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Morphological and behavioral development of the Mandarin Duck.—Although the literature of the Mandarin Duck (*Aix galericulata*) contains general naturalistic accounts (Savage 1952), little has been published on its biology and early development. Because of its widespread aesthetic appeal, this species occurs in many private breeding collections and zoos. This study compared egg morphology from known-age females and determined anatomical and behavioral growth rates of the ducklings (Bruggers 1974).

The study was conducted at the 10-ha estate of Mr. and Mrs. J. J. Schedel, Elmore, Ottawa Co., Ohio. Adult ducks had one wing pinioned and were either maintained in large outdoor lake-side pens or were free-ranging on two 0.6 and 1.0 ha interconnected lakes. Nest boxes were in the pens surrounding the lakes.

Nests were checked every other day during the laying period while adults were absent. All eggs were marked, measured with calipers, and weighed on a torsion balance at days 1 (fresh weight), 15, and at pipping. The shell membrane was removed following hatching and the shell thickness measured with an Ames Thickness Measure modified for curved surfaces. An average thickness for each egg was calculated from five readings taken around its center.

Body weight, culmen length and width, tarsus and middle toe lengths, and feather development of 5 males and 8 females were recorded at hatching and at one-week intervals during the summer. Measurements were made with vernier calipers, duplicating the methods of Northern Prairie Wildlife Research Center (Greenwood 1974).

The 13 ducklings were hatched under bantam hens within a 2-week period, individually marked, then reared successively in brooders, indoor pens with ponds, and lake-side pens. They were given a commercial starter diet.

Mandarin eggs are glossy and buff-white. The average length and the average maximum width of 106 eggs from 11 clutches was 52.86 × 38.64 mm, smaller than the 56 × 39 mm for eggs laid by Mandarins in Japan (Nakata 1965), but slightly larger than the 48.8 × 36.3 mm of 18 Mandarin eggs from England (Savage 1952). Width was less variable than length, a condition also noted by Preston (1958) for the eggs of many bird species.

Fresh egg weights averaged 43.72 g, similar to the 43-g average of 68 eggs provided by J. Kear in England (pers. comm.). Weights and lengths of eggs laid by second-year or older birds (46.26 g and 53.74 mm) were significantly greater ($P < 0.05$) than of those laid by yearling females (42.68 g and 55.52 mm), a phenomenon reported in many species (Romanoff and Romanoff 1949, Preston 1958). Egg weight decreased 10.5% (43.75 to 39.1 g) during development, which Romanoff (1967) ascribed to water evaporation. The shell thickness of 60 eggs (11 clutches) averaged 0.259 mm (range: 0.191–0.329 mm). This variation resulted from significant differences between clutches and the inclusion of shells from infertile eggs.

Ducklings weighed 20–30 g 12–36 hours after hatching (also recorded by Smart 1965 and J. Kear, pers. comm.), with males (29 g) heavier than females (25 g) (Fig. 1). Similar sexual dimorphism was reported (Prince et al. 1970) for Mallards (*Anas platyrhynchos*). Both sexes doubled their hatching weight in 1 week and were 13 times heavier after 5 weeks. Males averaged 100 g heavier than females at 6 weeks. Adult weight was attained after the first prealternate molt in October, a pattern similar to Wood Ducks (*Aix sponsa*) (Lee, pers. comm.).

The growth rate slowed during the physiologically stressful fledging period, body weight increasing only 8% (males) to 11% (females) during that time. Female Greenland Mallards (*A. p. conboschas*) gained only 55 g between the 6th and 8th weeks (Greenwood 1974), and Weller (1957) and Kear (1970) observed actual decreases in growth curves of Redhead (*Aythya americana*) and Tufted Duck (*Aythya fuligula*).

Rapid tarsus development, characteristic of pochards (*Aythya*) and presumably an adaptation for aquatic birds (Kear 1970), was complete by 6 weeks. This rapid growth in Mandarins (and probably Wood Ducks) also may be an adaptation to terrestrial locomotion. The ducklings spent considerably more time walking and picking at insects than swimming, a phenomenon also noted by Savage (1952) for wild Mandarin broods. Both he and Stewart (1958) observed movements of wild, newly-hatched duckling broods up to 5.6 km from the nest to reach water.

Newly-hatched Mandarin Ducks are brown dorsally and buff-yellow ventrally, with two light dorsal spots. The bills of both sexes have a conspicuous orange tip, an episematic pattern by which parents

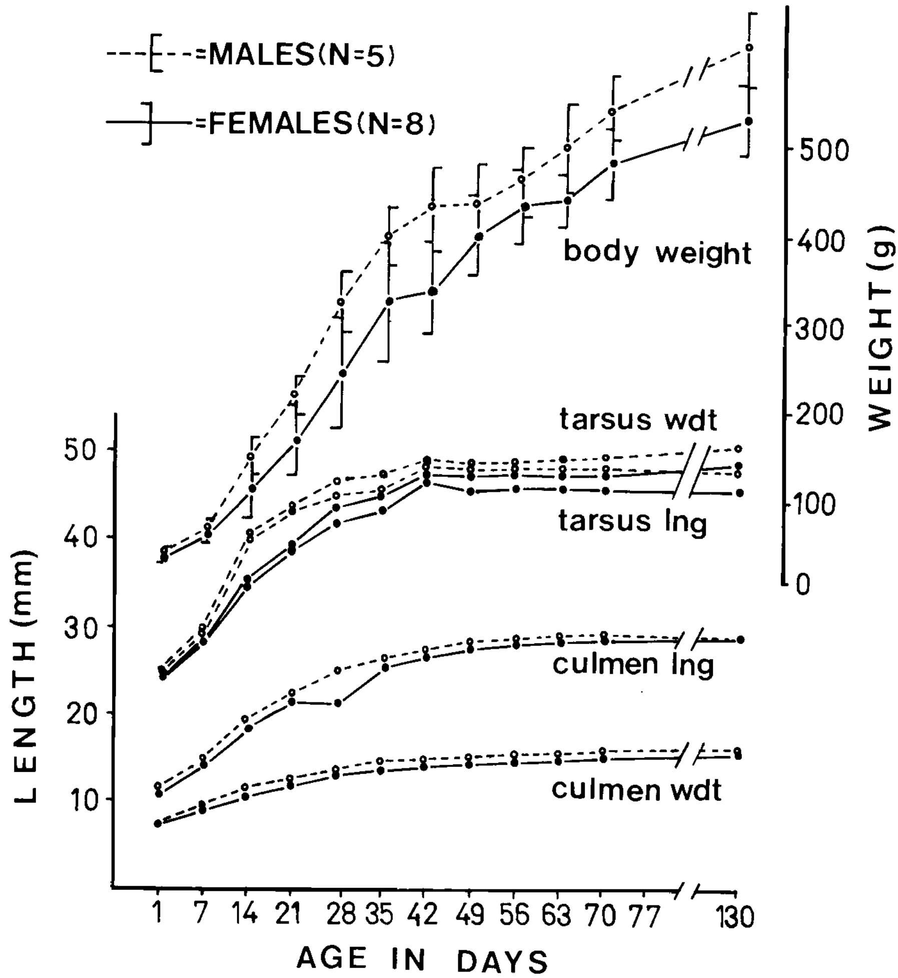

Fig. 1. Growth of Mandarin ducklings at 1-week intervals from hatching for 10 weeks and again on 28 October 1973. Mean (± SD for body weight) indicated.

recognize their ducklings (Nakata 1965). The only evidence of sexual dimorphism was the reddening of male bills at 28 days (usually not a reliable indicator for another 1 or 2 weeks) and change in the female's voice from the duckling contact call to the plaintive, more nasal "ack" at 6 weeks. The male's voice did not change to the whistle-like "pfrruib" until the 7th and 8th week.

The postnatal molt was noticed first at 2 weeks of age. Juvenal feather groups generally appeared simultaneously (Fig. 2). Scapular, tail, and belly feathers were the first to appear, with coverts and secondaries breaking the skin a week later. Primaries broke the skin at 3 and 4 weeks in females and males, respectively, with all 10 complete in both sexes by 10 weeks. Natal down in the lumbar region and under the wings was lost between 8 and 11 weeks.

Mandarin ducklings apparently do not have a basic I plumage, molting from the juvenal directly to the alternate plumage. Green feathers begin to appear on the head and mane of the males and black stripes on the chest at 10–12 weeks. The rectrices were replaced but not the remiges. The prealternate I molt was completed in all birds by the end of October.

Birds of both sexes flew at 7 weeks, with the first to seventh primaries cleared at this date. This was 1 week later than reported by Scott and Boyd (1957), but 1–3 weeks earlier than given for Mandarin and Wood Ducks by Savage (1952). This fledging period is similar to that of the Gadwall (*Anas strepera*) (Oring 1968) and other dabbling ducks (*Anas* spp.) (Weller 1957). Heinroth (1928) suggested that the shortened fledging

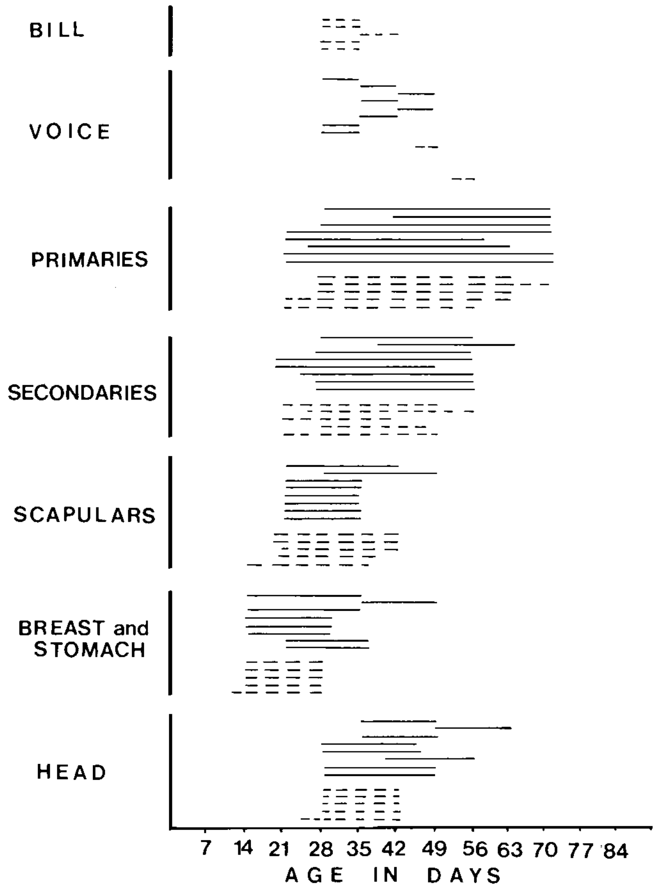

Fig. 2. Feather development and maturational changes in 5 male (broken lines) and 8 female (solid lines) Mandarin ducklings observed at 1-week intervals from time of hatching. Beginning and end of lines indicate first appearance and full emergence, respectively, of particular feathers or characteristics in each bird. No change occurs in female bill color.

period of the less-aquatic dabblers (relative to the divers) is related to their vulnerability to predators and pressure to shorten the period of relative helplessness.

The ability of day-old perching ducks to climb from a nest cavity and jump to the ground from as high as 15 m in response to the call of the female is well-known (Gottlieb 1968, Johnsgard and Kear 1968). Mandarins sometimes climb as much as 2 m inside a tree cavity from the nest to the entrance (Savage 1952). Day-old Mandarins were able to escape from a bushel basket in two jumps of 15–20 cm by digging a long (4 mm average), sharp, middle claw into the wood, hanging a few seconds, then springing and grabbing the top with the claw of the other foot. Meade-Waldo (1912) noted 2-day-old Mandarin ducklings leaping 45 cm from the water to a branch. The anatomical features, primarily thigh and leg muscle size related to this ability in perching ducks, have been discussed by Rylander and Bolen (1970). In comparison, Pengelly and Kear (1970) noted that Blue Ducks (*Mymenolaimus malacorphynchus*), nonperching ducks that inhabit fast-moving mountain streams, climb using their chins and could jump 15 cm after only 6 days. Despite 2 weeks difference in age, the Mandarin ducklings frequently nibbled at each other's necks and heads and, at least until release to the outdoor pens at 6 weeks, slept touching each other.

The rate and sequence of appearance for comfort movements (shaking, stretching, preening, bathing, and other such movements) was like that observed for Mallards (McKinney 1965) and Blue Ducks (Pengelly and Kear 1970). Most such movements appeared in the first 2 days (Table 1).

Newly hatched ducklings performed the same movements as adults. Brief nibbling and preening sessions

TABLE 1
AGE AT WHICH COMFORT MOVEMENTS FIRST APPEARED IN FIVE MANDARIN DUCKS[1]

Age (days)	Comfort movements
1	Nibbling movements—belly, neck, vent, wings, and occasionally in vicinity of oil gland
	Head-shake, body-shake, wing-flap, tail-wag, jaw-stretch, head-scratch, leg-and-foot peck
2	Swim-shake
3	Both-wing-stretch and wing-shuffle
4	Oil preen with head-roll on back and side (one duckling)
6	Dashing-and-diving (two ducklings)
7	All nibble at oil gland while swimming (first time observed)
8	Dashing-and-diving (all ducklings), high intensity bathing (pecking at sides, head, neck, and oil gland while head-dipping)

[1] Unless otherwise stated, the day indicates the time movements were seen for all ducklings.

(to belly, neck, and wings) were frequent during the first 3 days. As with Mallards (McKinney 1965), movements were made in the direction of the preen gland during the first 2 days; but fully-developed oiling sessions, with associated head rolls, were not seen until the 4th day. Dashing-and-diving, a rather complex motor activity, occurred in two Mandarin ducklings at 6 days and the others at 8 days. This was considerably earlier than the 13–14 days reported for Mallards.

As the birds utilized were from private breeding collections and inbred to an uncertain extent, they may not be wholly representative of this Asian wildfowl, but the data obtained were similar to those available from other investigators.

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Willow Ptarmigan remove broken eggs from the nest.—In the course of studies of the breeding behavior of Willow Ptarmigan (*Lagopus lagopus lagopus*) in northern Norway, we have now and again found single ptarmigan eggs lying near occupied nests. On Karlsøy Island, near Tromsø, an infertile egg with a hole in it was found some 80 cm from a nest containing newly-hatched chicks and several apparently infertile eggs. The hole might have been made by a bird's bill, and we assumed that the egg was removed by the hen. Jenkins et al. (1963) mention similar observations on Red Grouse (*L. l. scoticus*). During a study of egg and chick care by Willow Ptarmigan (Allen et al., ms.) at the University of Tromsø's Wildlife Station, cracked or broken eggs have occasionally been found on the floor of the observation rooms, beyond the nest scrape where a clutch was being assembled or incubated. Such eggs had thin, rough-surfaced shells, probably the result of dietary calcium deficiency (Roland et al. 1974). The contents of broken eggs were apparently sometimes eaten by the birds, which were certainly the only occupants of these rooms.

Detailed observations were made on a ptarmigan hen that began to lay on a scrape in some turfs placed on the observation room floor. Her first egg was rough-surfaced, and by the time she laid five more, it lay cracked about half meter from the nest. We replaced it in the nest and 3 days later found it smashed on the concrete floor, some 3 m from the nest. The next day the egg was completely eaten by one of the birds; no trace of the shell was found. The following day we marked two infertile eggs from another hen and added them to those in the nest, deliberately breaking one in the process. Three days later both eggs still lay with the clutch, which was covered with leaves and grass, although by now the broken egg was crushed. The following day it lay about a meter from the nest, almost empty; the hen subsequently incubated the other marked egg.

The hen of another pair incubated a clutch of only 3 eggs, one of which we found broken and encrusted with dried yolk, about 2 m from the nest on the 15th day of incubation. We replaced it in the nest which we watched by closed-circuit TV. After a few minutes the hen returned to the nest and resumed incubation. Twice in the next 2 hours she rose and turned the eggs as usual, but she pecked at them, apparently tasting and swallowing something, before settling again. The third time she rose she again pecked at the eggs, at first gently but then more violently. Within a few seconds she had speared the broken egg on her upper mandible and carried it out of the nest, dropping it about a meter away. We removed this egg, which contained only fluid and appeared to be infertile. We then broke an egg containing a dead, almost full-grown embryo, and placed it in the nest. The hen incubated this with her two remaining eggs, flattening it in the process, until we removed it for hygiene's sake a week later. Meanwhile one of her own eggs developed a longitudinal crack, probably from being incubated directly on the concrete floor, but the shell membranes did not rupture and the egg did not leak. The hen continued incubating until we removed her from the room 8 days later, well after the remaining eggs should have hatched.

This series of chance observations and opportunistic experiments can only partly explain how the hen recognizes and removes nonviable eggs. We suggest tentatively that the hen removes only broken, leaking eggs, recognizing the taste, smell, or texture of the dried matter sticking to the shell, as she turns them. Since such matter is easily transferred to other eggs, she may test the integrity of individual egg-shells by pecking at them, as we saw one hen do. The only hen we saw actually removing an egg, did so by "spearing" it, but others we have seen may have been pushed out of the nest with the bill, or simply kicked, as they were not holed. One captive hen was once seen catching up an egg between the underside of her bill and her neck, and moving it thus (Myhre, pers. comm.).

Broken eggs are non-viable, and there is good reason for the hen to clear them out of the nest; they are unnecessary burdens on her capacity to transfer heat to the clutch, and are possible sources of infection.