Movements and Survival of American Black Duck and Mallard Broods on Chesapeake Bay

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Abstract: We attached radio transmitters to day-old American black duck (*Anas rubripes*) and mallard (*A. platyrhynchos*) ducklings and monitored duckling habitat use, brood movements, and survival rates for 30 days. Ducklings moved an average of 2.3 km within the first 24 hours and another 1.5 km thereafter. After the initial move, broods usually moved once more. No differences in initial movement distance, subsequent movement distance, or total number of movements were found between black duck and mallard broods. There was some evidence that broods in more human-developed areas moved more than broods in less human-developed areas. Black duck duckling survival rates were greater than mallard survival rates in 1 of 2 study years.

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The decline of the American black duck (Rogers and Patterson 1984) might be related to many factors including habitat alteration and loss (Dennis et al. 1985, Diefenbach and Owen 1989), overharvest (Geis et al. 1971, Grandy 1983), pollution (Longcore and Stendell 1982, Haramis and Chu 1987), and competition and/or hybridization with mallards (*A. platyrhynchos*) (Johnsgard and DiSilvestro 1976). We investigated whether differential movement patterns and survival rates of black duck and mallard ducklings may be contributing to the differing population trends of the 2 species (Strange et al. 1989).

Movements of black duck broods frequenting salt-marsh habitat have been documented for the St. Lawrence Lowlands by Reed (1970), who monitored the movements of Class I–III black duck broods based on observations of marked hens and their accompanying unmarked ducklings. Class I ducklings range from 1 to 18 days, Class II ducklings range from 19 to 42 days and Class III ducklings range from 43 to 55 days (Bellrose 1976). Three patterns were documented (Reed 1970): 1) broods vacated the nest site within 24 hours, 2) broods sometimes moved great distances (3–6 km) to the initial brood-rearing area, and 3) broods usually did not move far or often after arriving at the initial brood-rearing area. Similar research on mallards has not been reported in salt-marsh wetlands.

Based on Reed's (1970) results, we chose to investigate the following null hypotheses: 1) black duck and mallard broods do not move away from the nest site within 24 hours of hatching, 2) black duck and mallard broods do not differ in the distance moved during the first or 'primary' movement, 3) black duck and mallard broods do not differ in the number or distance moved during the subsequent or 'secondary' movements, and 4) black duck and mallard broods do not move different distances during the overall movements away from the nest site during the subsequent 30 days.

Using unmarked ducklings, Laperle (1974) estimated that survival rates of black duck ducklings were less than those of mallard ducklings. We investigated the null hypothesis that the survival rate of mallard ducklings is less than or equal to the survival rate of black duck ducklings during the first 30 days after-hatch.

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Methods

The study area included both the mainland and islands ($N = 12$) in the middle region of the Eastern Shore of Chesapeake Bay from the Chester River south to the Choptank River. Nest searches on the mainland were discontinued after 1986 because few nests were found there. Only nest data collected from islands are reported. Storm tides sometimes cause severe fluctuations in water levels, but tidal amplitude generally varies 30–75 cm. The climate is characterized by mild springs and warm, humid summers (Matthews and Reybold 1966). Vegetation is typical of the coastal zone, which grades from salt marsh to oak-pine forests (Brown and Brown 1972).

From early March to August, we conducted nest searches on foot at 10-day intervals. We walked parallel transects, 8–30m apart depending on cover height and density, to search nesting habitats. We used a stick to disturb likely nesting sites. The species occupying each nest was determined by observation of the female or by breast feathers in the basin. We attempted to distinguish hybrids based on plumage (Palmer 1976), but because of differential expression of the mallard phenotype (Phillips 1915), we probably misidentified more hybrids as mallards than as black ducks. No information from hybrids was included in these analyses. Nest data were recorded following Klett et al. (1986). Dump nests were distinguished from normal nests if >1 egg was laid per day or if an egg was added to the clutch after a cessation in egg laying of 2 days.

Four of the 12 islands surveyed were located in the northern portion of the study area. This area contained marinas, low- and medium-density residential housing developments, and public-works projects. Extant fringe saltmarshes were fragmented and dispersed, up to 4 km apart. This portion of the study area was referred to as Bodkin Island. The remaining 8 islands were located in a relatively undisturbed area containing continuous fringe saltmarshes and extensive adjacent freshwater marshes. This portion of the study area was collectively known as the Poplars.

In 1988 and 1989, we monitored duckling movements using radio telemetry. Nests were monitored until the star pip stage (approximately 1 day before hatch). At this stage, all eggs were placed into a nylon lingerie bag that was tied shut. The bag of eggs was placed back into the nest bowl and covered with down. We returned to the nest site between 24 and 48 hours later. When we returned to the nest, the dry ducklings were removed from the bag, weighed, and web-tagged (Haramis and Nice 1980). If the brood size exceeded 7, 4 ducklings were radioed. Otherwise, half of the ducklings were radioed.

Two different methods of attaching radios were used during the study. In 1988 we implanted the radios. This method of attachment had been used successfully for 2 years on canvasback ducklings (*Aythya valisineria*) (C.E. Korschgen, U.S. Fish and Wildl. Serv., pers. comm.). In 1989, we attached the radios directly to the back of the duckling essentially following the methods used successfully for 3 years on mallards (G.L. Krapu, U.S. Fish and Wildl. Serv., pers. commun.). Two different attachment methods were used because we wanted to evaluate the different methods for use in future studies. A complete description of the attachment methods can be obtained from the authors.

Radio-marked ducklings were monitored twice daily for the first 48 hours and once daily thereafter (radio life = 30 days). The nest bowl was checked after the departure of the radioed ducklings to determine if all ducklings left the nest and also to confirm the timing of nest departure. We monitored ducklings only during daylight hours, but we varied the time of day when we determined the location and status (alive, dead, or censored [fate unknown]) of ducklings. Tracking was conducted mostly by boat while using hand-held antenna-receiver systems, and sometimes tracking was from vehicle or by air (Gilmer et al. 1981). Distances between locations were measured as straight line distances and so are conservative. To compare movements, we defined a movement as a change in location of the brood of more than 100 m. In 1988, radios had temperature sensitive mortality indicators, thus, the fate of a duckling was immediately investigated upon the change in pulse rate. In 1989, we investigated the fate of ducklings only if there was no signal modulation 2 days in a row. This difference in tracking resulted in less precise information in 1989. We estimated time of mortality to the nearest day using field evidence. When field evidence was unavailable, we estimated date of death as the midpoint between the date last known alive and day the carcass was located. Only movements of ducklings known to be alive were included in analyses.

Analysis

We were interested in the differences in movements between species. Within an ANOVA design, the effects of different attachment methods could not be separated from year effects and so we refer to the combined effect as time. A 3-way ANOVA was used to investigate the potential interactions among the 3 main effects, species, site, and time. Because no black duck broods were marked on Bodkin Island in 1988, the 2-way and 3-way interaction tests in the 3-way ANOVA are not unique. We conducted a Type IV ANOVA test (Milliken and Johnson 1984) to most efficiently use the available data. Three ANOVAs were conducted with 3 response variables: 1) the distance moved during the primary movement, 2) the distance moved during the secondary movements, and 3) the overall distance moved away from the nest. We tested separately whether the attachment of transmitters affected duckling survival rates using X^2 tests.

Period Survival Rate (PSR) estimates for ducklings were estimated using the Kaplan-Meier (KM) method (Kaplan and Meier 1958, Cox and Oakes 1984). Tests concerning species specific survival were performed using a censored data version of the Mann-Whitney-Wilcoxon Rank Sum (MWW) statistic (W.A. Link, U.S. Fish and Wildl. Serv., pers. commun.). The MWW statistic is used to test the hypothesis of equality of 2 survival functions against the alternative hypothesis of stochastic ordering.

Results

Brood Movements

In 1988, 4 broods of black ducks and 10 broods of mallards were marked and monitored. Because we were able to mark only 4 broods of black ducks, we decided to attach radios to more than half of the ducklings in 3 of these broods. In only 1 of 10 mallard broods did we mark more than half of the brood. In 1989, 10 broods of black ducks and 8 broods of mallards were marked; none of these broods had more than half of the brood marked.

Only some islands surveyed produced broods every year. Bodkin Island consistently produced broods in the northern area and this was the only island from the northern study area where broods were marked. No black duck broods were marked on Bodkin Island in 1988. On the Poplars, most islands produced broods in both years, and broods were eventually marked on 7 of the islands.

In both years, black duck and mallard broods were marked throughout the breeding season (i.e., there was no tendency to mark mallards early and black ducks late). Most broods were followed for <10 days, and only 2 broods survived 30 days.

All 29 broods for which we knew the time of departure from the nest left the nest within 24 hours of being marked. Broods generally departed the islands at night. Average distance moved from the nest site in the first 24 hours for both black ducks and mallards was 2.3 ± 0.39 (SE) km (Table 1). The maximum distance moved during the first movement was 6 km by a black duck brood from Bodkin Island. After the initial move, most broods moved only 1 more time for an average distance of 1.5 ± 0.35 km. The maximum number of secondary movements for a black duck brood was 9; for a mallard brood it was 22. The maximum distance of a secondary movement was 6.4 km. The total distance moved averaged 3.5 ± 0.41 km with a maximum of 6.6 km. One radio-marked duckling was found dead 12.4 km away

Table 1. Movement patterns of telemetered black duck and mallard ducklings for 30 days posthatching on Chesapeake Bay, 1988–1989.

	Black duck			Mallards		
Variable	*N* broods	$\bar{x}$ (SE)	Maximum distance	*N* broods	$\bar{x}$ (SE)	Maximum distance
Distance (km) of 1° movement	14	2.3 (0.53)	6	12	2.4 (0.60)	5.2
N of 2° movements	14	1[a]	9	13	1[a]	22
Distance (km) of 2° movements	14	1.8 (0.57)	6.4	13	1.2 (0.40)	5.4
Total distance (km) moved	14	3.7 (0.55)	6.5	14	3.3 (0.64)	6.6

[a] Discrete variable, mode presented.

from Bodkin Island 3 days after release. Anecdotal evidence suggested that this duckling reached this site with its hen.

We were first interested in the time effect which includes both attachment method and year effects. In none of the analyses was time found to be significantly related to distance moved (Table 2).

Table 2. Three-way ANOVA investigating the effects of time, site, and species on the response variables 1) distance (km) moved during the primary movement away from the nest, 2) distance (km) moved during the subsequent movements, and 3) total distance (km) moved away from the nest during the first 30 days of black duck and mallard broods on the Chesapeake Bay, 1988–1989.

Source	df	Type IV SS	*F*-value	*P*-value
		Primary distance moved		
Time	1	0.2829	0.08	0.78
Site	1	7.0027	2.03	0.17
Species	1	1.8892	0.55	0.47
Species * Site	1	0.1516	0.04	0.84
Species * Year	1	2.4959	0.72	0.41
Site * Year	1	2.6561	0.77	0.39
		Secondary distance moved		
Time	1	2.4068	0.65	0.43
Site	1	1.9927	0.54	0.47
Species	1	5.0194	1.35	0.26
Species * Site	1	0.3363	0.09	0.77
Species * Year	1	2.3935	0.65	0.43
Site * Year	1	0.3239	0.09	0.77
		Overall distance moved		
Time	1	1.096	0.26	0.62
Site	1	13.4923	3.15	0.09
Species	1	9.9435	2.32	0.14
Species * Site	1	0.8977	0.21	0.65
Species * Year	1	2.7410	0.64	0.43
Site * Year	1	8.3893	1.96	0.18

The next effect that we were interested in was site. Neither the primary distance moved nor the distance moved during secondary movements differed between sites, but there was a weak suggestion that the overall movement distance was greater for broods hatched on Bodkin Island than for broods from the Poplars ($P = 0.09$, Table 2). Broods from Bodkin Island moved an average 4.8 km whereas broods from the Poplars moved an average 2.9 km.

Finally, and of most interest, was the effect of species on brood movements. In no case, was an effect of species on brood movement found (Table 2).

Survival

We reobserved 9 broods between 1 and 30 days after release over the 2 seasons (6 broods in 1988, 3 broods in 1989, Table 3). In 1988, we found no difference in resighting between the control group and the group with radio transmitters attached ($X^2 = 6.77$, df = 6, $P = 0.34$). In 1989, we again found no difference in resighting between the 2 groups ($X^2 = 4.08$, df = 3, $P = 0.25$). Combining the 2 years, we found no significant difference in the resighting between the 2 groups ($X^2 = 10.85$, df = 9, $P = 0.29$). Although the sample sizes were small, these results suggested that transmitters had no effect on survival rate of ducklings.

Use of implanted radios allowed the determination of the mortality source more

Table 3. Chi-square test statistics for comparisons of reobserved telemetered and control ducklings by brood on the Chesapeake Bay, 1988–1989. Except for brood number Poplar V3, all broods were mallards.

Year	Broad No.	Treatment	Reobserved	Not reobserved	df	χ^2	*P*
1988	Bodkin Island 15	Control	1	6	1	0.63	0.427
		Telemetered	0	4			
	Bodkin Island 18	Control	3	5	1	0.75	0.386
		Telemetered	2	1			
	Bodkin Island 27	Control	2	3	1	0.23	0.632
		Telemetered	1	3			
	Bodkin Island 32	Control	5	2	1	0.51	0.475
		Telemetered	2	2			
	Jefferson 1	Control	3	1	1	4.05	0.044
		Telemetered	1	6			
	Poplar V 1	Control	0	2	1	0.60	0.439
		Telemetered	1	3			
	1988 Total				6	6.77	0.343
1989	Poplar III 9	Control	4	4	1	0.69	0.406
		Telemetered	1	3			
	Poplar V 3	Control	2	2	1	2.10	0.147
		Telemetered	3	0			
	Poplar V 6	Control	4	2	1	1.29	0.256
		Telemetered	3	0			
	1989 Total				3	4.08	0.253
	1988–89 Total				9	10.85	0.286

accurately than use of the external radios because the predator often ate the duckling including the radio transmitter. Transmitters continued to transmit from within the predator or we were able to locate the transmitter in the scat of the predator. In 1988 most black ducks were preyed on by reptilian predators (e.g., black rat snakes (*Elaphe obsoleta*) and snapping turtles (*Chelydra serpentina*)) while mallards were preyed on by mammalian predators (e.g., red fox (*Vulpes vulpes*), unidentified mustelids) or succumbed to disease or exposure (Table 4). In most cases, the commonly diagnosed disease was pneumonia. A single case of hemorrhagic enteritis was found. In 1989, we were able to determine the source of mortality on only 3 black duck ducklings, 2 of which died from disease or exposure. Mallards were especially prone to disease or exposure in 1989 with 14 mallard ducklings dying of pneumonia. The most striking observation regarding the fates of both black duck and mallard ducklings was that so few ducklings survived 30 days (Table 4). Most of the mortality occurred within the first week (Fig. 1) although the probability of detecting mortality after 7 days was low due to heavy censoring (i.e., lost, fate unknown) and mortality.

In both years, the period survival rates of black duck ducklings were equal to or higher than mallard survival rates with 2 exceptions (Fig. 1, days 1–2, 2–3 1988). The 1988 5-day survival rate of black duck ducklings leveled off at 58%. No deaths were observed after day 5. In 1989 the 5-day survival rate was 48%, and leveled off at 11%. Similar to the situation for black ducks, the period survival rates of mallard ducklings remained higher initially in 1988 than in 1989, but it was in 1989 that the single greatest drop in period survival rate occurred (day 1–2). The 1988 5-day survival rate of mallard ducklings was 56%, and leveled off at 28%. In 1989 the 5-day survival rate was 19%, and it leveled off at 14%. In both species, final period survival rate estimates were extremely low.

We tested between year differences in period survival rates for each species to determine whether years could be pooled. We found no significant difference in period survival rates between years for black ducks (Table 5); however, there was a significant difference between years for mallards with the 1988 period survival

Table 4. Fates and sources of mortality of black duck and mallard ducklings over the first 30 days after leaving the nest on the Chesapeake Bay, 1988–1989.

	N			Source of mortality				
	Radioed	Censored[a]	Survived	Mammalian	Avian	Reptile	Disease/ exposure	Unknown
Black Duck								
1988	17	11	0	1	1	3	0	1
1989	30	15	1	1	0	0	2	11
Mallard								
1988	41	15	1	7	1	1	9	7
1989	32	10	0	0	1	0	14	7

[a] Fate unknown.

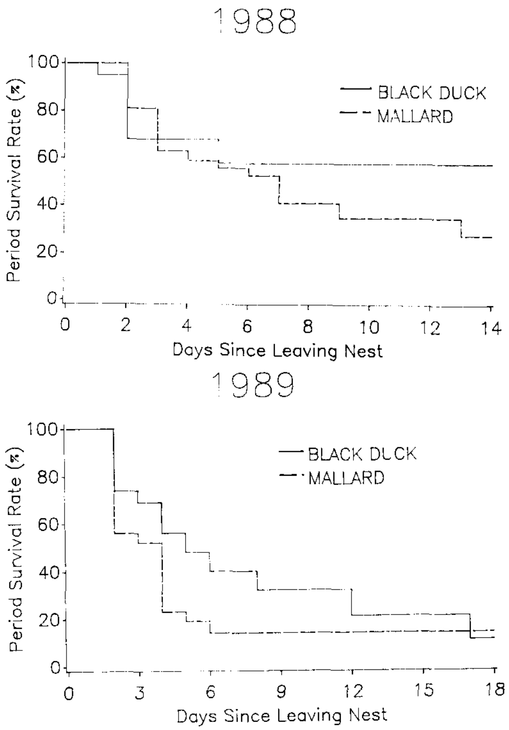

Figure 1. Period survival rates of black duck and mallard ducklings estimated using the Kaplan-Meier method on Chesapeake Bay, 1988–1989.

rates higher than 1989 period survival rates. Based on these results, we compared black duck and mallard period survival rates separately for each year. Period survival rates of black duck and mallard ducklings did not differ ($P > 0.05$) in 1988, but did in 1989 (Table 5). In that year, black ducks had a significantly higher period survival rate than did mallards. Again, in both years, a higher percentage of the black ducks were censored.

Discussion

Our findings were quite similar to those of Reed (1970, 1975) for black duck brood movements in the St. Lawrence Lowlands. Most broods left the nest site within 24 hours of hatching, the major movement made by a brood occurred within the first week after leaving the nest and few brood movements were made subsequently. In slightly different habitat (northern hardwood-spruce forest), Ringelman (1980) also found similar habits of black duck broods. In Ringelman's (1980) study, black duck broods moved away from the nest site within 72 hours after

Table 5. Comparisons of black duck and mallard duckling survival rates within and among years on the Chesapeake Bay, 1988–1989.

Comparison	N_1[a]	N_2[a]	Score[b]	P
1988 Black duck vs mallard	17	41	517.8	0.398
1989 Black duck vs mallard	30	32	1073.5	0.046
1988 Black duck vs 1989 black duck	17	30	430.5	0.326
1988 Mallard vs 1989 mallard	41	32	1003.5	0.028

[a] Refers to the sample size of the first and second stated categories, respectively.
[b] Mann-Whitney-Wilcoxon Rank Sum test statistic.

hatching, they moved an average of 2.8 km between the nest and rearing wetland, and secondary movements were rare.

In our study, the tendency of broods to move greater distances might be dependent upon site: the remaining salt marsh in the northern portion of our study area was highly fragmented. Housing developments, marinas and public-works projects have reduced the available salt-marsh habitat. This fragmentation of the brood-rearing habitat may have forced broods to move further between marshes.

Laperle (1974) investigated duckling survival rates of black ducks and mallards in sympatry. He conducted his study on unmarked birds, however, so his estimates do not take into account total brood loss. Reed (1975) pointed out that total brood loss can have substantial effects on conclusions regarding comparative brood success. Nevertheless, Laperle (1974) concluded that black ducks have significantly smaller broods throughout the brood rearing period than do mallards. We could not substantiate this with our data. Instead, we found that black ducks had higher duckling survival rates than do mallards.

Three studies have examined black duck duckling survival rates using modern methods of survival rate estimation (Reed 1975, Ringelman and Longcore 1982, this study). All 3 studies have documented substantial mortality of ducklings, especially during the Class I period. Reed (1975) estimated that up to 80% of brood losses occurred then, and that only 34% of estuarine-reared ducklings fledged. Much of this loss occurred on the initial movement across large open water to reach brood-rearing areas (Reed 1975). We suspect similar movements on the Chesapeake Bay are dangerous, but in addition, black duck ducklings on Chesapeake Bay are forced to make additional large scale movements because of severe habitat fragmentation. These additional movements probably explain why so few radio-marked ducklings survived the 30-day observation period. Ringelman and Longcore (1982) estimated the period survival rate of Class I–IIa ducklings to be 0.6073 (0.5431–0.6788, 95% CI). Our estimates for the same period were comparable in 1988 (0.5820), but were markedly less in 1989 (0.1610). However, we are reluctant to make strong conclusions because these studies differed in methods and geographic areas.

Neither Reed (1975) nor Ringelman and Longcore (1982) reported the sources of mortality other than to comment that exposure was an important source. We too found that exposure was an important source of mortality, and further that it apparently affected mallards more than black ducks. This may be related to the parental ability of mallards (see Alexander 1971).

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