Climbing ability of ducklings of some cavity-nesting waterfowl

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Introduction

A little over 60 years ago Heinroth (1910) published the first of his classical papers pioneering the study of waterfowl behaviour. In that paper an account is given of the remarkable ability of newly hatched American Wood Ducks *Aix sponsa* to climb up the often vertical and sometimes almost smooth inner walls of nest-cavities. Normally a highly competent observer who interpreted his observations with a great deal of insight and clarity, Heinroth stated that in order to succeed in its climb the Wood Duckling is provided with needle-pointed claws which can effectively catch on to the climbing surface, and, further, the duckling is able to climb up a perpendicular or even an overhanging face, like a woodpecker but without the aid of the tail.

When a newly hatched Wood Duck is examined an obvious feature is the relatively long and stiffened caudal down. These special natal tail feathers were noted and described by Beebe & Crandall (1914) who, however, made no attempt to explain their function.

The Wood Duckling does not normally dive for its food, so why should it have a tail very different to that generally possessed by ducklings of other surface-feeding anatids whose young also frequent ponds and other placid waters? Apart from differences in agility, Wood Ducklings forage similarly to downy young of Mallard *Anas platyrhynchos* and other dabblers (Beard, 1964). The answer is that the newly hatched Wood Duck uses its tail in climbing up vertical faces, and, contrary to Heinroth's (1910) statement, the specialized tail actually functions as a brace, somewhat as in woodpeckers.

Once having established that Wood Ducklings used their tails in climbing, I extended my observations to measure the climbing ability of the species and other cavity-nesting waterfowl.

Material and methods

Newly hatched young of the following species were used in the tests: Wood Duck *Aix sponsa*; Mandarin *Aix galericulata*; American Goldeneye *Bucephala clangula*; Hooded Merganser *Mergus cucullatus*; Mallard *Anas platyrhynchos.*

Goldeneye and Mallard eggs were taken from wild birds nesting at Delta, Manitoba, and those of the other species came from the Niska Waterfowl Research Station near Guelph, Ontario. There were three separate clutches of Wood Duck eggs, three of Mallard and one each for the remaining species. Hatching of the eggs occurred in an incubator. Each clutch was incubated separately and hatched as a separate brood to maintain normal sibling relations. As soon as the ducklings were 'dry' they were taken straight from the incubator and placed in a high-sided, darkened carton, where they were kept for 24 hours. Thus, all had had a minimum of visual experience—similar to that which they would have had when hatching in a hole deep in a tree. The carton was kept in a semi-darkened, constant-temperature room.

The testing apparatus was a chimney (Figures 1, 2), built of three hollow cement bricks (known to the building trade as 'breeze-blocks', which are formed from a mixture of lime mortar and coarse sand). Ducklings were introduced, singly, into the chimney. Their responses were observed from a vantage point above its opening. A screen made it possible to observe the ducklings without disturbance. Since the bricks had been made of coarse sand, the chimney's internal walls were just rough enough to provide 'claw-holds' for the ducklings. The tower of three bricks sloped at an angle of 10° from the vertical, and was so placed that light from an electric bulb above penetrated part of the way down the chimney. Thus, when at the bottom of the chimney, a duckling was exposed to a more or less unidirectional source of light—resembling that which it would have seen when looking up at an entrance hole above the gloom of a natural cavity.

At the end of 24 hours in the darkened carton individual ducklings were transferred directly to the testing room, which was effectively sound-proofed. The duckling was placed on its own at the bottom of the chimney and its responses noted during a 5-minute period, after which it was removed from the test-room. Each of its siblings was then tested in the same way—in isolation. Immediately after the conclusion of this

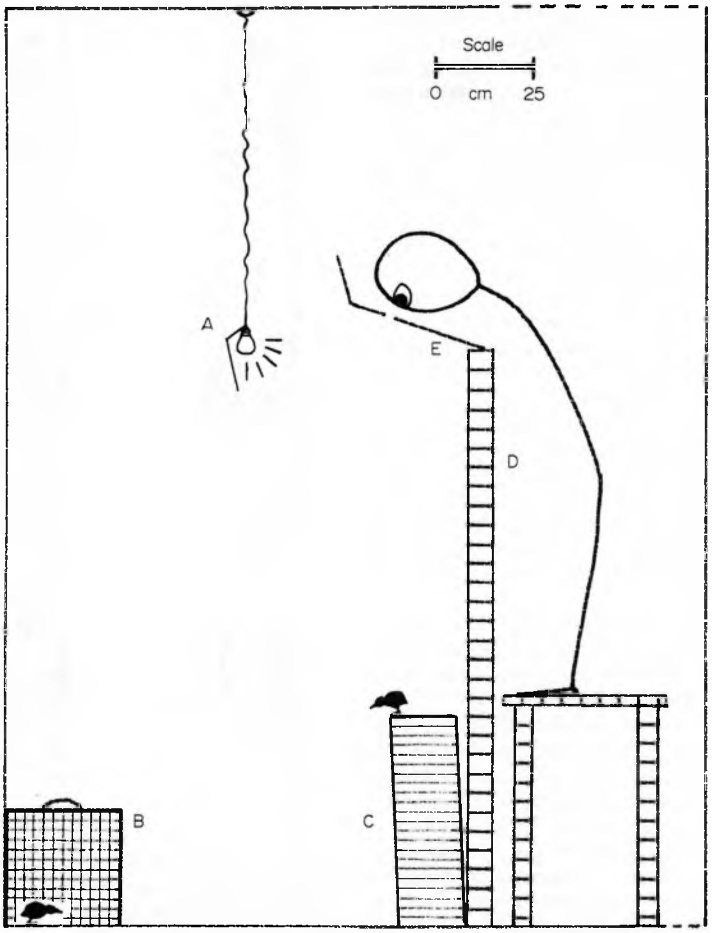

Figure 1. The experimental set-up. A, electric light bulb; B, wire cage containing ducklings when test individuals were permitted vocal contact with their siblings; C, chimney having internal dimensions 11·5 x 9·5 cm. D and E, screens.

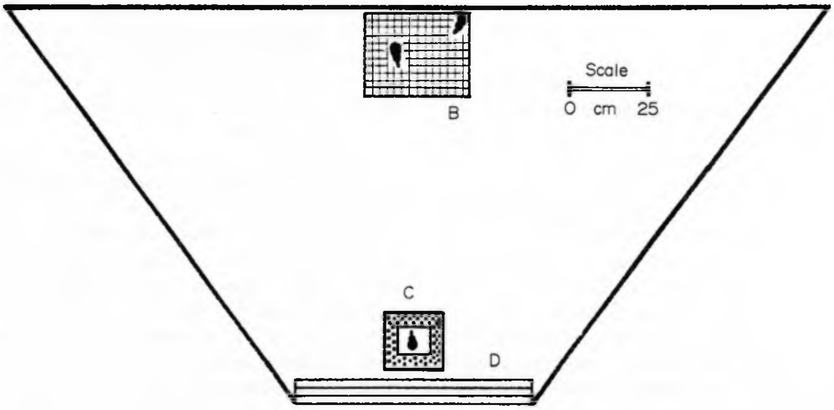

Figure 2. Ground plan of testing room and experimental set-up. B, C and D as in Fig. 1.

series, a second series of trials was started in which the bird in the chimney could hear the calls of its siblings kept in a wire-netting cage near the base of the tower (Figures 1, 2). Thus, every duckling was subjected to two trials. The time before each duckling initially vocalized, the time before it initially climbed, and the total time spent climbing while in the chimney were recorded. Also noted was the number of separate attempts (jumps initiating climbs) made by an individual duckling. Series of trials were operated alternately over a run of test-days. Between test-days, the ducklings were kept in a heated brooder room; they had free access to food and water.

Motion pictures of the climbing activities of Wood Ducklings were taken at sixty-four frames per second; and frame-by-frame tracings were obtained. The ducklings were photographed while climbing the vertical sides of a rigid container made from panels of fine wire gauze, normally used to screen small insects.

Three 1-day-old specimens of each species were X-ray photographed, to facilitate the measuring of skeletal parts. All linear measurements of bones were taken between their articulating surfaces. Functional limb: trunk ratios were computed after the method of Spring (1965). The angle of curvature of the claw on the middle tow was determined by the method of Engels (1940). Values for length and width of the shafts of caudal down were obtained as follows: the lengths of all shafts on the tails of three specimens were summed and then divided by the total number of shafts: measurements of the width of the two central shafts were taken at five standard points between the base and distal end of each shaft, and the results averaged for each species.

Results

Figure 3 illustrates a 1-day-old Wood Duckling's mode of progression up a vertical surface. It is clear that the duckling progresses by a series of leaps, rather than by a foot-over-foot climb. The bird leaps upwards against the vertical surface, to which it clings with the aid of the claws on its toes. The hooks on the wings provide no assistance to climbing. When clinging, the bird's body is placed between its legs and feet which generally are splayed outwards with toes fully spread. From a stationary clinging position, the next stage upwards proceeds by an inwards pulling, or hitching, of the body followed by an upward lift, retaining the body's long axis in a vertical plane. This movement is aided by the bracing effect of the stiffened caudal down, pressed against the climbing surface. At the zenith of the body-lift, the feet are released and the wings are swung outwards and upwards and then inwards. The tail is generally kept in contact with the surface throughout this part of the climbing motion, and is only flipped outward in the last phase of the upward movement when the feet, extended upwards, make new contact and purchase.

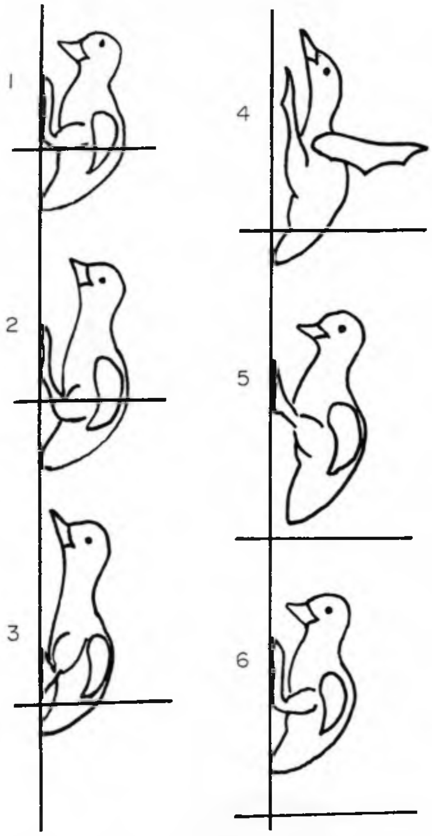

Figure 3. Climbing in 1-day-old Wood Ducks, drawings traced from cine film. Numbers 1–6 denote sequence of progress.

It is apparent that, in a number of aspects the Wood Duckling's climbing strategy, particularly the way in which the tail is used, resembles, and functions similarly to, the method employed by woodpeckers in climbing vertical surfaces. Bock & Miller (1959) and Spring (1965) discuss the gravitational forces acting on woodpeckers. The longer gravitational component passes from the centre of gravity of the bird through the tail feathers to a point where they make contact with the climbing surface. The shorter

Table 1. **Average linear dimensions and toe-claw curvature in 1-day-old ducklings. All measurements in millimetres except caudal down shaft-width (epu) and toe-claw curvature (degrees of arc)**

Species	Culmen	Hook on wing	Femur	Tibio-tarsus	Tarso meta-tarsus	Total leg length	Middle toe	Claw length	Claw curvature	Caudal down shaft	
										Length	Width
Wood Duck	14	Yes	14	27	19	60	25	3·3	89	18·2	23
Mandarin	15	Yes	15	30	17	62	25	4·0	102	17·9	17
Hooded Merganser	17	No	16	31	27	74	25	4·0	107	17·4	18
Goldeneye	17	Yes	20	30	21	71	25	3·9	110	17·7	20
Mallard	20	No	16	30	19	65	24	3·3	94	9·1	15

Table 2. **Average functional limb-trunk ratios in 1-day-old ducklings. Ratios computed after the method of Spring (1965)**

Femur	Tibiotarsus	Tarsometatarsus	Total leg length	
Species	(4 TV)	(4 TV)	(4 TV)	(4 TV)
Wood Duck	165	323	223	711
Mandarin	200	407	227	834
Hooded Merganser	229	443	393	1,065
Goldeneye	286	429	300	1,014
Mallard	254	462	292	1,008

4 TV = four thoracic vertebrae.

component is directed at right angles to the first and tends to pull the bird outward. The first component is effectively countered by anteriorly directed toes and minimal slippage of tail, and the second by laterally directed toes orientated at right angles to the trunk. In the upward lift, hitching inwards of the body decreases that gravity component tending to pull the bird off the trunk. If the bird is able to maintain this position, with the help of the tail, until the feet are extended upward, there will be a minimal tendency to fall outwards while the feet are moving to a new purchase point. Short leg bones increase the efficiency of fixation while the bird is pulling its body toward the climbing surface. Also, short bones generally increase the effective power of muscles inserting on them.

Based on the data contained in Tables 1 and 2, it appears that, comparatively speaking the Wood Duckling has relatively short legs; strongly decurved toe-claws; and, relatively long and broad caudal down shafts.

The main findings of the climbing trials are summarized in Tables 3–7. The data are intended to do no more than suggest trends. Refined analyses are unwarranted in view of the small samples; in particular the availability of only one brood of each of three of the species tested.

Table 4 shows the degree of success that ducklings had in climbing out of the chimney. The Wood Duck was consistently most successful, followed by the Goldeneye. Mandarins and Hooded Mergansers were less successful, and all Mallards failed the test. Wood Ducklings were consistently lighter than ducklings of the other species (Table 3). The heaviest ducklings were Goldeneyes, yet generally they were more successful at climbing than the lighter Mandarins and Hooded Mergansers. Ducklings usually fared best when between 2 and 3 days old. All species were more successful then than when first tested at 1 day old. Exempting the Wood Duck, after 3 days an increasing

Table 3. **Average weights in grams of ducklings, and numbers of ducklings tested and successful at climbing out of a chimney**

	Day 1			Day 2			Day 3			Day 4		
Species	Weight	Birds successful	Birds tested	Weight	Birds successful	Birds tested	Weight	Birds successful	Birds tested	Weight	Birds successful	Birds tested
Wood Duck	22	5	7	24	6	8	35	7	7	38	13	13
Mandarin	26	2	8	29	5	8	36	1	8	46	2	8
Hooded Merganser	31	3	11	34	3	9				44	1	4
Goldeneye	36	3	16	43	10	14	48	9	14	54	4	14
Mallard	29	0	10	31	0	12	34	0	12			

Table 4. Climbing success (number of individuals which climbed out of chimney as a percentage of number of ducklings tested), and average time (and S.D.) in seconds taken by successful ducklings in climbing (sample sizes as in Table 3)

Species	Day 1		Day 2		Day 3		Day 4	
	Success	Climb	Success	Climb	Success	Climb	Success	Climb
Wood Duck	71	78±64	75	80±71	100	32±13	100	68±65
Mandarin	25	132±152	62	120±87	12	254	25	
Hooded Merganser	27	135±76	33	116±103			25	
Goldeneye	19	199±27	73	145±70	64	113±85	29	158±78

Table 5. Climbing success and the climbing performance of older successful Wood Ducklings

	Day 5	Day 6	Day 7	Day 8
No. birds tested	17	19	17	16
Percentage successful	100	79	59	25
Mean weight (g)	39	45	52	62
Mean climbing time(s)	60±60	60±31	111±38	194±53
Mean no. jumps	9·1±11·2	8·2±6·0	17·0±7·5	32·2±16·8
Mean no. jumps/minute	8·1	7·0	6·8	9·1
Mean time before call (s)	24±25	47±67	29±27	21±17
Mean time before jump (s)	33±27	62±76	44±29	40±25

proportion of ducklings failed to get out of the chimney. The Wood Ducklings' climbing performance started to decline sharply after 5 days (Table 5). Thus, they sustained their relatively high rate of success longer than the other species.

Amongst the Wood Ducklings which were successful in their climbing, older birds generally made most attempts (number of jumps), and remained longest in the chimney. Older and heavier ducklings were less adept at clinging on to the sides of the chimney; they fell back repeatedly and had to make renewed starts. Wood Ducklings which failed the test performed on average 7·0 jumps per minute as against 7·9 recorded for successful ducklings of the same age and tested in the same manner. Thus for the Wood Duck, at least, it seems as if the successful birds were those which were most persistent in their efforts.

In comparison with the other species, Wood ducklings tended to make fewer starting jumps before emerging from the chimney. This suggests a superior climbing ability. However, climbing (or escape) tendency, as measured by number of jumps by successful birds per unit time, did not differ much between the four cavity-nesting species (Table 6). It is of interest that day-old Mallards made relatively many more jumps (on average 17·1 jumps per minute) than any of the other species; 2-day-old Mallards, by contrast, made fewest attempts (on average 4·1 jumps per minute) at getting out of the chimney. Table 7, again based only on successful birds, shows the ducklings' initial response to the experimental situation. With

Table 6. Average number of jumps, taken before initiation of a successful climb, and rate of jumping (mean number of jumps per 60 seconds) performed by successful ducklings (sample sizes as in Table 3)

Species	Day 1		Day 2		Day 3		Day 4	
	No. jumps	Jumping rate	No. jumps	Jumping rate	No. jumps	Jumping rate	No. jumps	Jumping rate
Wood Duck	7·4±3·8	7·1	11·5±10·1	7·6	9·4±8·7	8·3	9·4±8·7	8·1
Mandarin	15·0±18·3	5·7	13·5±10·8	7·1	25	5·9		
Hooded Merganser	47·0±54·0	9·7	9·0±7·5	7·1				
Goldeneye	26·0±7·6	7·7	21·4±10·0	8·8	10·8±10·4	5·6	20·7±10·3	7·1

Table 7. **Average time (and S.D.) in seconds elapsed before successful ducklings commenced jumping and vocalizing (sample sizes as in Table 3)**

Species	Day 1		Day 2		Day 3		Day 4	
	Call	Jump	Call	Jump	Call	Jump	Call	Jump
Wood Duck	46±41	73±46	27±17	49±39	7±4	8±5	9±7	19±10
Mandarin	16±9	30±21	40±54	60±49	20	21		
Hooded Merganser	10±9	28±18	4±2	14±9				
Goldeneye	48±53	55±48	15±18	23±18	16±20	54±39	5±3	59±24

the exception of the Mandarin, and leaving aside the Mallards, time before vocalizing of the remaining three species was shortest coincident with age at which they were most successful at climbing. One-day-old Wood Ducks, Goldeneyes and Hooded Mergansers took longer to utter first 'distress' calls than they did when 2 and 3 days old. Similarly, a longer interval preceded first attempts to climb in day-old ducklings than later when they were performing best.

Vocally and in attempting to jump out of the chimney, day-old Mallards responded with greater alacrity than any of the other species. Mallards were observed to be less well orientated in their efforts to escape, directing their jumps to all corners and sides of the chimney. The ducklings of the cavity-nesters all tended to orientate their jumps in direction of the overhead light. Data on this was gathered only for the Goldeneye: in day-old ducklings 70% of their jumps were directed at the light ($n=141$ jumps, ten test ducklings); at 2 days 80% ($n=312$ jumps, thirteen test ducklings); and at 4 days 97% ($n=123$ jumps, ten test ducklings).

Discussion

As mentioned, the samples were small and the experiments limited and relatively crude, and caution is required in interpreting the data and in reaching conclusions. Nevertheless, some of the results appear definite enough to justify discussion, including some speculation.

It is clear that the Wood Duck performed best—apparently due to its relatively superior initial response, climbing (motoric) ability and sustained effort. The Mandarin's poor showing is somewhat surprising in view of the species' supposedly close relationship to the Wood Duck. The Wood Duck's superior performance also is of interest in relation to the Goldeneye, and especially regarding a difference in nest-site ecology. Prince (1968) found in New Brunswick, Canada, that Wood Duck nest-cavities averaged deeper than those of Goldeneyes—61·0±61·0 cm (2–183 cm) for the Wood Duck, as against 46·2±19·6 cm (15–76 cm) for the Goldeneye.

Paucity of knowledge concerning the ecology and functional anatomy of the various ducklings considered here precludes discussion on climbing ability in relation to the advantages of particular anatomical arrangements; and Bock & Miller (1959) have pointed out that anatomical differences among species are not always explicable in terms of relative functional advantage. In the case of the Wood Duckling, however, it seems fair to state that the specialized caudal down represents an adaptation facilitating egress from relatively deep and vertically walled nest-cavities.

In relating the Wood Duck's apparent superior climbing ability to the natural situation, allowance must be made for factors such as specific auditory stimulation which would come from the maternal parent, and play an important part in facilitating egress of ducklings from the nest-cavity. In this context, ducklings of the other hole-nesters tested might have fared relatively better had they had the benefit of maternal calls to prompt their climbing. In other words, although female vocalizations promote a following-response in all the species, it is possible that auditory cues are of greater importance in some species than in others. Be that as it may, the fact that the experimental ducklings of all the hole-nesting species attempted to climb when first tested in isolation, and without previous experience, is in itself of interest. In nature, healthy Wood Ducklings accomplish the exodus from the nest well within 4 minutes from the time the parent begins calling from outside (Gottlieb, 1963). Later, Gottlieb (1968) concluded that the ducklings perceive and refine identification of maternal vocalizations during the 2 days or so before they leave (or attempt to leave) the nest, and that the initial jumping and climbing is a direct response to the call of the female. The current tests indicate that such activities can occur without auditory stimuli. Further, the tests suggest that motoric behaviour is most strongly developed and successful when the ducklings are 2–3 days old—the age at which they normally leave the nest in nature.

My observations, although mainly qualitative, indicated that Wood Ducklings, and the ducklings of the other cavity-nesters, tended to orientate their initial jumps towards light. In discussing the responses of Wood Ducklings to parental calls as well as visual stimuli, Klopfer (1959) postulated the existence of a releaser (for climbing activity) constituted by a light object in a darker field, which is the pattern presented by the nest entrance. However, according to Leopold (1951) female Wood Ducks often temporarily leave their newly hatched young in the cavity, returning later to brood. During the female's absence, the ducklings remain quiet and make no attempt to leave the nest. Therefore, in nature a round and bright nest entrance in itself is not enough to release climbing. Obviously the female's call is important in eliciting a following-reaction from the ducklings; and so promoting integrated departure, and guiding direction of the young from the nest. This need not, however, invalidate a suggestion that the female's call is a function of the 'instinctive' nature of the ducklings' motoric readiness. In short, it seems reasonable to believe that the female's call is not a releaser (strictly speaking) for climbing.

If the differences in response and ability to climb, as indicated among the hole-nesters tested here, are real, they must result from particular environments acting on the species. Clearly, more comparative studies and experimental analyses are needed to reach understanding of the processes and conditions under which parent and young have come to perceive selectively and to respond to particular stimuli.

Acknowledgments

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Summary

The tendency and ability of newly hatched ducklings to climb out of an experimental chimney were examined in the following species: American Wood Duck *Aix sponsa*, Mandarin *Aix galericulata*, American Goldeneye *Bucephala clangula*, Hooded Merganser *Mergus cucullatus* and Mallard *Anas platyrhynchos*. The Wood Duck performed consistently best. In climbing up a vertical surface, the Wood Duckling proceeds by a series of leaps and uses its tail as a brace, rather like a Woodpecker. The Wood Duckling has relatively short legs, strongly decurved toe-claws, and long and broad caudal down shafts. The importance of stimuli prompting the young of cavity-nesting waterfowl to leave the nest, is discussed.

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