Canada Goose Gosling Mortality and Characteristics of Predation at Monticello Reservoir, South Carolina

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Abstract: Gosling survival of a resident flock of Canada geese (*Branta canadensis*) was studied on a 2,750-ha reservoir in Fairfield County, South Carolina, in 1987. The brood-rearing season began in early April and ended in early June. A final count of all goslings on the reservoir 4 weeks after the last nest hatched yielded a gosling survival rate of 4.4%. Only 6 (15%) of 40 goslings from 10 broods equipped with radio-transmitters survived to 8 weeks of age. Gosling survival was estimated as 21.2% ± 0.15% (95% CL), using the Kaplan-Meier survival estimator that censors disappearances and 4.0% ± 0.04% (95% CL) assuming disappearances as deaths. Primary predators included red fox (*Vulpes vulpes*), crow (*Corvus* spp.) and unknown avian.

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The South Carolina Wildlife and Marine Resources Department (SCWMRD) estimated that wintering Canada geese declined from 44,450 in 1964 to 2,694 in 1986 (Strange 1986). Conversely, during this same period, Canada geese were increasing in the Atlantic Flyway (Conover and Chasko 1985). The decline of geese in South Carolina is attributed to changes in food preference and agricultural practices at more northern latitudes (Crider 1967). Harvests, land development, and other disturbances along migration routes also may have contributed to the decline (Hankla and Rudolph 1967). The decline of South Carolina's Canada geese has decreased hunting and other recreational opportunities.

Since 1979, SCWMRD has released 9,000 non-migratory Canada geese (captured in northeastern states) at 305 sites ($\bar{x}$ = 29.5 geese/site), including 529 geese at Monticello Reservoir near Jenkinsville. Nesting surveys by SCWMRD indicated that Canada geese at Monticello Reservoir were breeding successfully (e.g. 606

hatchlings from 145 successful nests in 1986). However, survival of goslings seemed extremely low. In 1985, SCWMRD conducted a preliminary study of gosling survival at the Monticello Reservoir. Mortality was 100% for 20 radio-marked goslings which were killed by predators or disappeared within 2 weeks.

The purpose of our study was to enhance and strengthen previous evidence regarding the causes and magnitude of mortality of Canada goose goslings at Monticello Reservoir, South Carolina.

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Methods

The study was conducted on Monticello Reservoir, a 2,750-ha nuclear power cooling reservoir owned by South Carolina Electric and Gas Company (SCE&G) north of Jenkinsville, South Carolina. Most (99%) Canada goose nests were located on 10 islands (0.1 to 7.8 ha in area) and 2 peninsulas in the reservoir. Island habitats were a mixture of pine stands and pasture. Mainland habitat consisted of loblolly pine (*Pinus taeda*) plantations (78%) of different ages, cattle pasture (11%), and scrub-shrub (4%). The nuclear power plant occupies 7% of the study area and is located on the south end of the reservoir. Three filtration ponds ($\bar{x}$ = 0.1 ha) are located near the power plant.

Based on morphological characteristics, the current population of Canada geese on Monticello Reservoir consists of 3 sub-species: primarily *Branta canadensis interior* and *B. c. canadensis*; <3% of the population consists of giant Canada geese (*B. c. maxima*).

Egg laying data from a concurrent study was used to estimate date of hatching. Nests were encircled with grey cloth screen (Day et al. 1980) 3 days prior to estimated hatch date to capture goslings. After all goslings in a brood had dried and gained strength, they were fitted with radiotransmitters and returned to the nest. Transmitters were glued to the skin of goslings' backs just to the side of the vertebral column with "Duro" brand super-glue (cyanoacrylate). Transmitters weighed 2.5 g (about 2.5% of hatchling weight) and had a range of 0.4 km.

Radiotelemetry was used to locate goslings every 2 hours. Visual sightings with binoculars were made when possible, but we stayed away from the radio-marked broods to avoid human disturbance. Goslings and broods were visually inspected when locations were inconsistent with normal movement behavior or when goslings became separated from broods. When radio-marked goslings disappeared, systematic searches were immediately conducted from high points of land along transects around the last known location and eventually throughout the study area.

Gosling survival was estimated by the percent of radio-marked goslings surviving to 8 weeks, by a final count of goslings present on the reservoir 4 weeks after the last nest had hatched, and by 2 forms (censored and uncensored) of an extended Kaplan-Meier procedure which allow for staggered entry of broods into the study (Pollack et al. 1989). One form allows individuals which disappear without a trace to be censored from the data at the time of disappearance. The other form assumes mortalities have been caused by predation.

Results and Discussion

Radiotransmitters were attached to 10 broods (40 goslings) during the day (1300–1500) from 7 April to 15 May. Five broods remained on the nests 18–26 hours, and 5 broods left the nests within 2 hours of transmitter attachment. Broods were generally observed grazing at mainland pastures during the day and resting on islands at night. Two broods returned at least once to their nesting island at night. However, broods mostly moved to islands other than their nest island during nocturnal periods.

Only 6 goslings (15%), from a single brood, survived 8 weeks. Immediately after radio-marking, the parents of these goslings moved the brood from their nest on island 9 to the plant site filtration ponds where they remained throughout the study. The filtration ponds, located adjacent to the nuclear power reactor, provided a protective park-like habitat for about 25 goslings in 1987. A 2-ha area of grass surrounding the ponds was mowed every 2 to 3 weeks and provided food for brood rearing. The presence of SCE&G personnel, motorized traffic, and security lights at the filtration pond site probably account for the absence of predation on these goslings.

Mortality and disappearance of goslings was discovered within 2 to 4 hours. Nineteen mortalities (47.5%) were confirmed predations, 1 gosling died when it became impaled on a blackberry (*Rubus* spp.) thorn, 6 survived until the end of this study and 14 disappeared. Of the 14 (35%) goslings that disappeared, 10 disappeared at the same time other brood mates disappeared or were killed by predators (Table 1). Gosling emigration was extremely unlikely because surrounding habitat, primarily pine plantations, was unsuitable for brood rearing. We believe it is also unlikely that the 10 disappearances were due to transmitter malfunction: transmitters had been randomly attached to the goslings and had been activated <48 hours (expected transmitter life was 2160 hours) on birds that disappeared. We subsequently tested the same transmitter attachment method on goslings in pens: transmitters remained attached 21 days. All deaths and disappearances in our study occurred before 21 days of radio-attachment. In addition, the average time from hatching to disappearance (3.86 days) was not different ($t = -0.5333$; $P < 0.05$) from the time of hatching to confirmed predation (3.0 days).

Survival of goslings killed by predators ranged from 4 hours to 18 days. Transmitters with skin, blood, or muscle adhering to them at the attachment site indicated predation. Transmitter antennas often were bent by predators. The geo-

Table 1. Fate of radio-marked Canada goose goslings on Monticello Reservoir, South Carolina, 1987.

Brood and gosling no.	Age at death (hours)	Age at death (days)	Approximate time of death	Fate
1.1				Survived
1.2				Survived
1.3				Survived
1.4				Survived
1.5				Survived
1.6				Survived
2.1	18	0.75	0700	Unk. avian
2.2	42	1.75	0700	Unk. avian
2.3	102	4.25	1900	Unk. avian
2.4	142	5.90	1100	Accident
2.5	426	17.75	0700	Unk. avian
3.1	18	0.75	0500	Red fox
3.2	18	0.75	0500	Red fox
3.3	18	0.75	0500	Red fox
3.4	18	0.75	0500	Red fox
3.5	18	0.75	0500	Red fox
3.6	18	0.75	0500	Red fox
3.7	18	0.75	0500	Red fox
4.1	18	0.75	1900	Unk. avian
5.1	18	0.75	0700	Disappeared
5.2	22	0.92	1100	Disappeared
5.3	162	6.75	0700	Disappeared
5.4	342	14.25	0700	Mammal
6.1	72	3.00	1500	Crow
6.2	384	16.00	1500	Disappeared
7.1	22	0.92	1100	Disappeared
7.2	22	0.92	1100	Disappeared
7.3	22	0.92	1100	Disappeared
7.4	68	2.83	0900	Unk. pred.
7.5	72	3.00	0500	Unk. pred.
8.1	46	1.90	1100	Disappeared
8.2	46	1.90	1100	Disappeared
8.3	46	1.90	1100	Disappeared
9.1	4	0.17	1700	Crow
9.2	4	0.17	1700	Crow
9.3	46	1.90	1100	Disappeared
10.1	6	0.25	1900	Crow
10.2	70	2.90	1100	Disappeared
10.3	194	8.10	1500	Disappeared
10.4	198	8.25	1500	Disappeared

graphic location of transmitters indicated the type of predation. For example, transmitters found beneath fence posts or under perch trees suggested avian predators and transmitters recovered at entrances to red fox dens indicated fox predation.

Goslings killed by red fox characteristically were bitten once through the midportion of the body. Some goslings were eaten on the spot, and others buried in a food cache or transported to dens. For example, 5 of 7 goslings from 1 brood killed by a red fox, were buried in a food cache, 1 was eaten (with transmitter), and 1 was carried 2.3 km to a den. One fox den was located by following an adult fox that had ingested a transmitter. During a predator control program in 1985, 53 foxes were trapped, on and adjacent to the study area, which indicated a high fox density.

Crows killed and ate 4 radio-marked goslings on the ground. Crow predation was characterized by scattered down in an oval-shaped area (35 × 60 cm) surrounding a partially eaten gosling with severe head trauma. Cranial cavities often were punctured and their contents eaten first. Gizzards usually were eaten last or not at all. Attacks by crows usually occurred in open pasture and were the most easily observed incidents.

Although avian predators killed more goslings, fox could be the primary predators because they can kill more than one gosling at a time (e.g. 7 goslings killed by 1 red fox Table 1). Mammals prey on waterfowl 3 to 4 times more often than avian predators (Stout and Cornwell 1967).

Recorded predatory incidents on unmarked goslings included 16 by crow, 1 freshly hatched clutch by fire ants (*Solenopsis saevissima*), and 1 by an unknown raptor (gosling remains found in raptor casting). Predators on radio-marked goslings included red fox, crow, unknown avian, unknown predator and unknown mammal (Table 1).

Unsuccessful predator attacks on unmarked goslings included domestic dog, red-tailed hawk (*Buteo jamaicensis*), and crow. One gosling that had been separated from the flock was lifted out of the water by a crow and carried 10 m to the shore where it was killed and eaten.

Attempts to control predators are often ineffective and unjustifiable. Control measures that only target primary predators (fox and crow) may result in compensatory predation making the effort futile (Balser et al. 1968). However, reducing fox population densities to alleviate predation has biological, economic, and moral implications (Sargeant 1972) and could only be justified on a short-term, emergency basis.

Little defensive behavior was displayed by adult geese during observed predator attacks on goslings. In 3 separate incidents, crows attacked goslings attended by adult geese in open pasture. The adult geese would vocalize distress calls but exhibit little or no aggressive behavior toward the crows. Adult Canada geese exhibited little or no defensive behavior when their nests were checked and broods were radio-marked. Except for 1 incident, adult geese fled their nests and goslings without displaying defensive behavior when approached by humans. Owen (1980) reported that goslings were in danger from aerial attack only when they are separated from the family. Parental males delay their moult in order to protect young goslings. A

single adult goose can repel most avian predators, and will often fight a predator until death in defense of nest and brood. This type of aggressive behavior was not evident in our study.

During a study on St. Marks National Wildlife Refuge in Florida, stocked free-flying geese (resident geese) did not seem as wary and self-sufficient as migratory geese (Oberheu 1973). Also, giant Canada geese seem more successful in other southeastern resident goose populations. Oberheu (1973) suggested the size of Canada geese makes them most capable of dealing with predators. Several refuges which maintained decoy flocks of other subspecies were unsuccessful in starting local flocks until they acquired maxima stock.

A final count of surviving goslings was taken 4 weeks after the last nest hatched. In July, 320 of 500 geese were captured for banding during post-nuptial moult. Only 3 were 7–9 weeks old, categorized by Yocom and Harris (1954) as feathered-flightless. A survey of the entire reservoir and filtration pond area immediately after the banding operation revealed 22 additional goslings. A companion study of the same area revealed 563 goslings produced from 883 eggs. Only 25 of 563 hatchlings reached 4–8 weeks of age which is an estimated survival rate of 4.4%. In other studies comparing average brood size to average number of eggs hatched, survival rates of goslings of resident Canada geese range from 37% to 82% (Table 2). Our follow-up estimate may be low due to the difficulty in distinguishing feathered-flightless young from adult geese, and some goslings may not have been observed. In contrast, 6 of 40 radio-marked goslings (15%) survived to 8 weeks. However, the higher telemetry survival rate could be positively biased by the 1 brood that was raised on a protected brooding area. In addition, the Kaplan-Meier procedure to estimate survival taking into consideration the staggered entry of broods into the study and censoring all disappearances (not counting them as deaths), yielded a survival estimate of 21.2% ± 0.151% (±95% CL). The same method, counting

Table 2. Estimates of gosling survival of resident Canada geese on Monticello Reservoir, South Carolina, 1987.

Species	Survival rate (%)	State	Citation
B. c. canadensis and *B. c. interior* w/ <3% *B. c. maxima*	15	S.C.	This study (1990)
B. c. maxima w/ *B. c. canadensis* and *B. c. interior*	37		
	38	Ala.	Combs et al. (1984)
B. c. maxima	49		
	58	Mo.	Brakhage et al. (1987)
B. c. maxima w/ *B. c. interior* and *B. c. canadensis*	65	Ala.	Johnson and Kenamer (1976)
B. c. maxima	68	Minn.	Saylor (1977)
B. c. maxima	72	Mich.	Sherwood (1966)
B. c. maxima	82	Ohio	Warhurst (1972)

Table 3. Kaplan-Meier survival estimates for Canada goose goslings radio-marked on Monticello Reservoir, South Carolina, 1987.

Week (t)	N at risk	N of deaths	N censored	Survival	±95% CI
			Censored		
1	11	2	0	0.818	0.205
2	21	10	2	0.429	0.139
3	11	1	1	0.390	0.175
4	14	4	3	0.278	0.124
5	13	2	5	0.235	0.111
6	10	1	1	0.212	0.116
7	8	0	2	0.212	0.124
8	6	0	0	0.212	0.151
			Uncensored		
1	11	2		0.818	0.021
2	21	12		0.351	0.121
3	11	2		0.287	0.143
4	14	7		0.143	0.071
5	13	7		0.066	0.126
6	10	2		0.053	0.107
7	8	2		0.040	0.277
8	6	0		0.040	0.040

disappearances as deaths (not censoring disappearances), estimated survival at 4.0% ± 0.04% (±95% CL) (Table 3).

Management Implications

Wildlife agencies must consider that a large release of Canada geese (529) on a small reservoir (2,750 ha) with limited and concentrated brood rearing habitat may contribute to high gosling mortality. Releases on large reservoirs or isolated farm ponds with scattered nesting and brood rearing habitats might increase gosling survival. Additional study is needed on this aspect of resident Canada goose release programs.

Also, a higher percentage of giant Canada geese should be used in such releases because they may be more adaptable and capable of succeeding on marginal habitat due to their tendency to attempt to defend broods from predators.

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