewhere) from female Chestnut Teal. Wild hybrids occur between Grey and Chestnut Teals; difficult to recognize, specially as females. Male hybrids resemble almost complete eclipse Chestnut Teal and from this stage difficult to distinguish except that hybrids remain in this condition indefinitely. For differentiation of Grey and Chestnut Teal from somewhat similar Brown Teal *A. chlorotis* and Auckland Teal *A. aucklandica* see those species. Only other small duck in our region is **Pink-eared Duck** *Malacorhynchus membranaceus* which looks pale at distance but has large bill, dark eye-patch and strongly barred plumage. In flight Pink-eared Duck lacks speculum but has white trailing-edges to uniformly dark wings and diagnostic tail pattern formed by white rump-patch contrasting with black tail with broad white tip. Also twittering call in flight distinctive.

Seen in pairs, small groups to large flocks on many types of wetland. Widely distributed throughout Aust. but particularly characteristic of wetlands of inland. In NZ widely distributed but never common. Swim buoyantly with head held high but often loaf on water with head tucked in scapulars or withdrawn onto shoulders. Young dive freely and adults occasionally do so to feed; otherwise only dive to escape or during bathing routine. Feed by filtering at surface of water or in soft muds and upend in shallow waters. Will strip seed heads from aquatic plants and pick up grain. Rise swiftly from water with explosive leap. Flight fast and often in small to large flocks. Walk readily on land with nearly horizontal carriage. Female has loud laughing call (Decrescendo) and various other distinctive female vocalizations; male has clear loud whistle, *gedee-oo* (Burp) and several other characteristic male calls, especially during display. Display bouts include several distinctive postures and calls that distinguish Grey Teal from all but Chestnut Teal (P.J. Fullagar).

HABITAT Widespread on terrestrial wetlands, sheltered estuarine and marine waters, and occasionally on farm dams in grasslands. Mainly aquatic, feeding in shallow open water <1 m deep or in flooded marginal vegetation; occasionally in deep water, especially where floating aquatic vegetation; also out of water on exposed shores and mudflats, damp grassland, pasture or crops (Frith *et al.* 1969; Briggs 1979; Goodrick 1979; Norman *et al.* 1979). More tolerant and opportunistic in choice of habitat than any other A'asian duck; but in Aust. favour large shallow productive inland waters when available, attracted by abundant food (aquatic vegetation, seeds, invertebrates) accessible from surface (Gentilli & Bekle 1983); respond rapidly to flooding on inland alluvial plains, following edge of spreading waters and gathering in floodplain swamps, channels and pools vegetated with sedges, canegrass or lignum (*Eleocharis*, *Gahnia*, *Scirpus*, *Juncus*, *Eragrostis*, *Muehlenbeckia*) (Frith 1959; Fjeldså 1985); strongly opportunistic in arid and semi-arid zones, moving onto any wetlands filled by rain or flood, especially large open shallow salt lakes (Badman 1979; Gentilli & Bekle 1983; Lane 1984). Also recorded often or in high numbers in fresh meadows, shallow fresh swamps, deep swamps with tall emergent vegetation (*e.g. Typha*, *Phragmites*), lakes, reservoirs, rivers, creeks, billabongs and pools (Corrick & Norman 1980; Gosper 1981; Fjeldså 1985); often on wetlands with inundated or fringing timber, but prefer open or discontinuously, rather than densely, wooded wetlands (Frith 1959; Vestjens 1977; Gosper 1981; Fjeldså 1985). Readily use habitats provided by agriculture and settlement; flooded or irrigated pasture, grassland, grain crops, irrigation channels, farm dams, roadside ditches, sewage ponds and ornamental ponds (Hobbs 1956; Frith 1959, 1982; Frith *et al.* 1969; Fjeldså 1985; Hewish 1988); artificial wetlands too small and unproductive for feeding may be used for drinking, preening and loafing (Gentilli & Bekle 1983). Saline or hypersaline wetlands may at times support large part of population; coastal waters (estuaries, coastal lagoons, inshore waters) used as non-breeding refuge during dry season or drought (Lavery 1972; Delroy 1974; Gentilli & Bekle 1983; Norman 1983); and influx to inland salt lakes when filled by seasonal or irregular rainfall (Gentilli & Bekle 1983; Lane 1984). Also occur on saltpans, saltmarshes, saltfields, and tidal reaches of rivers (Crawford 1975; Corrick & Norman 1980; Jaensch & Vervest 1988a,b). Birds feeding in saline water claimed to need local freshwater for drinking (Lavery 1972; Norman 1983).

In small numbers in NZ, where prefer shallow freshwater lakes, pools and swamps with much marginal cover; occasionally use saline or brackish waters. Expansion may be limited by scarcity of shallow freshwater wetlands (Mills 1976); NZ lacks wide alluvial plains and salt-lake country, which support huge numbers of birds and major breeding events in Aust.

In Aust., breed mainly S of 20°S (Aust. Atlas); opportunistic inland, on large shallow floodwaters over alluvial plains and on inundated salt lakes of arid and semi-arid zones (Frith 1959; Gentilli & Bekle 1983); these water-bodies large enough to persist until ducklings fly and shallow enough so that submerged food accessible (Gentilli & Bekle 1983). Early stages after drying and refilling provide ideal conditions for breeding, with increased levels of organic matter, and abundant aquatic flora and invertebrates (Crome 1988). A few birds nest in or beside other wetlands (swamps, dams, lakes, saltmarsh); sometimes some distance from water (Cunningham & Welch 1955; Kenyon & O'Connor 1956; Vestjens 1977; Frith 1982).

Extremely mobile; fly readily, reaching considerable heights. Roost close to feeding grounds in areas partly or

wholly isolated by water; at Corner Inlet, Vic., on flat ground facing intertidal flats and backed by mangroves (Norman 1983); at Serendip, Vic. (freshwater wetland), mainly on short grassland on banks and islands (Norman *et al.* 1979). Use of underwater habitat limited to depths reached by upending (Frith *et al.* 1969).

Breeding on alluvial plains may be threatened by flood-mitigation schemes (Frith 1982), and many freshwater wetlands suitable for feeding and breeding destroyed or modified by drainage, increased salinity, clearing, grazing and burning (Riggert 1966; Goodrick 1970; Corrick & Norman 1980; Corrick 1981, 1982). Artificial impoundments support large numbers of birds (Braithwaite *et al.* 1985); pastures and crops used for feeding. Permanent dams and bores allow extension of range in arid zone; may have removed limitations on breeding in some places, by providing freshwater for drinking (Ford 1966; Gentilli & Bekle 1983).

DISTRIBUTION AND POPULATION Aust., NZ; vagrant to Indonesia, S. Moluccas, Timor, New Guinea region, E. Solomon Is, New Caledonia, Lord Howe and Macquarie Is.

AUST. Throughout, mostly E and SW. **Qld**. Throughout, including islands off SE, visitor Torres Str. islands (Draffan *et al.* 1983). **NSW**, **Vic**. Throughout (Morris *et al.* 1981; Vic. Atlas). **Tas**. Widespread; also King & Furneaux Is (Green 1977; Thomas 1979; White 1985). **SA**. Widespread, mostly E, also Kangaroo I., rarer elsewhere but most widespread duck in SA (Parker *et al.* 1985). **WA**. Throughout, rarer in interior regions; also Houtman Abrolhos Is. (Serventy & Whittell 1976; Saunders & de Rebeira 1985). **NT**. Throughout, but normally small numbers, also Groote Eylandt (Aust. Atlas).

NZ Formerly rare and local, but increasing, with aid of nest boxes, and now widely scattered over NI and SI (NZCL; Falla *et al.* 1981; McFadden 1981; NZ Atlas).

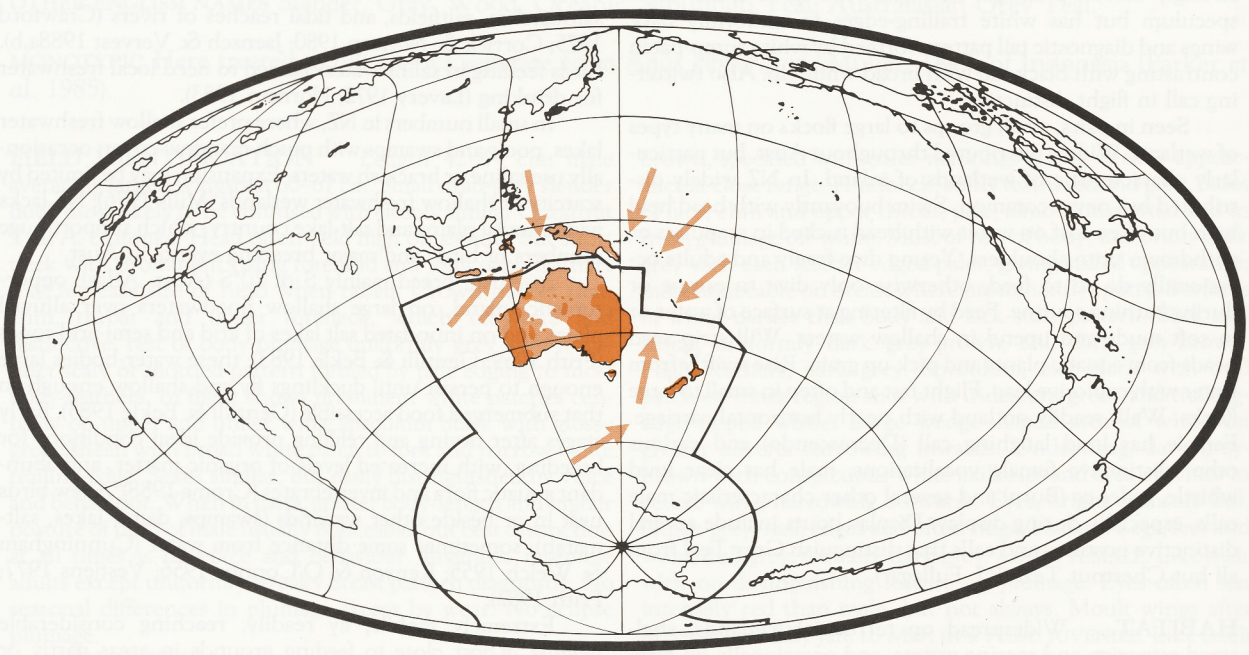
LORD HOWE I. Vagrant; five in Aug. 1957 (McKean & Hindwood 1965); one, 24 May 1975 at airport lagoon (P.J. Fullagar).

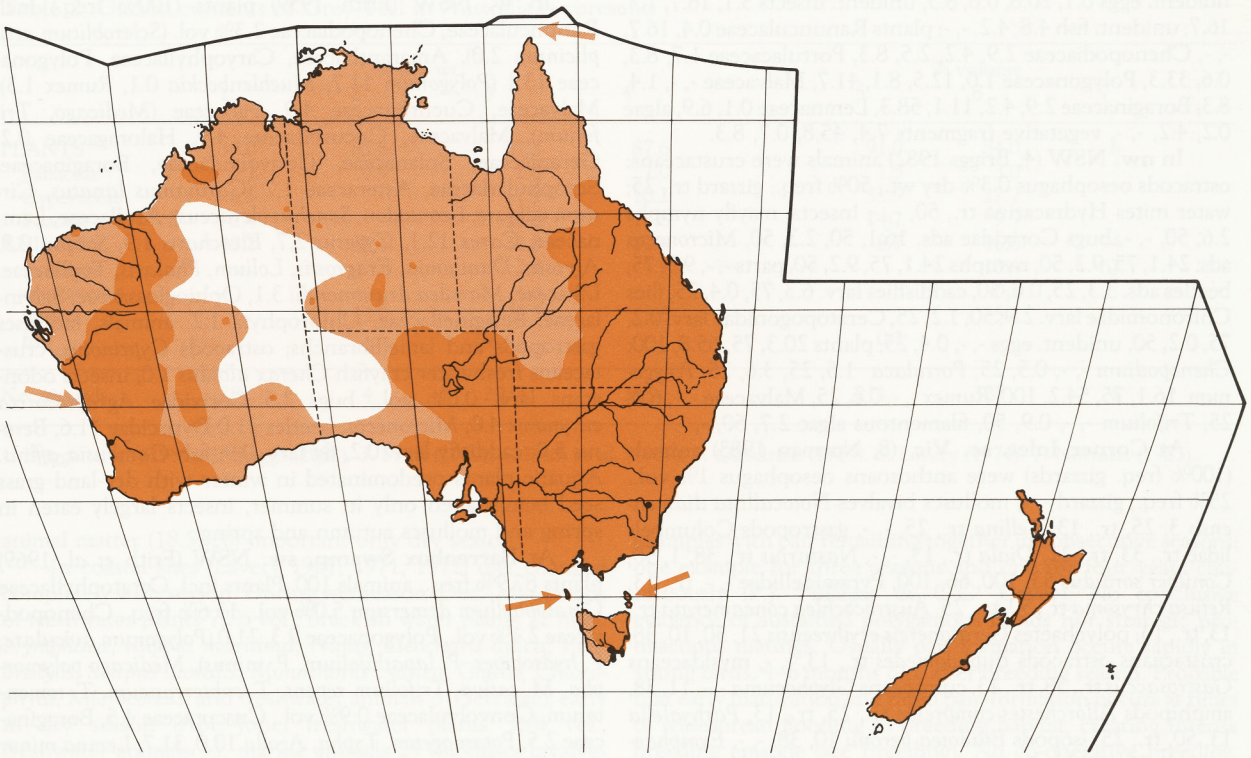
MACQUARIE I. Vagrant; several, Apr. 1957 (Keith & Hines 1958).

POPULATION Indices of abundance from annual aerial surveys (transect counts) of wetlands in about 12% of land area of e. Aust., Oct. 1983–88 were: 336 876; 1 081 287; 348 431; 61 236; 95 140; 127 022 respectively; in 1988, 41–80% of birds recorded on floodplains at confluence of Murrumbidgee and Lachlan Rs, central s. NSW (Braithwaite *et al.* 1985a,b, 1986, 1987; Kingsford *et al.* 1988, 1989). Counts in Vic. summer surveys, 1987–89, were: 50 034 on 332 wetlands; 70 303 on 472 wetlands; 88 360 on 626 wetlands respectively; making up 24–29% of all ducks counted (Martindale 1988; Hewish 1988; Peter 1989). Counts in sw. Aust., 1986–88, were: 41 280 on 872 wetlands; 67 512 on 1201 wetlands; 70 054 on 1398 wetlands respectively (Jaensch & Vervest 1988a,b). Max. of *c.* 1300 in Townsville region, n. Qld, 1959–63 (Lavery 1970a). Total NZ population estimated at fewer than 20 000 (Mills 1976), but increasing (NZ Atlas).

Pre-season counts in Vic. indicate that exposure to hunting high; 71–72% of total counted were on waters open to shooting (Martindale 1988; Hewish 1988; Peter 1989). Shot much and usually forms high proportion of total harvest in se. Aust.; favoured target of shooters (Norman *et al.* 1984; Briggs *et al.* 1985; Loyn 1987). High proportion of Grey Teal on sample of waters in Vic. harvested in 1987 open season, but in that year most of population probably secure on inland waters (Loyn 1987).

MOVEMENTS Highly dispersive from breeding sites and responding to climatic changes with movements over great distances. Banded birds have been recovered in a wide scatter all over continent and in New Guinea (Frith 1957, 1959, 1962, 1963) though there may be some regular pattern corresponding to seasonal variation in availability of water. Thus reporting rate in Vic. highest in spring and summer,





which suggests regular movement to se. Aust. as inland waterbodies dry out (Morgan 1954; Vic. Atlas) but in ne. NSW most abundant on coast Mar.–Oct. (Gosper 1981), though this possibly artefact of exceptional seasons (Gosper *et al.* 1983). In n. NT virtually absent in wet season (Crawford 1972; Morton *et al.* 1989) but peaking in large numbers in dry season (Morton *et al.* 1989); largely dry-season visitor to nw. Aust. (Gowland 1988), Atherton district, n. Qld. (Bravery 1970) and islands in Torres Str. (Draffan *et al.* 1983). Mixing between e. and w. populations likely to occur in n. Aust. with recoveries in sw. Aust. of birds banded in se. Aust. (Downes 1955) and of birds banded in se. Aust. recovered in n. NT and vice versa (Frith 1959); may also travel directly E-W. In n. Qld, apparently regular movement between wet-season breeding swamps inland and coastal mudflats used during dry season (Lavery 1972; Longmore 1978; Garnett & Bredl 1985). These movements exaggerated in years of low rainfall in inland NSW when large numbers first move towards the coast or permanent waterholes (White 1987) then travel widely (Frith 1962), numbers in se. Qld. being negatively correlated with rainfall inland (Woodall 1985), those in ne. NSW being negatively correlated with discharge of inland rivers (Gosper *et al.* 1983). May follow storm fronts across dry areas (Brooker *et al.* 1979) and have been recorded moving onto new waterbodies within an hour of rain (Badman 1979), banded birds moving several hundred kilometres in a few days in response to wet weather (Frith 1982). In NZ, first recorded 1866 but may have been there longer; large numbers first became established 1957 after series of wet years in Aust. (Frith 1982). At same time some also reached Macquarie I. (Keith & Hines 1958; Norman 1987). Current pattern of movement in NZ shows some evidence of flocking Jan.–Jun. with birds dispersing to breeding swamps July–Dec. Erratic long-distance movements frequent and numbers on water bodies can change dramatically in a few days.

BANDING AUST. Recoveries of birds from all over se. Aust. and PNG, dispersal showing no pattern with exchanges between banding sites over long distances. Of birds banded at Griffith, se. NSW, 54% recovered >160 km away in year of banding, >70% in subsequent years (Frith 1962; 1963). NZ. Pattern of returns of adults and immatures similar with 75% of recoveries <100 km <7 weeks after banding but 60% >100 km >7 weeks. Some birds, however, remain sedentary at breeding swamps for ≥2 years (Mills 1976).

FOOD Mostly seeds of aquatic plants but dietary analyses using gizzard samples probably biased against animal matter, which may make up most important fraction of food. BEHAVIOUR. Food obtained by up-ending, dabbling at water surface, dredging mud at water's edge and by stripping seeds from emergent vegetation. Feeding by both day and night but most probably occurs about dawn and dusk (Lavery 1972) or at night (Frith 1959).

ADULT Summarized Tables 1 and 2. At **Willandra and Kinchega, w. NSW** (24 samples; Briggs *et al.* 1985) animals incl. molluscs: gastropods oesophagus 0.7% dry wt., 4.2% freq., gizzard -, -; crustaceans: cladocerans tr., 8.3, -, -, ostracods 0.3, 12.5, 4.1, 58.3; insects: odonatans Anisoptera 0.1, 8.3, -, -, bugs Corixidae 10.2, 25.0, 1.1, 41.7, Notonectidae 4.7, 16.7, 0.4, 8.3, beetles Dytiscidae ads. -, -, 0.1, 8.3, Hydrophilidae larv. 0.1, 12.5, 23.5, 66.7, ads. tr., 4.2, tr., 8.3, unident. beetles 0.1, 4.2, 0.2, 8.3, caddisflies 0.1, 8.3, flies Tipulidae larv. tr., 4.2, -, -, Culicidae larv. 7.0, 25.0, -, -, pupae 8.2, 12.5, -, -, Chironomidae larv. 5.9, 37.5, 29.1, 91.7, pupae 2.1, 4.2, 0.3, 8.3, ads. 0.4, 8.3, -, -, Simuliidae larv. 3.7, 4.2, -, -, pupae 0.3, 4.2, -, -, unident. fly larv. 0.2, 4.2, -, -, ads. 4.2, 12.5, 0.3, 8.3,

unident. eggs 0.1, 20.8, 0.6, 8.3, unident. insects 5.1, 16.7, 1.3, 16.7; unident. fish 4.8, 4.2, -, -; plants Ranunculaceae 0.4, 16.7, -, -, Chenopodiaceae 2.9, 4.2, 2.5, 8.3, Portulacaceae 1.7, 8.3, 0.6, 33.3, Polygonaceae 1.0, 12.5, 8.1, 41.7, Malvaceae -, -, 1.4, 8.3, Boraginaceae 2.9, 4.2, 11.1, 58.3, Lemnaceae 0.1, 6.9, algae 0.2, 4.2, -, -, vegetative fragments 7.4, 45.8, 0.7, 8.3.

In **nw. NSW** (4; Briggs 1982) animals were crustaceans: ostracods oesophagus 0.3% dry wt., 50% freq., gizzard tr., 25; water mites Hydracarina tr., 50, -, -; insects: mayfly nymphs 2.6, 50, -, -, bugs Corixidae ads. 16.1, 50, 2.3, 50, *Micronecta* ads. 24.1, 75, 9.2, 50, nymphs 24.1, 75, 9.2, 50, parts -, -, 9.5, 75, beetles ads. 3.3, 25, 0.6, 50, caddisflies larv. 6.3, 75, 0.4, 25, flies Chironomidae larv. 2.9, 50, 1.2, 25, Ceratopogonidae larv. 0.2, 75, 0.2, 50, unident. eggs -, -, 0.4, 25; plants 20.3, 75, 65.8, 100: *Chenopodium* -, -, 0.5, 25, *Portulaca* 1.5, 25, 3.6, 25, *Polygonum* 16.1, 75, 54.2, 100, *Rumex* -, -, 0.6, 25, Malvaceae -, -, 6.0, 25, *Trifolium* -, -, 0.9, 50, filamentous algae 2.7, 50, -, -.

At **Corner Inlet, se. Vic**. (8; Norman 1983) animals (100% freq. gizzards) were anthozoans oesophagus 1% vol., 25% freq., gizzard -, -; molluscs bivalves *Notocallista diamenensis* 3, 25, tr., 13, *Tellina* tr., 25, -, -, gastropods Columbellidae tr., 33, tr., 22, *Diala* tr., 13, -, -, *Nassarius* tr., 38, 1, 50, *Conuber sordidus* 53, 100, 66, 100, Pyramidellidae -, -, tr., 13, *Retusa chrysoma* tr., 50, tr., 25, *Austrocochlea concamerata* tr., 13, tr., 13; polychaetes *Ceratonereis erythreensis* 21, 50, 10, 38; crustaceans ostracods *Euphilomedes* tr., 13, -, -, mysidaceans *Gastrosaccus* tr., 38, tr., 13, cumaceans *Glyphocuma* -, -, 11, 38, amphipods *Allorchestes compressa* tr., 25, tr., 13, *Parhyalella* 13, 50, tr., 25, isopods *Euidotea peronii* 10, 38, -, -, *Exosphaeroma* 1, 50, tr., 38, *Brachynotus spinosus* tr., 13, tr., 13, *Halicarcinus ovatus* tr., 13, -, -; plants 75% freq. in gizzards.

At **The Coorong, SA** (19 oesophagi, 17 gizzards; Delroy 1974) *Lamprothanium papulosum* tuber oesoph. 41% vol., gizz. 2, *Ruppia* tuber 50, 2, tuber sheaths 0, 34, seed 2, 21, foliage 1, 0, Lepilaena cylindrocarpa seed 6, 8.

On **n. coast NSW** (Goodrick 1979) plants (100% freq.; almost entirely seeds) incl. Ceratophyllaceae 5.0% vol., *Ranunculus inundatus* 26.7, Amaranthaceae 0.6, *Polygonum* 0.6, *Trifolium*, *Ludwigia peploides* 2.4, *Cuscuta australis*, Potamogetonaceae 3.3, *Eleocharis*, *Lepironia*, *Echinochloa colona*, *Pseudoraphis spinescens* ; animals, molluscs: *Glyptophysa* and other small Planorbidae 24.3% freq.; crustaceans ostracods; spiders; insects: odonatans, bugs, Corixidae 7.2, beetles Dytiscidae 15.8, Hydrophilidae 7.9, fly larv., lepidopterans, caddisflies.

In **w. NSW** (Frith 1959) plants (100% freq.) incl. Ranunculaceae, Chenopodiaceae 2.3% vol. (*Scleroblitum atriplicinum* 2.0), Amaranthaceae, Caryophyllaceae, Polygonaceae 13.1 (*Polygonum* 11.7, *Muehlenbeckia* 0.1, *Rumex* 1.3), Malvaceae, Cucurbitaceae 4.9, Fabaceae (*Medicago*, *Trifolium*), Malvaceae, Cucurbitaceae 4.9, Haloragaceae 0.2, Geraniaceae, Solanaceae, Convolvulaceae, Boraginaceae, Scrophulariaceae, Asteraceae 1.7 (*Carthamus lanatus*, *Cirsium vulgare*, *Leontodon*, *Sonchus oleraceus*), Azollaceae, Lemnaceae, *Carex* 12.1, *Cyperus* 2.7, *Eleocharis* 1.9, *Scirpus* 0.9, *Agrostis*, *Danthonia*, *Eragrostis*, *Lolium*, *Phalaris*, Typhaceae, Liliaceae, *Marsilea drummondii* 3.1, Ophioglossaceae, Salviniaceae, Selaginellaceae, Chlorophyta 1.2; animals, molluscs gastropods and lamellibranchs; ostracods *Cyprinotus*, crustaceans freshwater crayfish *Cherax albidus* 1.0; insects odonatans larv. 0.6% vol., bugs 2.5 Corixidae *Agraptocorixa eurynome* 4.0, *Micronecta*, beetles 21.0 Dytiscidae 11.6, *Berosus* 5.0, caddisfly larv. 0.2, fly larv. 0.9; fish *Gambusia affinis*. Aquatic plants predominated in winter with dry-land grass seed being taken only in summer, insects largely eaten in spring and molluscs autumn and spring.

At **Barrenbox Swamp, sw. NSW** (Frith *et al.* 1969) plants 87.9% freq., animals 100. Plants incl. Ceratophyllaceae *Ceratophyllum demersum* 5.0% vol., 13.6% freq., Chenopodiaceae 2.1% vol., Polygonaceae 9.3, 21.0 (*Polygonum aviculare*, *P. hydropiper*, *P. lapathifolium*, *P. minus*), *Medicago polymorpha*, *M. sativa*, *Trifolium repens*, *T. subterraneum*, *T. tomentosum*, Convolvulaceae 0.9% vol., Cuscutaceae 4.5, Boraginaceae 2.5, *Potamogeton*, *Typha*, *Azolla* 10.0, 31.7, *Lemna minor* 6.4, 19.7, *Cyperus* 2.7, 6.5, *Schoenoplectus validus* 4.3, 20.0, *Avena sativa* 0.6% vol., *Echinochloa crus-galli* 5.3, 8.8, *Oryza sativa* 7.6, 13.1, *Triticum aestivun* 0.6% vol., Typhaceae 1.4, Marsilea 0.8, Chlorophyta 6.2, 11.4; animals incl. molluscs 1.9 (bivalves *Corbiculina permena*, gastropods *Glyptophysa*, *Gyraulus*) and insects 9.8 (odonatan larv. 0.6 vol., bugs 2.5 Corixidae 2.8 *Agraptocorixa*, *Micronecta*, *Sigara*, beetles 1.2 *Ilybius*, *Berosus*, *Hydrophilus*, caddisfly larv. 3.8, 25., flies 1.8 Chironomidae larv. 1.7).

In **n. Qld** (Lavery 1970b) plants 96.7% freq. incl. Nymphaeaceae 5.3% vol., 11.7% freq., Menyanthaceae 20.2 32.2, Fabaceae 14.3% freq., Cyperaceae 67.1, Poaceae 26.1, Ponterderiaceae 3.5 4.6; animals 20.2% freq., molluscs 10.1, crustaceans 2.6, insects 13.0, fish 0.3. Diet dominated by Cyperaceae throughout year (wet season 53.9% vol., 55% freq., dry season 22.7, 69) with Menyanthaceae (23.1, 29) and

Table 1. Oesophagus contents of Grey Teal in Australia (+=present)

	% dry wt.			% vol.	% freq.			
	1	2	3	4	1	2	3	4
PLANTS	42.3	20.3	2	100	81	75	50	100
Fabaceae	9.0				33			
Cyperaceae	1.3				21			
Poaceae	15.4				42			
ANIMALS	58.2	79.6	98		75	100	100	
molluscs	0.7		56		4		100	
crustaceans	0.3	0.3	24					
insects	52.5	79.4	+				25	
No. oesophagi	28	4	8	19				

1. Briggs *et al.* (1985). 2. Briggs (1982). 3. Norman (1983). 4. Delroy (1974).

Table 2. Gizzard contents of Grey Teal in Australia (+=present)

	% dry wt.				% volume		
	1	2	3	4	5	6	7
PLANTS	39.0	65.8	67.2	87.6	91.0	84.0	6
Fabaceae	5.7	0.9	2.6	7.0	1.5	3.0	
Cyperaceae	6.5		17.9	10.2	31.9	27.7	
Poaceae	2.4		15.3	18.8	14.7	9.9	
ANIMALS	40.2	34.1	32.8	12.4	8.7	16.0	94
molluscs			2.4	1.9		10.4	67
crustaceans		+	1.4			0.5	
insects		33.0	28.3	9.8		5.1	
fish			+		0.1		
No. gizzards	28	4	2037	315	211	307	8

1. Briggs *et al.* (1985). 2. Briggs (1982). 3. Frith (1959). 4. Frith *et al.* (1969). 5. Goodrick (1979). 6. Lavery (1971). 7. Norman (1983).

animal matter (18.5, 20) important only dry season.

In coastal sites (Lavery 1967, 1971, 1972) diet changed completely with season. During wet season (Dec.–Mar.) seeds of freshwater plants 72% vol., brackish water plants 22 (incl. *Nymphaea, Ruppia maritima, Najas, Eleocharis dulcis, Fimbristylis, Scirpus litoralis, Monochoria cyanea, Chara, Chlorophyta, Microcoleus*) and freshwater animals 6 (Gerridae); early in dry season (Apr.–June) freshwater plants 36% vol., freshwater animals 35, marine animals 29 (molluscs bivalves *Modiolus*, gastropods *Salinator, Assiminea, Cerithiidae, Cassidula, Paplares angusta* 1, Nassariidae, Naticidae, *Neritina oualaniensis* 19, *Odostomia*, crustaceans copepods Harpactacoida, amphipods, isopods, tanaidaceans); in late dry season freshwater plants 34, marine animals 66 (*Paplares angusta* 12, *Neritina oualaniensis* 23). The *Neritina oualaniensis* were 0.34 cm (0.01, 118).

Other records: plants *Chenopodium* (seeds and leaves, Lea & Gray 1935; seeds, Vestjens 1977), Amaranthaceae, *Polygonum* , *Medicago sativa, Trifolium* (Vestjens 1977), *Cucumis myriocarpus*, Poaceae leaves (McKeown 1944), *Oryza* seed (Ellis 1940); animals (Mathews 1910): molluscs *Cantharidus* (McClymont 1906); spiders (Vestjens 1977); insects: odanatans Anisoptera larv. (McKeown 1944), bugs, water beetle ads., larv. (Vestjens 1977) incl. *Berosus australiae* (Lea & Gray 1935), weevils.

YOUNG In n. Qld contained seeds of Pontaderiaceae *Monochoria cyanea* 69.8% vol. (Lavery 1971).

SOCIAL ORGANIZATION Some information presented by Frith (1982) and Johnsgard (1965), but based mainly on observations by P.J. Fullagar and C.C. Davey. Typically in pairs throughout year; gregarious when not breeding, at times forming large flocks. No non-breeding territories held. Flocks formed by congregation of pairs; often mixed with some unpaired birds of both sexes, usually sub-adults at stage before pair-formation. Size of flock can range up to several thousands. Feed strictly in pairs or in family parties in breeding season but outside breeding season normally feed as flock.

BONDS Sustained or long-term monogamous pair-bond, usually life-long. Divorce rare but occasionally male will form temporary liaison with second female to form trio when original partner incubating. Almost invariably returns to original partner. At one site at Canberra, ACT, partners of 15 females were traced through 5 years (1981–85). There were 5 examples with pair remaining together in consecutive seasons; one example for three seasons and one for four years continuously (P.J. Fullagar & C.C. Davey). No conclusive evidence of sustained polygamous bonds nor strategic promiscuous matings. Usually pair-formation occurs rapidly in young birds, 4–6 months old, after breeding season. Probable that early maturation and rapid pair-formation occurs at times of widespread flooding in breeding habitat, creating intense breeding episode (see Breeding). No co-operative breeding. Female incubates while male remains nearby; latter particularly aggressive near nest-site. Close parental care of young by both sexes. Brood may remain in close association with parents for some weeks after independence on gaining flight, but this varies and probably depends on whether adults lay again.

BREEDING DISPERSION Solitary nesting but can be close if suitable sites close together e.g. numerous hollows in a large tree. Distance between sites varies greatly; no accurate measurements of density available. At one site at Canberra, ACT, up to 10 pairs bred most years in 2.5 ha of ponds, but these were artificial wetlands in semi-urban area (P.J. Fullagar & C.C. Davey). Male defends area near nest-site, nest-site territory. Parents defend moving territory, brood-territory, for some metres round ducklings, specially early in brood rearing. Not territorial at other times.

ROOSTING Frequently roost (loaf) communally; sometimes in very large flocks. Often haul out on logs, stumps, fallen branches or along shoreline. Less often on water. Most loafing, diurnal; also at night when not feeding. Male attending incubating female will seek out a loafing site for resting and preening during incubation spells; only occasionally forays to disperse intruders and rarely to engage in feeding or stray far from nest-site. Loafing sites in general usually command view of potential threats and birds remain alert and ready to depart at slightest disturbance.

SOCIAL BEHAVIOUR Based on observations by P.J. Fullagar and C.C. Davey, incorporating those of Prawiradilaga (1985), the only detailed published study, and some summarized by Frith (1982) and Johnsgard (1965). Displays conspicuous and noisy and readily observed in field. Many displays useful to indicate nature of activities; most sexually diagnostic and can often be used for field identification (see elswhere). Displays typical of *Anas* dabbling ducks and essentially ident-

ical to those of Chestnut Teal *A. castanea*. Repertoire of displays and vocalizations intermediate between Mallard-like ducks, *A. platyrhynchos* and allies, and Pintails, *A. acuta, A. georgica, A. bahamensis and A. erythrorhyncha*; if anything more like Pintails. No pursuit flights but see hostility between pairs described below. On water **Wing-flaps** and lateral **Tail-wags**, probably assertive in intent, and various Bill-dipping actions used frequently by both sexes, but especially males, in social encounters. **Bill-dips** usually precede or punctuate other signals. Flattening of crown by males and other movements of head- or neck-feathers create illusions of shine or mat appearance of these feathers and at same time alter outline. FLOCK BEHAVIOUR. **Pre-flight** signal without vocalization given by both sexes. Typical of *Anas* ducks with rapid upwards jerking of head causing body to rise and fall on water in slightly forward tilting motion.

AGONISTIC BEHAVIOUR Individual distance maintained by **Forward Stretch**, similar to **Forward Greeting**, with bill slightly open. Will lunge, jab and fight. Male specially aggressive to conspecifics whenever near nest-site at laying and constantly during early incubation. Vigorous defence of space near brood maintained by male and female. Male will defend brood and attack if brood threatened. THREAT. (1) Males challenge each other with high Chin-lift postures; used less often in females compared with males, but intention similar. **Chin-lift**: on land or water, neck and head raised with feathers sleek and bill pointing up to varying extent (Fig. 1); height increased by rapid downwards paddling by feet to lift body in water. In male accompanied by chittering sound, male conversation call (see Voice), given with bill slightly opened; female call different (see Voice). (2) Near nest-sites in breeding season, males occasionally perform distinctive parallel swimming activity, **Synchronic Swims**: with much twisting and turning in unison on water, each male adopts unusual head-tucked-into-shoulders posture, with feathers of crown flattened (Fig. 2). Unilateral eyelid closure observed often during such aggressive encounters; significance unknown (P.J. Fullagar & C.C. Davey). Intention seems to be for one male to escort opponent away from defended area; either both are trying to do this or one male is attempting to infiltrate space of other. Pathway followed can be elaborate. Sometimes results in rapid overland chases before returning to water and performance often broken off only when resolved by one male taking flight. (3) Male **Down-up** display of typical *Anas* type performed only on water; often seen among groups of disputing males. Fans and raises tail very high, tilting body sharply forwards with bill dipping into water, follows by suddenly lifting head up to same height as tail, in the process streaming water as a 'dribble' (Fig. 3); a loud whistle-call given while momentarily holding final position (see Voice). Linked series: **Chin-lift**, **Down-up**, **Chin-lift**, often given. (4) Male **Burp** display given with elevated head; feathers of crown and nape raised to form large disc-shaped profile to head and bill in slightly down-tilted posture; calls loudly with sharp whistle (see Voice) at same time raises head forwards slightly in a nodding manner (likened to someone heading a football; F. McKinney). Signal often repeated, 3 to *c.* 5 times, in quick succession (Fig. 4). (5) Female's Inciting display used against males, other females, other waterbirds and even inanimate objects that elicit hostile response. **Inciting**: involves sideways pointing movements, with harsh rattling calls; head raised high after each bout of calling. Given mostly on water but also occasionally on land and in flight. Typically given on water by female pointing towards offending male while positioned between him and partner. (6) Female **Repulsion** posture given on leaving nest-site and during brood rearing if threatened. Call resembles Inciting call but even harsher and more insistent (see Voice). ATTACK AND FIGHTING. Hostile encounters take form of pursuit, on land occasionally, but most often on water. In breeding season, attacks directed by established male at female of another pair. Attacking male will attempt to grasp and force female underwater, but she will most often take wing and is followed in rapid flight until driven away from area (see forced copulation; Breeding). Female's defence is to dive or retreat giving Inciting call to partner or giving loud Persistent Quacking or Repulsion calls (see Voice), eventually leading to flight and noisy retreat. Female often seen with tail depressed on water when pursued in these encounters, but this also often appearance of any breeding female; function of signal therefore uncertain. Chase invariably leads to **Three-bird-flights** with female leading, pursued by hostile male and both usually followed by partner of female; female often calls loudly, giving Repulsion signal and even Inciting postures on the wing. Frequently followed by other males that join the flight. Male in pursuit will peel off and return to nest-site or partner and give very deliberate Forward Greeting display (see below) and usually several loud Burp signals with Preen-behind-wing etc., all of which assumed to re-establish pair-contact and pair-bond. Encounters between females will develop into chases and attacks if Forward stretch not enough, or Inciting signal to partner does not result in displacement of offending hostile threat; usually another female or pair. Defence of young by male and female take this form with the addition of injury-feigning by female. ESCAPE. Adults dive if pressed. Female defence against attack of male is to dive or retreat by flight (see Three-bird-flights). Ducklings dive readily, commonly as first response to threat. Following hostile encounters adults Wing-flap, preen and often signal with Forward Greeting and Preen-behind-wing or Preen-dorsally displays. Strong defence and dominance by pair most noticeable from early stages of laying to early incubation and again early in brood rearing. INJURY-FEIGNING distraction display given by female. MOBBING OF PREDATORS. In typical manner of most ducks; close-in towards predator and remain vigilant; will sometimes follow predator at close range until it departs.

SEXUAL BEHAVIOUR Courtship communal and performed on water. ADVERTISING DISPLAYS. Male Burp signal used in advertising and similarly female uses Decrescendo call (see Voice). Almost all advertising displays highly stereotyped and function in pair-formation, pair-bond maintenance or pair-bond testing. Sequence of displays highly predictable. Pursuit flights not part of pair-formation and no component of aerial display. Communal, seasonal and diurnal; mostly seen at time of maturation of young, following post-juvenile moult, or in adults usually at completion of post-breeding moults, which in general, late summer, autumn or early winter in S Aust. Courting bouts often switch between heterosexual displays and male to male contests as males jostle for optimum position with respect to female; leads to Down-up displays synchronically performed by two or more males and two or more males swimming up to each other in prolonged Chin-lift displays (Fig. 5) where dominant male assumes most elevated posture. PAIR-FORMATION: MALE. (1) **Head-shakes**: quick lateral movement of head without tail-wags. (2) **Head-roll**: rotation of head about axis with head pointed slightly upwards and withdrawn during display; again no tail-wags. (3) **Introductory Shake**: head thrust upwards and neck extended during rotation causing neck feathers to ruffle; forward thrust

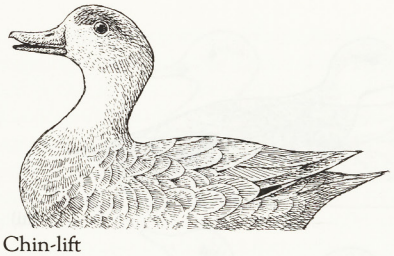


Fig. 1 Chin-lift

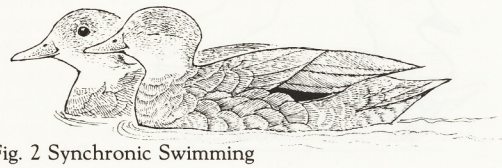


Fig. 2 Synchronic Swimming

of head causes body to rise slightly from water; always accompanied by tail-wags, before and after. None of these displays associated with a call; used in preliminary phase of courtship activities at varying intensities and without necessary sequence or preference but Head-shakes probably most numerous and Introductory shake most likely to precede next phase (Fig. 6). (4) Grunt-whistle given in isolation or linked with main series (see later). **Grunt-whistle**: dips bill into water as body rises with arching motion, then sudden flick of head causes stream of water drops to be thrown to one side from bill; brings head up and back so bill against breast as body tilts almost to vertical before falling back onto the water; vigorous tail-wag concludes display with forwards stretch. At peak of display clear whistle-call given, followed immediately by deep grunt (see Voice). In classic form followed in sequence by entirely stereotyped series: **Head-up-tail-up**, **Turn-towards**

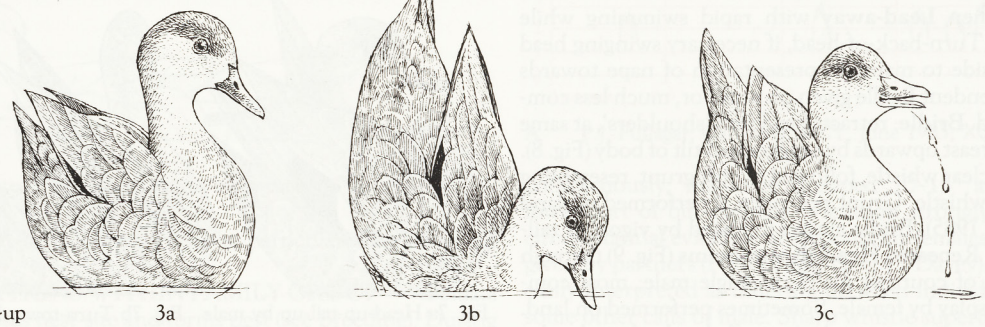


Fig. 3 Down-up 3a 3b 3c

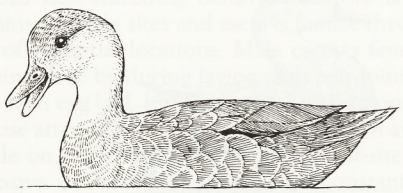


Fig. 4 Burp

Fig. 5 Chin-lift by two males

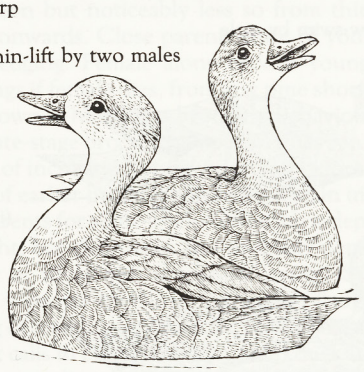
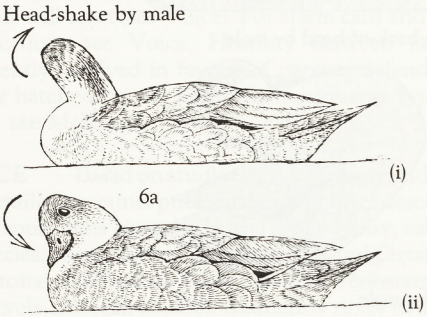


Fig. 6a Head-shake by male



(i)

6a

(ii)

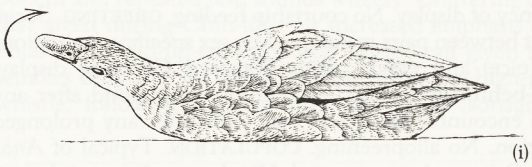
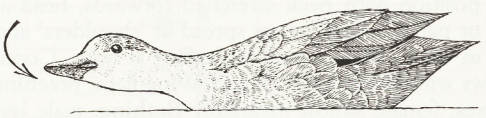


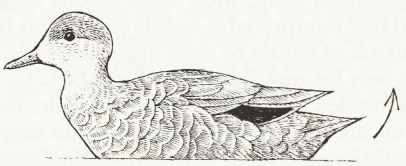
Fig. 6b Head Roll 6b

(i)



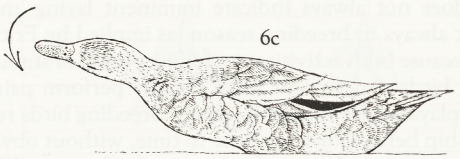
(ii)

Fig. 6c Introductory Shake



(i)

6c



(ii)

Female, Head-throw-swim (being single, very conspicuous action combining a **Bridle** with a **Nod-swim**) and **Turn-back-of-head** followed by **Lead-away** with **Turn-back-of-head** (see Fig. 7). Sequence, all given on water, often incomplete and aborted at various stages, but order consistent. **Head-up-tail-up**: lateral to courted female; first, pulls head back, then thrusts upwards, at same time tail fanned and cocked high and flicks wings to show speculum. Head, wing-tips and tail almost meet at apex of posture and at that moment male turns head and body towards female (Turn-towards-female), giving clear whistle, like that of Burp whistle. **Head-throw-swim**: pulls head backwards, at same time thrusts breast upwards, then arches head over and forwards at the moment when suddenly shoots forwards with push from feet; direction of movement usually away from female. **Turn-back-of-head**: nape directed towards female, feathers of neck flattened, sometimes head held low but often neck raised and crown feathers often flattened. May then **Lead-away** with rapid swimming while continuing to Turn-back-of-head, if necessary swinging head from side to side to maintain presentation of nape towards female. Independent Bridle given on water or, much less commonly, on land. **Bridle**: retracts head into 'shoulders', at same time throws breast upwards by exaggerated tilt of body (Fig. 8). At peak gives clear whistle, followed by soft grunt, resembling call of Grunt-whistle. Grunt not given if performed on land (Prawiradilaga 1985). Bridle always followed by vigorous tail-wags. FEMALE. Repeated **Head-throw-swims** (Fig. 9) through or past group of courting males or single male; most commonly seen display by female. Sometimes performed on land. Female gives constant conversation-call that leads to louder versions and typical **Decrescendo** attention-seeking call (see Voice). More details in Prawiradilaga (1985), including study of duration of postures, variations in performance and frequency of display. No courtship feeding. GREETING. Social contact between pairs maintained by sex specific vocalizations (see Voice) and typical *Anas* **Forward Greeting** display. **Preen-behind-wing** used to re-inforce pair-bond after any hostile encounter and when pair unite after any prolonged separation. No allopreening. COPULATION. Typical of *Anas* ducks. Pre-copulation mutual **Head-pumping**, synchronically and asynchronically followed by female adopting pre-copulatory position with neck stretched forwards, head at water-level or partly below, wings spread at 'shoulders' and body sunk in water. Male mounts, grasping at nape. Copulation follows with Bridle by male and Wing-flaps; preening by both sexes; female almost invariably **Bathing**, male less consistently doing so. Copulation often performed up to months before laying. Occurs at all times of day and frequently after laying. Evidence of forced copulations or extra-pair copulations scant. Most observations suggest not successful and best interpreted as hostile encounters between pairs, with pursuit of female by most aggressive male to shift her from area near his nest-site (P.J. Fullagar & C.C. Davey); further study needed. Defence of mate by male, indefinite pair-bonds and parental care by both sexes might suggest that extra-pair copulations less likely to occur, see Birkhead (1988). Copulation does not always indicate imminent laying and courtship not always in breeding season (as implied by Frith 1957; 1959) because both activities can follow period of stimulation among birds. Adolescent birds usually perform pair-formation displays before breeding season. Breeding birds revert to courtship behaviour from time to time, without obvious reason, except stimulation of others in display; possibly serve to test pair-bonds or result of threats to existing pair-

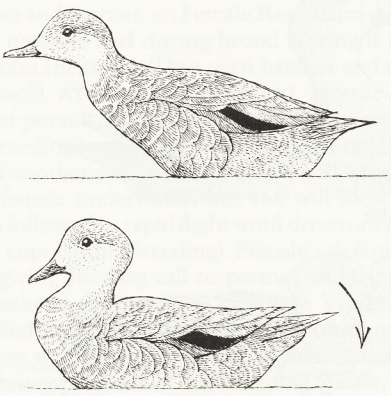


Fig. 6

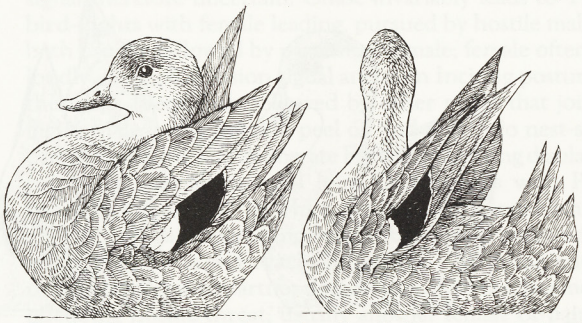


Fig. 7a Head-up-tail-up by male Fig. 7b Turn-towards-female by male

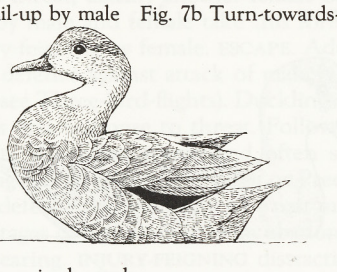


Fig. 7c Head-throw-swim by male

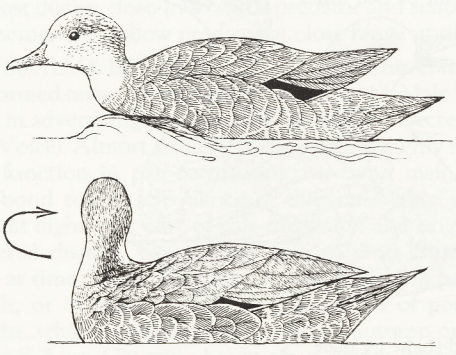


Fig. 7d Turn-back-of-head by male

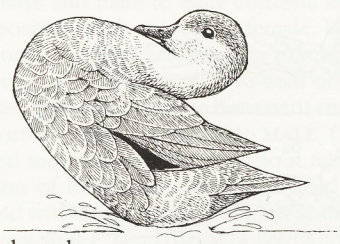


Fig. 8 Bridle by male

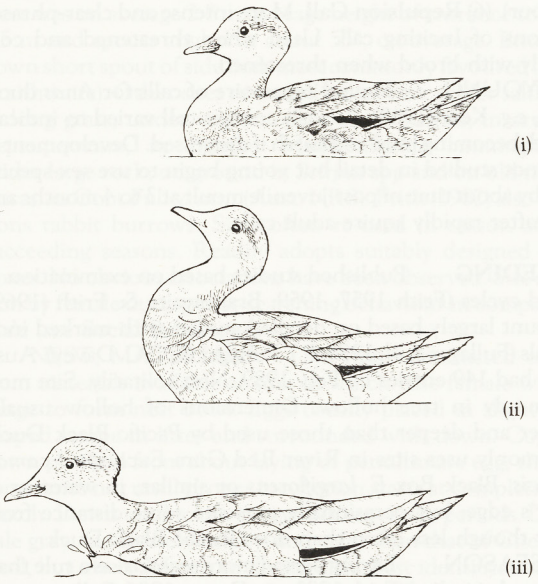


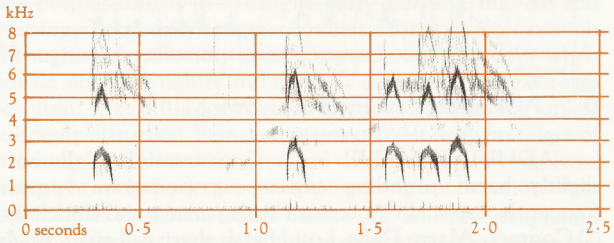
Fig. 9 Repeated Head-throw-swims by female

bonds from unpaired individuals, particularly by unpaired males.

RELATIONS WITHIN FAMILY GROUP Female alone chooses nest-site and forms nest (see Breeding). During obvious nest-searching behaviour before laying, male will examine possible sites and escorts female throughout inspection of potential locations. Male escorts female to nest and remains close by during laying with pair joining immediately after each egg laid. Incubation by female alone. Male remains in close attendance for whole of incubation and accompanies female on occasions of recess from nest-site. Male specially defensive of nest-site at laying and constantly during early incubation but noticeably less so from third week of incubation onwards. Close parental care of young by both sexes until fledging. Female alone broods young. Male can rear ducklings if female dies, from any time shortly after hatching; not known if he adopts brooding behaviour. Male often attends late-stage brood when partner has returned to laying or at start of incubation of new clutch if before time of independence of earlier brood. Brood may remain in close association with parents for some weeks following independence on gaining flight, but this varies and probably depends on breeding activity of adults (*i.e.* successive laying). Siblings frequently remain together for short period after fledging. FEEDING. No feeding of ducklings by parents. COMMUNICATION. Adults use contact calls in communication with ducklings and ducklings have responding or attention-seeking calls to which both parents will react (see Voice). For alarm calls and sibling communication, see Voice. Hostility between family parties frequently resolved in favour of parents defending most recently hatched brood. Comfort movements typical of *Anas* duck, see McKinney (1965).

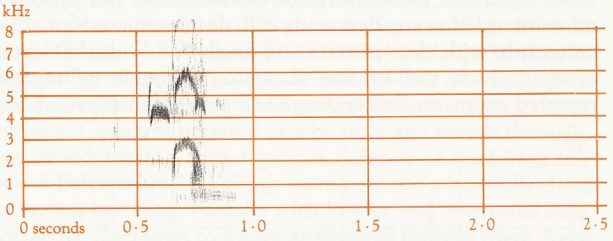
VOICE Based on studies by P.J. Fullagar and C.C. Davey. No detailed accounts published except brief descriptions with some sonagrams given by Frith (1982). Noisy; calls diagnostic of species, except almost identical calls and certainly identical repertoire of Chestnut Teal. Call almost constantly, at least at low levels, in social contact; frequently noisy in flocks, during bouts of social displays and in flight. Most characteristic calls, female's Decrescendo and male's Burp. Calls loud and harsh in female, brief whistles in male, but both sexes have specific, much softer calls used in short-distance communication. Wide range of signal-specific calls. No call shared by sexes; which helps in field identification. Individual variation suspected but no detailed study. No regional variation. Non-vocal sounds include swishing of wingbeats in flight and some noise of splashing water during some displays.

ADULT MALE (1) **Burp** call. Loud whistle *gedee-oo* (sonagram A, three males) given with bill opened



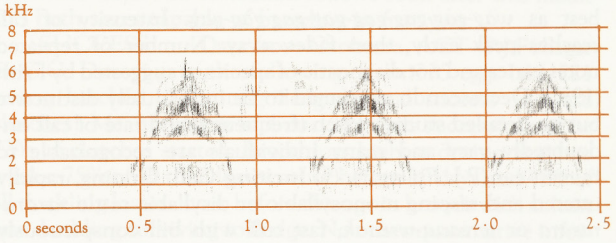
A P.J. Fullagar; Canberra, ACT, June 1983; X076

conspicuously, mandible dropped 10–15° and pattern of lower part of bill exposed. Variation strongly suspected on circumstantial evidence of response by females when this call given by partners (P.J. Fullagar & C.C. Davey). Structure less easily interpreted as differing between individuals than with some other calls of male. Sharp whistle superimposed on rising and falling set of transients, which may constitute main part of conversation calls (see below). Call given during Down-up probably same as that of Burp without whistle component and repeated fast; sounds wheezy. Chittering call like that given during Chin-lift, but increased emphasis at end. Following Head-up-tail-up muted whistle-call given that resembles Burp call. (2) **Grunt-whistle**, explosive high-pitched whistle, followed by deep throb-like grunt (sonagram B).



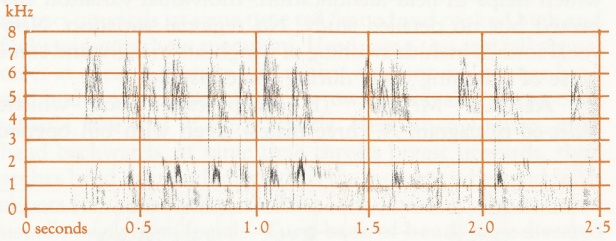
B P.J. Fullagar; Canberra, ACT, June 1983; X076

Whistle is complex and seems to vary distinctively between individuals but no detailed study. **Bridle** call closely resembles this call. (3) Short *thew* contact call sounds like 'tongued' hiss of very low amplitude (sonagram C). Given almost constantly



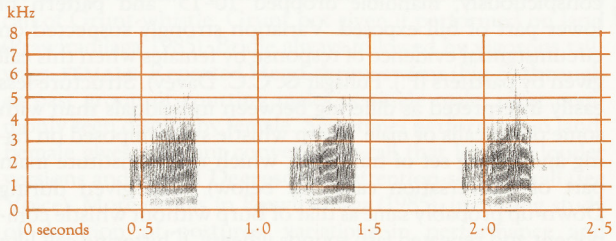
C P.J. Fullagar; Canberra, ACT, June 1983; X076

in social signalling to partner and when accompanying brood; also given in flight. Louder variant given during **Chin-lift** display as *cuc-cuc-cuc-cuc-coooo* or *thew-thew-thew-thew-theoo* (sonagram D), fast hissing sound and all of these calls seem to be similar to unwhistled portion of **Burp** call.



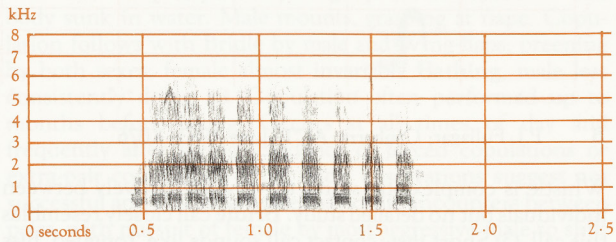
D P.J. Fullagar; Canberra, ACT, 1984; X116

ADULT FEMALE (1) **Conversation Call**, soft, slightly harsh sounding *cug-cug-cug* (sonagram) given frequently, especially in contact with partner and ducklings. (2) **Contact, Alarm Calls**. Loud harsh sharp call given singly or repeated steadily; often in flight. Best described as *wreee-ak* or *wreee-ow* or *wreee-aah* (sonagram E), emphasis on last syl-



E P.J. Fullagar; Canberra, ACT, June 1983; X076

lable. Louder in alarm and probably functions something between Conversation (short-distance) call and next call. (4) More rapid and louder form of Conversation call probably more intended as an advertising call; developing to **Slow Decrescendo** with clear phrases and finally full-bodied **Decrescendo**, which well-known 'laughing' chuckle of rapidly repeated notes on descending scale (sonagram F); rendered



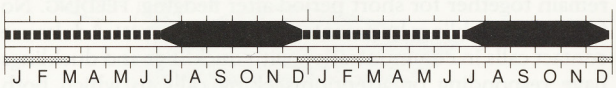
F E. Slater; Canberra, ACT, May 1984; X075

best as *wag-gag-gag-gag-gag-gag-gag-gag*. Intensity of call reaches peak early, then fades away. Number of repeated notes varies and not diagnostic of species as suggested by Frith (1982). Decrescendo presumed to be individually distinctive but no detailed studies. Pitch (frequency) and rate of call undoubtedly vary and many individuals are recognizable to human ear (P.J. Fullagar). (5) **Inciting Call**. Grating, rapidly uttered and rasping monosyllabic or disyllabic rattle *rararara-rarara* or *wreaaa-wreaah*; fast trill with bill conspicuously open and head thrust sideways repeatedly (see Social Behaviour). (6) **Repulsion Call**. More intense and clear-phrased versions of Inciting call. Used when threatened and constantly with brood when threatened.

YOUNG Typical repertoire of calls for *Anas* ducklings, *e.g.* Kear (1968). Peevish contact call varied to indicate mood; becoming loud and harsh if distressed. Development of calls not studied in detail but young begin to use sex-specific calls by about time of post-juvenile moult at 3 to 4 months and thereafter rapidly aquire adult calls.

BREEDING Published studies based on examination of gonad cycles (Frith 1957; 1959; Braithwaite & Frith (1969). Account largely based on detailed studies with marked individuals (Fullagar *et al.* 1988; P.J. Fullagar & C.C. Davey). Aust. NRS had 149 entries by Feb. 1989. Nest solitarily. Site most commonly in tree hollow. Dimensions of hollow usually smaller and deeper than those used by Pacific Black Duck. Commonly uses sites in River Red Gum *Eucalyptus camaldulensis*, Black Box *E. largiflorens* or similar; in water or at water's edge; but occasionally uses site some distance from water though less often than does Pacific Black Duck.

SEASON Laying period more seasonal as a rule than previously implied (Frith 1982; see Crome 1986, Fullagar *et al.* 1988). Over most of range, i.e. S of summer-rainfall regions of subtropics and tropics, most commonly lays between June and Feb., but out-of-season laying within this area does occur occasionally if exceptional and persistent summer-rainfalls with unseasonal flooding. Laying dates later in n. Aust. (Lavery 1970b), where many fewer seem to breed compared with s. Aust. Aust. NRS gives three records; two of eggs in mid and late Mar. and one brood, 'well grown' in mid-Apr. for N of lat. 25°. Opportunistic character of breeding has been overemphasized (*e.g.* Braithwaite 1976), whereas more properly described as seasonal (Fullagar *et al.* 1988). Crome (1986) gives dates for laying at Booligal, NSW in four seasons (1976–79) between late June and Dec. with peak periods in Aug.–Sept. or Oct.–Nov. At Canberra, ACT, recorded laying from late July until Feb. in eight seasons (1981–88) (Fullagar *et al.* 1988; P.J. Fullagar); earliest start 8 July and latest 4 Feb. Exceptional summer and autumn rain in 1989 gave rise to resumed laying by Grey Teal in Apr. and May. Pairs were same as those that had bred some months before (P.J. Fullagar & C.C. Davey). No other data based on observed or calculated dates for laying except Aust. NRS, which much less reliable but give following approximate dates. All records from s. Aust. (below lat. 25°): sample of 21 events gave two in July; two, Aug.; four, Sept.; seven, Oct.; two, Nov.; one, Dec.; two, Jan. and one, Feb. from records since 1973.



(s. Aust.)

SITE Most often uses cavities within tall timber along watercourses, in flooded forests or near large wetlands. Often uses River Red Gum *Eucalyptus camaldulensis*. Tree-hollows were used in 77% of 44 observations, excluding four in boxes (Aust. NRS). Much less often on ground. No details on aspect chosen but sites varied much. Nest always well concealed and often some distance from entrance of chosen cavity. Average depth 1.3 m (n=53) of sites measured in River Red Gum at Booligal (L.W. Braithwaite). For same sites at Booligal, circumference of trunk (at breast-height) of nesting

trees was on average 2.8 m; average height of entrance to nest, 3.5 m and spouts angled at about 55°, on average. Entrance down short spout of side limb most commonly favoured (L.W. Braithwaite). Other sites recorded have been: under saltbush; in long grass; under vegetation or small bushes; in scrubby *Leptospermum*; in lignum *Muehlenbeckia cunninghamii*; under large rock; on ground in *Scirpus* spp and on old nest of Eurasian Coot *Fulica atra* (Aust. NRS). Frith (1982) also mentions rabbit burrows. Sites often re-used in season and in succeeding seasons. Readily adopts suitably designed nest-boxes. No obvious associations have been observed. Site selection by female during nest-searching behaviour in company of male (see Social Behaviour).

NEST, MATERIALS No nest constructed except from materials available at site; in which case female will arrange to form nest bowl. Eggs usually placed in slight cup-shaped scrape in litter and surrounded with down. Copious down plucked from about laying of penultimate egg, though sometimes not until proper incubation starts at completion of clutch. Down used to cover eggs during recess periods. Down pale grey, moderately 'sticky' and paler than that of Chestnut Teal, but often difficult to distinguish. Best identification can be presence of other more distinctive body feathers.

EGGS Elliptical, sometimes more oval (North); fine textured and greasy (Campbell); close-grained, smooth and almost lustreless (North); cream or light creamy-white. MEASUREMENTS: 50 (49–58; 126) x 36 (35–42) from 24 nests (Frith 1982); 49.0 (46.7–51.6; 31) x 35.8 (34.0–38.6) from 3 nests (Campbell; North).

CLUTCH-SIZE Reported as varying from 6 to 14, but dump nesting up to 30 eggs has been found (Frith 1982). In 54 clutches distribution was 1xC/4; 3xC/5; 9xC/6; 12xC/7; 14xC/8; 7xC/9; 2xC/10; 4xC/12; 2xC/14 (Frith 1982), showing that clutches of 7 or 8 seem normal. Broods of more than 10 ducklings recorded six times (Aust. NRS); 2 x 11, 2 x 12, 1 x 13 and 1 x 32. Last seems improbable (Mystic Park, Vic. 18 Dec. 1975). Critical data on clutch-size obtained at Canberra, ACT, 1981–89 (P.J. Fullagar & C.C. Davey) gave mean of 8.3 (6–11; 54). Many of these sites were under daily observation and some electronically instrumented to follow incubation activity more closely. Only clutches where size confirmed used. All clutches with inconsistent laying sequences and clutches where dumping was known, excluded. Examples of incompleted clutches, where no incubation followed, amounted to 4% of 48 nesting attempts. Dumped eggs were found in 13% of 30 nests in 4 seasons. Data on clutch-size in Aust. NRS of doubtful value because these and other details were not critically analysed. Variation in clutch-size not studied in detail but no significant relation between clutch-size and laying date from these reliable data from Canberra (P.J. Fullagar).

LAYING Eggs laid at intervals of about 24 h, but precise interval not known. Laying occurs in early morning, probably within two to three hours of first light. Pairs lay again within a few weeks of premature loss of brood; shortest interval recorded was 20 days (P. J. Fullagar & C.C. Davey). Second clutches usually start at time of fledging of first brood; earliest recorded was at 32 days from hatch of earlier brood (P.J. Fullagar & C.C. Davey). Commonly, pairs rear two broods in season (7 of 20 pairs in four seasons; P.J. Fullagar & C.C. Davey) and many pairs produce several clutches in season if loss of brood occurs. Probability of rearing more than two broods in season seems unlikely unless ducklings grow very rapidly and abandoned quickly, at least by female. This possibility needs further investigation. Known that brood often escorted by male in transition period when female again laying and brood may become more or less responsibility of male once female again incubates (P.J. Fullagar & C.C. Davey).

INCUBATION Only critical data from wild obtained from close study by Fullagar *et al.* (1988) and P.J. Fullagar and C.C. Davey. Mean of 28 ± 2 days (25–31; 21), from marked eggs, instrumented nest-sites and daily observation. Unhatched eggs abandoned on completion of hatch and departure of ducklings. Incubation by female alone. Recess periods usually in 3 sessions, early morning, mid-day and evening. Total daily length of recess 75 mins. No variation throughout incubation except towards last few days when female sits more tightly and typically does not then leave eggs so often, if at all. Eggs covered by down on leaving unless suddenly disturbed. Female remains on nest from first signs of hatching until brood hatched and dry; most often completed overnight with departure in early morning but occasionally at other times if circumstances dictate (*e.g.* an early completion of hatch during daytime or a disturbance resulting in premature departure of brood that would otherwise have remained overnight to leave following morning). No indication that eggs can be recognized by female and no disposal of egg-shells.

YOUNG Downy, precocial and nidifugous. Dark grey-brown on back and head and off-white below. Two prominent dark-brown stripes on head, one through eye and one below it with surrounding areas pale grey and lacking any warm tones. Contrasting pale chin and throat conspicuous. Pale patches on trailing-edges of wings and one particularly obvious each side of rump. Feet and bill, dull lead-grey; eyes, brown (Frith 1982; Delacour 1956; P.J. Fullagar). No accurate data on growth weights and measurements but sequence typical of most dabbling ducks and capable of flight at 55 days; shortest 46 days and longest 64 days from 20 broods (P.J. Fullagar & C.C. Davey).

GROWTH Data from P.J. Fullagar and C.C. Davey. Rate typically as follows: small (s), hatch to 15 days old; small to half grown (shg), 15 to 28 days; half-grown (hg), 28 to 35 days; half-grown to large (hgl), 35 to 42 days; large (l), 42 to 55 days; full-grown (fg), 55 days onwards. No data on weight gains nor any other changes in body measurements during development. Constant parental care by male and female throughout brood rearing with vigorous defence of ducklings (see Social Behaviour). Ducklings leave nest-site when fully dried following hatching. Female, with louder and imprinted calls, will signal ducklings to follow and in this way call them down from elevated sites. Usually male present at this time. Ducklings will jump and 'float' to ground or water below; never carried. Duckling exodus usually early morning, occasionally other times of day. Brood remains tightly together at first and will follow female very closely. Juvenile plumage differs from adults (see Plumages) but replaced at post-juvenile moult at about 100 days. Pair-formation follows soon after this moult and both sexes capable of breeding in first year.

SUCCESS Data from Canberra, ACT (P.J.Fullagar & C.C. Davey) gave the following: from 235 eggs laid, 221 young hatched, 83 young fledged; total success 35% (28 clutches). Mean number of 4 ducklings per successful pair or 72% of clutches started. Brood loss highest during first two weeks; 75% of all total losses occur before 10 days and 48% of all duckling losses occur before this age in broods with at least one duckling surviving to fledge. No other quantitative information. PREDATORS. Avian predation of ducklings presumed

to be important, especially early in life, but other aquatic or terrestrial predators must play some part in high losses at this time. Other factors must also be of importance and probably, at times, most significant. Of these, most likely to be of overriding importance, is failure of ducklings to obtain adequate and effective food. This is possibly coupled at times with complications of adverse weather causing chilling. None of these factors adequately studied in this species (P.J. Fullagar).

PLUMAGES

ADULT Age of first breeding for many, possibly most, first year. HEAD AND NECK. Crown to nape, black-brown (119); feathers, edged brown (119B), giving streaked appearance. Hindneck, dark brown (121), narrowly tipped brown (119B). Sides of face, dull white to cream (54) with feathers narrowly edged dark brown (119A), giving face streaked appearance. Throat to lower foreneck, dull white. UPPERPARTS, dark brown (121), glossed dark-olive (49), fringed buff (124); fringes broadest on mantle; scapulars similar but more narrowly fringed. Upper tail-coverts, dark brown (121), fringed light grey-brown (119D). Scapulars, dark brown (121) with olive (49) gloss and fringed light brown (223D). TAIL, dark brown (121), fringed light grey-brown (119D); pale margins of feathers more obvious when worn. UPPERWING. Primaries, greater primary coverts and alula, dark brown (121); slight dark-olive gloss on outer web of greater primary coverts. Rachis of remiges, dark brown (219). Marginal, lesser and median primary coverts, and marginal, lesser and median coverts, dark brown (121), glossed dark-olive (49); concealed bases, dark brown (121). Outermost median coverts, tipped white on inner web; this overlies white greater covert. Greater coverts, white on distal half of feather; basal half, dark brown (119A); outermost greater coverts, basally dark brown (121) for one-quarter length of feather; rest white. From innermost greater coverts, feathers have pink-buff (121D) shaft-streaks and tipped white; white tips become progressively smaller from innermost to outermost, with slight brown (121C) tips on outer webs. Ten secondaries have black (89) outer webs, forming speculum; inner webs, dark brown (121). Outer webs of secondaries subterminally tipped light brown (223D), tipped white. In some lights, s8–10 have glossy dark-green (162A) outer webs, bordered by black (89); on s10, gloss occurs at base of black (89) web. Tertials, dark brown (121), narrowly edged light brown (223D) on outer web. When wing closed, speculum bordered by white tips to greater coverts and white tips to secondaries. UNDERPARTS. Upper breast, dull white with large subterminal black-brown (119) webs, giving underparts generally spotted apppearance; feathers fringed dull white. Spots on mid-breast, dark brown (119A); on flanks, abdomen and under tail-coverts, brown (119B). Spots on flanks, larger and more obvious. Axillaries, white. UNDERWING. Primaries have glossy tegmen on inner web. Greater primary coverts, glossy brown-grey (79). Marginal, lesser and outermost median coverts, dark olive-brown (129). Some innermost marginal coverts, near axillaries, tipped white. Rest of median coverts to carpal joint, glossy brown-grey (79), narrowly fringed dark olive-brown (129). Rachis on underside of remiges, white. Greater coverts and median coverts, glossy brown-grey (79); median coverts narrowly edged white on inner web. Outer median coverts, dark olive-brown (129) narrowly tipped white or buff (124). Rest of median coverts towards inner wing have progressively more white tips and are basally dark brown (129). Lesser coverts have subterminal buff (124) tips, and are tipped white; innermost white, dark olive-brown (129) basally.

DOWNY YOUNG HEAD AND NECK. Crown and hindneck, dark brown (119A). Faint dark-brown (119A) loral stripe extends from bill, through eye to ear-coverts; similar malar stripe, extends from malar region to ear-coverts. Narrow light-brown (223C) supercilium, becomes light-brown (223D) distally. Throat and foreneck, dull-white. UPPERPARTS, brown (119B) with light grey-brown (119C) tips on down. From back to tail, down hair-like and pale dark-brown (119A). On each side of back and rump, large oval-shaped white patch; largest on rump. TAIL, dark brown (119A); open pennaceous and hair-like. UPPERWING. Posterior margin of folded wing, white; rest, dark brown (119A). UNDERPARTS, mostly dull white, washed cream (92). At junction of foreneck and breast, down duller. Thighs, dark brown (119A); white patch on rump, connects with upper thighs. UNDERWING. On radius-ulna, dark brown (119A); on posterior margin, narrow white band. Rest of wing, white, tipped brown (119B). Feathers appear on ducklings at *c.* 23 days. At 37 days-old, underparts well feathered. At 63 days-old, birds reach flapper-stage, where wings fully developed (Cunningham & Welch 1955). Full details of plumage development to juvenile, given in Cunningham & Welch (1955) and Lavery (1972).

JUVENILE HEAD AND NECK. Crown and hindneck, dark brown (119A), feathers edged light grey-brown (119D), giving both streaked appearance. Feathers of nape, very light grey-brown (119D), narrowly edged dark brown (119A). Sides of face, creamy white; feathers, narrowly edged light grey-brown (119D) on malar region and ear-coverts, giving finely streaked appearances. Chin to lower foreneck, creamy white. UPPERPARTS, mostly dark brown (119A), fringed light grey-brown (119D); fringes broadest on mantle; scapulars similar but more narrowly fringed. Upper tail-coverts, dark brown (121), fringed light grey-brown (119D). TAIL, dark brown (121), fringed light grey-brown (119D); rectrices notched. UPPERWING. Tertials, dark brown (119A), narrowly edged light grey-brown (119D) on outer web; faintly edged on distal inner web. Marginal, median, lesser coverts and alula, dark brown (119A); marginal coverts, approaching black-brown (119). Greater coverts, basally dark brown (119A) for one-third length of feather, rest white. Innermost greater coverts, tipped pale pink-buff (121D). Primaries and inner webs of secondaries, dark brown (121). Innermost secondaries, broadly tipped white with subterminal buff (124) wash; white tip narrower on inner web. Rest of outer web of secondaries, black-brown (119); in some lights, glossy dark-green (162A) speculum evident. UNDERPARTS. Paler than adult, with smaller spots on breast. Breast to upper abdomen, dull white, fringed light grey-brown (119D); feathers have rather small subterminal central brown (119B) spots. Spots on flanks larger and more obvious. Abdomen to vent less spotted; slightly so from vent to under tail-coverts. Axillaries white. UNDERWING. Underside of primaries, brown-grey (79); tegmen dark brown (121). Greater and lesser coverts, dark brown (121); medians, slightly paler; innermost lesser coverts, tipped white.

HYBRIDS Hybrids recorded in the wild with Pacific Black Duck *A. superciliosa* and Australasian Shoveler *A. rhynchotis* (Zietz 1912). Hybrids with Chestnut Teal *A. castanea* reported by Phillips (1923) and confirmed by additional observations in wild by P.J. Fullagar. Johnsgard (1960) adds following: hybrids from captivity and wild either sterile or fertility unrecorded with Chestnut Teal *A. castanea*. At least

one hybrid known from captivity with Mallard *A. platyrhynchos*.

ABERRANT PLUMAGES Partial albinistic birds have been recorded; Lavery (1972) observed bird with white abdominal feathers, which persisted through at least four moults. Skin at MV has white breast and some white primaries. Birds often show ferrous oxide staining on underparts (Lavery 1962; Hall 1974).

BARE PARTS Based on P.J. Fullagar.

ADULT Iris varies from vivid crimson-red to dull red in both sexes; some details of coloration in Lawler & Briggs (1989). Upper mandible, bluish-grey often black on ridge. On lower mandible, basal half of sides bluish grey, anterior half, dull yellow. Mouth, whitish with pinkish tongue (Hall 1974). Bill, dark blue-grey (78); nail, grey-black (82). Legs, recorded as grey or greyish-brown. Further details of bare parts in Cunningham & Welch (1955).

DOWNY YOUNG Iris, brown. Bill, legs and feet, dull lead-grey.

JUVENILE Iris, light brown or hazel (Lawler & Briggs 1989; P.J. Fullagar). Rest, as adult.

MOULTS Few studies in Aust. Lack of significant plumage changes hampers studies in wild without handling birds (c.f. male Chestnut Teal). No suggestion that moult differs from typical *Anas*. Body-moult includes tertials and tail but excludes wing surfaces which only moult with remiges. Some information in Braithwaite (1971) from studies in captivity and Lavery (1972). Information here based on recent observations in se. Aust. by P.J. Fullagar and C.C. Davey. Most active body-moult occurs between Dec. and Mar and wing-moult takes place then; in breeding pairs earlier in males than females, usually in fresh plumage by May. Juveniles moult at about 7 weeks, replacing most body-feathers and tail; plumage then identical to adult. Moult can be detected in most tracts throughout year but greatest intensity post breeding.

ADULT POST-BREEDING Complete; remiges simultaneous. In se. Aust., moult can be Sept.–Dec. but, in breeding birds, delayed till late summer, often Feb.–Mar. Partial or asynchronic moult (observed by Braithwaite 1971) aberrant and unlikely to occur in wild. Similar anomalous moults also observed in stressed ducks in captivity by P.J. Fullagar and C.C. Davey. Duration to completion of wing-moult (from Braithwaite 1971), 30 days in males, 31–33 days in females. Growth of remiges proceeds rapidly for first 20 days; when most lost, 3–5 primaries remain sheathed. Thereafter, moult slows until at *c.* 28 days, all sheaths lost. All secondaries and innermost five primaries mature at about same time, at *c.* 18 days after loss of remiges. Flight regained at *c.* 16 days, a week earlier than in Pacific Black Duck. Average daily growth of remiges for first 20 days is *c.* 5 mm. Most have new plumage >4.1 months after moult. Birds failing to moult in 12-month period show class-3 feather wear (for details of wear categories see Braithwaite [1971] and Braithwaite & Norman [1974]).

ADULT PRE-BREEDING Partial; involves body-moult; in n. Qld, in captive birds, Feb.–May (Lavery 1972).

POST-JUVENILE In NZ, body-moult started Mar., at 94 days and completed by mid-May (Cunningham & Welch 1955, which see for full details); timing confirmed at Canberra by P.J. Fullagar and C.C. Davey. Confined to body-feathers and complete replacement of tail. Timing in most seasons ensures juvenile characters in most young lost well before late summer.

Adults do not have to moult annually, and may, depending on environmental conditions such as prolonged wet season, postpone moult, for as long as is biologically possible (Braithwaite 1971; Lavery 1972). Moult coincides with increasing gametogenetic activity; development of testes can occur at any time, before, during or after the normal moult period; immediate environmental conditions determine this (Braithwaite 1971; Braithwaite & Norman 1974). Lavery (1972) noted that post-juvenile moult occurred in inland freshwater habitat in connexion with breeding season; first immature post-breeding moult recorded only in freshwater habitat, but both far from breeding grounds. Further details of moult of age classes, based on shot samples, and details of feather wear, given in Braithwaite & Norman (1974).

MEASUREMENTS (1) NZ, adults, live birds; methods unknown (M.J. Williams). (2) NZ, juveniles, live birds; methods unknown (M.J. Williams). (3) Details unknown (Frith 1977). (4) Adult, skins; other details unknown (MV).

		MALES	FEMALES	
WING	(1)	208.5 (4.27; 200–215; 10)	197.1 (3.31; 193–202; 7)	*
	(2)	201.6 (5.86; 189–210; 13)	192.8 (5.65; 182–208; 16)	*
	(3)	205 (175–220; 209)	198 (164–243; 148)	
	(4)	203.0 (3.87; 195–211; 12)	192.6 (5.34; 185–203; 11)	*
TAIL	(1)	88.2 (4.32; 81–97; 8)	81.8 (4.13; 77–89; 6)	*
	(2)	78.1 (6.80; 63–86; 11)	79.2 (4.06; 72–86; 12)	
BILL	(1)	38.2 (1.38; 36.3–40.1; 10)	35.7 (1.32; 33.7–37.7; 7)	*
	(2)	37.6 (2.30; 34–41.2; 13)	36.4 (2.18; 33.3–41.7; 16)	
	(3)	37 (32–43; 210)	36 (32–39; 148)	
	(4)	38.1 (1.48; 34.4–39.4; 12)	35.8 (0.89; 34.2–37.2; 11)	*
TARSUS	(1)	36.0 (1.73; 33–38; 10)	34.4 (1.64; 31–36.4; 7)	
	(2)	35.3 (1.77; 31–37.7; 12)	34.0 (1.62; 31–37.2; 16)	
	(4)	35.0 (1.34; 32.7–37.4; 12)	33.6 (1.27; 31–35.9; 11)	*
TOE	(1)	47.3 (1.44; 44.5–49.4; 10)	44.4 (1.66; 40.7–46.4; 7)	*
	(2)	45.9 (1.39; 43.4–47.8; 12)	44.6 (2.06; 42.1–50.4; 15)	
	(4)	48.1 (1.44; 46–50.8; 12)	45.7 (1.28; 44.2–48.7; 8)	*

Llangothlin Lagoon, NSW, unsexed live adults; methods unknown: (5) Sept. 1976, (6) Nov. 1977 (ABBBS).

		UNSEXED
WING	(1)	202.6 (9.97; 178–215; 14)
	(2)	202.0 (10.26; 183–214; 14)
BILL	(1)	38.1 (1.27; 35.9–40; 14)
TARSUS	(1)	45.0 (1.85; 41.7–47.9; 14)

WEIGHTS (1) Aust., dates unknown; details unknown (Frith 1977). (2) NZ, live adults, dates unknown (M.J. Williams). (3) NZ, live juveniles, dates unknown (M.J. Williams). (4) se. Aust., label data from skins collected Mar., June and July (MV).

	MALES	FEMALES	
(1)	507.0 (395–670; 210)	474.0 (350–602; 138)	
(2)	524.7 (17.40; 500–547; 10)	420.0 (42.34; 376–499; 7)	*
(3)	456.0 (46.02; 359–505; 13)	409.1 (43.65; 323–524; 16)	*
(4)	533.5 (17.22; 510–550; 4)		

Live unsexed adults, Llangothlin Lagoon, NSW: in Sept.,

499.6 (36.84; 440–565; 20); in Nov., 500.0 (46.9; 430–565; 16) (ABBBS). Data on monthly changes in wild and captive birds in Lavery (1972). No significant weight loss occurs during moult (Lavery 1972).

STRUCTURE Wing, short and broad. Eleven primaries: p9 longest, p10 1-2 mm shorter, p8 3–5, p7 10–14, p6 20–24, p5 30–36, p4 43–48, p3 54–61, p2 65–73, p1 77–85, p11 minute. Full details of lengths of primaries and secondaries in Lavery (1972). P10 emarginated on inner web; p9 on outer and inner; p8 slight on outer and inner. Fourteen secondaries, four of tertial form. Tail, pointed. Usually 16 rectrices, t1 longest, t8 27–40 mm shorter than t1. Birds in moult may have fewer in 267 adult and 'sub-adult' birds, 87.5% had 11 rectrices; 0.4%, 12; 10.9%, 14; 0.8%, 15; 0.4%, 18 (Lavery 1972). Rectrices notched in juveniles. Bill, slender; deep at base, sloping distally (see illustration in Ripley [1942], Parker *et al.* [1985]). Distal tip of upper mandible, rounded; coarse lamellae extend along tomia. Interramal space, bare. Tarsus, slender. Feet, webbed. Outer toe *c.* 96% of middle, inner *c.* 75%, hind *c.* 25%.

SEXING, AGEING Plumages and cloaca of adults and juveniles illustrated and discussed by Braithwaite (1971). Following post-juvenile moult, plumage inseparable from adults. Lawler & Briggs (1989) suggest colour of iris related to age but their interpretation incorrect (P.J. Fullagar & C.C. Davey). All adult males have vivid-red iris, females similar, but sometimes a shade lighter. Intensity can vary to some extent with mood (P.J. Fullagar). Juveniles have hazel iris.

GEOGRAPHICAL VARIATION Monotypic. Sometimes considered subspecies of *A. gibberifrons*. Ripley (1942; Fig.2A) showed that *A. gibberifrons* of Indonesia and Andaman Is differed from *gracilis* and Chestnut Teal *A. castanea*, in having pronounced enlargement of frontal sinus. Parker *et al.* (1985) regard *gibberifrons* and *gracilis* as allospecies, stating that *gibberifrons* includes *A.g. albogularis* of Andaman Is and that *gracilis* includes *remissa* of Rennell I., Solomon Is. However, *A. albogularis* is distinct island species restricted to Andaman Is (P.J. Fullagar; see Phillips 1923; Scott 1988). Mees (1982) and White and Bruce (1986) suggest that *gibberifrons* and *gracilis* likely to intergrade in Indonesia.

RMO

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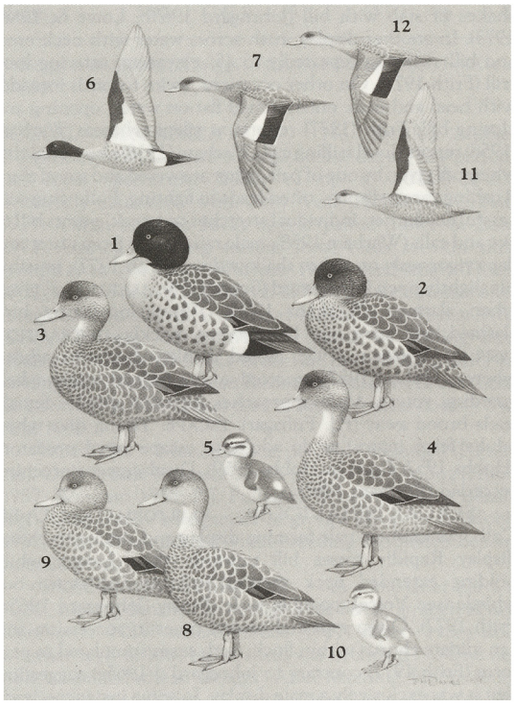

Volume 1 (Part B), Plate 91

Chestnut Teal *Anas castanea*
1. Adult male breeding
2. Adult male non-breeding
3. Adult female
4. Juvenile
5. Downy young
6. Adult male breeding (flight), ventral
7. Adult female (flight), dorsal

Grey Teal *Anas gracilis*
8. Adult
9. Juvenile
10. Downy young
11. Adult
12. Adult