Nesting Biology of a Resident Flock of Canada Geese[1]

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Abstract: Productivity, nesting biology, and gosling survival of a resident flock of Canada geese (*Branta canadensis*) were studied in southeastern Alabama and southwestern Georgia from 1977 to 1982. A total of 323 nests contained 1,631 eggs. The nesting season usually began in late February and ended in early June. Yearly nest success varied from 27% to 64%. Flooding resulted in the destruction of 35% of total nests and was ranked as the major cause of nest failure. Nest success on artificial nest structures and beaver (*Castor canadensis*) lodges was higher than on islands and the shoreline. More than 63% of the nests were located on islands, and 24% were located on artificial nest structures. Mean clutch size was 5.6 eggs/nest, but mean brood size at nest departure was only 4.0 goslings/nest. About 38% of the goslings that hatched survived to fledging.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 38:228-238

Many resident flocks of Canada geese have been established in the southeastern United States since the mid-1960s (Oberhou 1973, Chabreck et al.

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1974, Tennessee Valley Authority 1978). Between 1966 and 1971, 154 geese were released at Eufaula National Wildlife Refuge (ENWR) in southeastern Alabama and southwestern Georgia. Approximately 116 remained to breed, beginning nesting in 1968 (Johnson and Kennamer 1976). Most nesting geese resembled *B. c. maxima* (Hanson 1965), although individuals of 3 subspecies (*B. c. canadensis, interior,* and *maxima*) were released. The Eufaula flock had grown to about 500 geese by 1982.

The reproductive success of the flock was first investigated from 1975 to 1976 (Johnson and Kennamer 1976). This report summarizes additional data which were collected between 1977 and 1982. The results are useful in managing resident Canada goose flocks in the Southeast because they assess long-term productivity. This paper also documents natural and man-induced impacts on the flock and changes in nesting biology as flock size increases.

The authors thank the personnel of ENWR for assistance with equipment and fieldwork and all the individuals that participated in the goose banding drives. Special thanks are extended to G. Baldassarre, D. Brakhage, L. Fredrickson, R. Lishak, R. Mirarchi, and F. Reid for reviewing the manuscript. S. Clark and D. Brakhage were indispensable in preparing the manuscript. This project was funded through the Auburn University Agricultural Experiment Station.

Methods

Study Area

The 4,500-ha ENWR is located on the upper portion of the Walter F. George Reservoir on the Chattahoochee River, 10 km north of Eufaula, Alabama, and 70 km south of Columbus, Georgia. Before 1982, planned reservoir levels were 56.2 m above mean sea level between 15 November and 15 May and 57.9 m between 15 May and 15 November. The planned water level is now 57.5 m year-round. Rainfall and drainage patterns cause actual water levels to vary approximately 1 m during the nesting season.

On ENWR, water level fluctuations result in the exposure of approximately 3,200 ha of mudflats and shallow open water which support emergent and moist-soil plants. Waterfowl impoundments, totaling 200 ha, support similar vegetation as well as submergents. Rowcrops are grown on approximately 400 ha of the upland portion of the refuge. Beaver ponds, pastures, and riparian woodlands comprise the remaining 700 ha.

Available goose nesting sites varied only slightly during the study and included approximately 100 islands, 20 artificial nest structures (ANS), 15 beaver lodges, and 130 km of open, herbaceous, or woody shoreline.

Techniques

Nests were located by systematically searching the area weekly between 1 February and 30 May 1977–82. Nest checks were conducted weekly to determine details of hatch or failure. When nests were located after incubation had begun, initiation dates were estimated by backdating from the hatch using a laying rate of 1.5 days/egg and an incubation period of 28 days (Kossack 1950, Brakhage 1965). Embryos in unhatched eggs were aged as described by Cooper and Batt (1972) and used to determine initiation dates of unsuccessful nests.

Gosling survival rates were estimated in 1980 and 1981 using clutch and brood sizes of geese individually marked with different combinations of colored leg bands. Renesting data were also collected on marked geese.

Statistical Analysis

Chi-square analysis was used to test differences in success ratios by week, month, and year; differences in percentage of nests successful, flooded, and destroyed by predators by type of nest site; and yearly differences in the percentage of eggs that hatched from successful nests. Analysis of variance was used to test differences in mean clutch size among months and years. Least significant differences (LSD's) were calculated to determine differences in means if the analysis of variance was significant. Statistical procedures follow Snedecor and Cochran (1976).

Results and Discussion

Productivity

From 1977 to 1982, 323 nests were located on the study area (Table 1). The presence of 3 to 5 broods per year with marked adults that were not located on nests suggests that a few nests were not found each year. Nesting density was less than 0.1 nest/ha from 1977 to 1982. This density is misleading because 90% to 95% of ENWR consists of open water and uplands and is unsuitable for goose nesting.

Nest success is the percentage of nests in which at least 1 young emerges,

Table 1. Nest and egg success of resident Canada geese at Eufaula National Wildlife Refuge, Alabama-Georgia, 1977–82.

Year	Total nests	Successful nests	Nest success (%)	Total eggs	Eggs hatched	Egg success (%)
1977	34	19	56	169+[a]	74	44
1978	38	23	60	223	88	40
1979	50	25	50	251+	101	40
1980	71	19	27	314+	74	24
1981	74	20	27	370+	76	20
1982	56	36	64	304+	160+	53
Total	323	142	44	1,631	573	35

[a] Outcome of some nests occurred before nests were located.

and egg success is the percentage of eggs that are successful (Cooper 1978). Nest success at ENWR differed among years ($P < 0.005$), varying from 27% in 1980 to 64% in 1982 (Table 1). Average nest success at ENWR is far below success rates for other resident goose flocks (Table 2). No differences were detected in success rates of nests initiated in different months ($P > 0.10$) within a year. Of the 785 eggs laid in successful nests only 573 (73%) hatched. Mean brood size at nest departure, thus, equalled 4.0 goslings/nest. There was no difference in mean brood size among years ($P > 0.50$).

During the 6 years of the study, 1,631 eggs were present in 323 nests (Table 1). Mean clutch size (5.6 eggs/nest) was estimated from 277 completed nests which contained 1,541 eggs. Two nests, containing 9 and 13 eggs, were considered dump nests and are not included in this calculation. Yearly mean clutch sizes varied from 5.2 in 1980 to 5.9 in 1978 but did not differ significantly ($P > 0.05$). This average is similar to that of other studies of resident goose flocks (Table 2). Median clutch size was 6 eggs/nest (Fig. 1).

Mean clutch size did not differ between nests initiated in February ($N = 15$, $x = 6.1$) and March ($N = 160$, $x = 5.8$) ($P > 0.10$). Mean clutch size differed between March and April ($N = 91$, $x = 5.2$) ($P < 0.01$) and between April and May ($N = 7$, $x = 3.7$) ($P < 0.01$). Late nesting geese at ENWR, thus, laid fewer eggs than early nesters. Renesting geese and young geese generally lay small clutches late in the season (Cooper 1978) and were probably prevalent among late nesters at ENWR.

The number of nesting attempts per year increased each year from 1977 to 1981 then declined in 1982 (Table 1). The increase in nesting attempts was probably influenced by an increasing population. However, during years in which nest success was high, a small number of renests resulted in fewer total attempts. In 1981, nest success was only 27% because of extensive flooding. Renesting was verified for 9 of 43 marked nesting pairs. Undoubtedly, additional renesting occurred because some geese were not marked; verification of markings on each incubating bird was impossible. In 1982, nest success in-

Table 2. Mean clutch size and nest success for selected flocks of resident Canada geese.

Location	Mean clutch size	Nest success (%)	
Trimble, Mo.	5.3	65	Brakhage 1965
Huron River, Mich.	5.4	82	Kaminski et al. 1979
Northeastern S.D.	5.2	87	Hilley 1976
Twin Cities, Minn.	5.6	67	Sayler 1977
Rockefeller Refuge, La.	4.4	60	Chabreck et al. 1974
Eufaula National Wildlife Refuge, Ala., Ga.			
(1961–76)	5.6	51	Johnson and Kennamer 1976
(1977–82)	5.6	44	This study

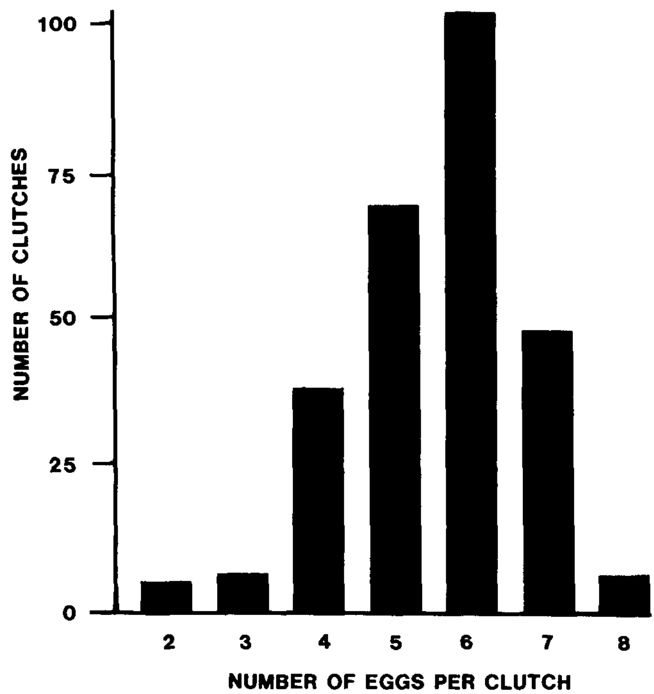

Figure 1. Clutch size distribution for Canada geese at Eufaula National Wildlife Refuge, Alabama–Georgia, 1977–82.

creased to the highest level in the study (64%); only 1 renest was verified for 49 marked nesting pairs.

Renesting following destruction of first nesting attempts was verified for 14 marked pairs in 1980 through 1982. Mean clutch size was 5.9 for first nests and 5.1 for renests. Eleven of these 14 initial attempts were destroyed during the first few days of incubation, and 1 was lost during laying. The other 2 initial attempts had been incubated for 15 and 19 days before destruction. These last mentioned renests were unusual because renests were not observed when nest loss occurred after the fifth day of incubation in a Missouri flock (Brakhage 1965) or after the second day in a Manitoba flock (Cooper 1978). The interval between loss of first nests and initiation of second attempts at ENWR ranged from 12 to 33 days ($x = 20$). The renesting interval averaged 13 days in Missouri (Brakhage 1965) and 11 days in Manitoba (Cooper 1978). Most initial nests were lost during laying in northern areas before energy reserves had been depleted, promoting a short renesting interval (Cooper 1978). The longer interval observed at ENWR probably resulted from nests being destroyed during incubation.

Nesting Period

Length of the nesting season is the time from initiation of the first nest to the hatch of the last nest. Mean length of the nesting season at ENWR was 95 days and varied from 84 days in 1982 to 113 days in 1980. First nests were initiated at ENWR in late February and early March, and hatch of last nests occurred in late May and early June (Fig. 2). Median initiation dates varied from 19 March in 1982 to 4 April in 1980 (Fig. 2). This variation is probably related to weather conditions early in the nesting season and the amount of renesting. Length of nesting season averaged 78 days in northwestern Iowa (Nigus and Dinsmore 1980), 65 days in northern Michigan (Sherwood 1965), and 70 days in southern Manitoba (Cooper 1978). The shorter nesting season at higher latitudes reflected later initiation dates in the north. Because of mild climates, southern nesting geese have longer nesting seasons which potentially provide renesting options unavailable to northern nesters.

Causes of Nest Failure

Flooding was the major cause of nest destruction during the study and was the major factor influencing success rates, length of the nesting season, and amount of renesting. The percentage of nests that were flooded varied from 18% in 1978 to 51% in 1980 (Fig. 3). Nest losses for 1980 and 1981 might be slightly high; eggs from 35 nests were hatched in an incubator because inundation seemed imminent. A few of these nests did not flood as expected, but they were included in the flooded category.

Flooding was especially severe in 1980 and 1981. During the last week of March, 22 nests were lost in 1980 and 24 in 1981. In 1982, the water level remained low until 25 April when it reached the peak of the previous 2 years. Most nests hatched before this time; hence, only 10 nests were destroyed. The timing, as well as the depth, of spring flooding is critical in determining impacts on nesting geese.

Nest abandonment and nest loss caused by human disturbance varied from 4% in 1982 to 16% in 1978 (Fig. 3). These 2 factors were combined as abandonment because the cause of abandonment could not be determined in most cases. Eleven entire clutches lost between 1977 and 1982 were probably stolen. Most other impacts from human disturbance occurred during laying. At least 3 incomplete clutches probably were abandoned because of researcher disturbance.

Once incubation began, nest abandonment was rare but at least 3 nests were abandoned late in incubation probably because of fire ants (*Solenopsis saevissima*). Ant mounds were incorporated within the nesting material of all 3, and the ants were aggressive and formed large swarms when the nesting material was disturbed. At least 5 other nests hatched successfully despite the presence of ant mounds within 1 m. Geese also ceased nesting on at least 3 traditionally used beaver lodges after ants colonized the sites. Fire ants apparently spread to islands and beaver lodges in compact, floating swarms dur-

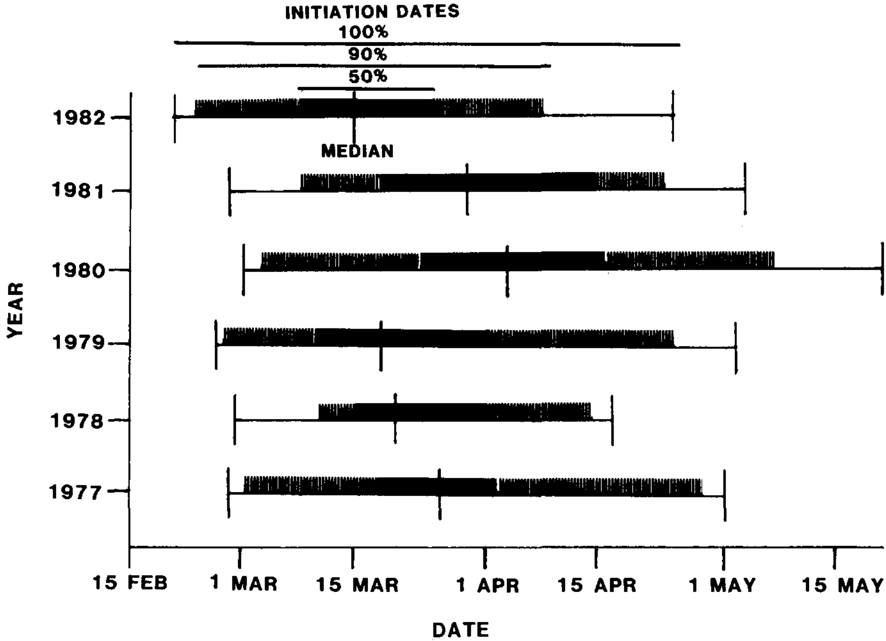

Figure 2. Chronology of nesting of Canada geese at Eufaula National Wildlife Refuge, Alabama–Georgia, 1977–82. Vertical bars demonstrate the range and median initiation dates, while horizontal bars represent the interval when 50% and 90% of nest initiation occurred.

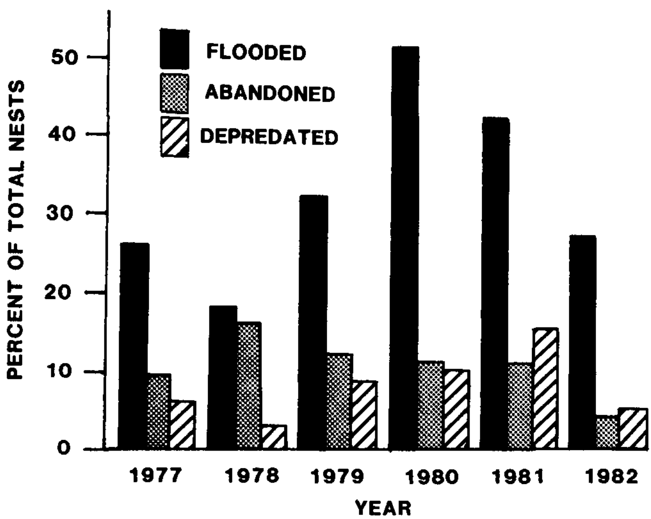

Figure 3. Percentage of Canada goose nests flooded, abandoned, and destroyed by predators at Eufaula National Wildlife Refuge, Alabama–Georgia, 1977–82.

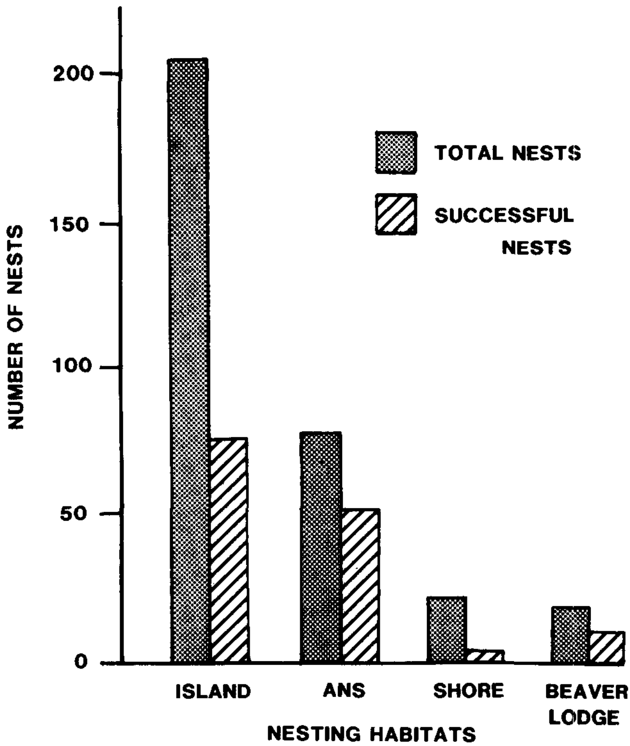

Figure 4. Distribution of Canada goose nests in relation to nesting habitats at Eufaula National Wildlife Refuge, Alabama–Georgia, 1977–82.

ing floods. Fire ants seemed to be increasing at ENWR during this study, and their impact on nesting geese warrants further study.

Only 27 nests (8%) were lost to predation from 1977 to 1982 (Fig. 3). Predation loss has been considered the limiting factor in a Michigan flock (Sherwood 1965) but has little impact on success rates at ENWR. The tendency for geese to nest on islands at ENWR reduced predation. Predators destroyed 46% ($N = 10$) of shoreline nests but only 5% ($N = 17$) of the nests where access to the mainland was restricted. Some common egg predators at ENWR include raccoons (*Procyon lotor*), skunks (*Mephitis mephitis*), bobcats (*Lynx rufus*), foxes (*Vulpes vulpes* and *Urocyon cinereoargenteus*), dogs (*Canis domesticus*), crows (*Corvus* spp.), and gulls (*Larus* spp.). A 1.7-m rat snake (*Elaphe obsoleta*) consumed an entire brood of 4 newly-hatched goslings in a nest in 1981 but did not eat 1 egg that failed to hatch. Another rat snake was unsuccessful in an attempt to swallow an egg from a flooded nest because of the large egg size.

Other minor causes of nest failure included egg infertility (5 nests) and the collapse of an ANS (1 nest).

Nest Sites

Islands were used as nest sites by 63% of nesting geese, and ANS were used by 24% (Fig. 4). Few nests were found along the shoreline (Fig. 4), probably reflecting behavioral modifications to reduce predation pressure. Most beaver lodges were used as nest sites unless colonized by fire ants.

The percentage of nests that were successful, flooded, and destroyed by predators differed among nesting sites ($P < 0.01$). Nests located on ANS and beaver lodges had higher success rates because they were protected from predators by surrounding water and were high enough to reduce flooding losses (Fig. 4). Predator losses were minor on islands (5%), but 47% of all island nests were flooded. Few (31%) of shoreline nests were successful because of predation (46%) and flooding losses (23%).

Gosling Survival

Productivity is best measured by number of goslings fledged rather than number of eggs hatched (Sherwood 1965). In 1980, only 13 of 35 (37%) goslings in broods of marked parents survived to fledging; 16 of 42 (38%) survived to fledging in 1981. Gosling survival rate was not calculated in 1982. The causes of gosling mortality were uncertain, but predation was suspected. High gosling mortality in 1975 was attributed to coccidiosis (*Eimeria* spp.) in a 10-ha enclosure (Johnson and Kennamer 1976), but no evidence of disease was observed from 1977 to 1982.

Gosling survival rates were estimated as 68% in Missouri (Brakhage 1965), 68% in Minnesota (Sayler 1977), and 72% in Michigan when disease was not prevalent (Sherwood 1965). An earlier estimate of survival at ENWR (65% in 1976) (Johnson and Kennamer 1976) may be high because the survival rate was estimated from average brood size. Gosling survival rates calculated by comparing average brood size to average number of eggs hatched are biased because they do not account for the loss of entire broods (Sherwood 1965). Loss of complete broods was substantial at ENWR because all goslings from 3 of 8 broods with marked parents were lost in 1980, and 4 of 11 broods were lost in 1981. Low gosling survival may be a major factor restricting flock expansion at ENWR. Additional research, preferably with radio marked broods, should be conducted on brood movements and survival.

Management Implications

Annual productivity of the resident Canada geese at ENWR is highly variable. Rainfall and drainage patterns determine the depth and timing of flooding and have major impacts on annual success rates. Other goose flocks nesting primarily on low islands on large reservoirs may show similar trends.

Success rates are higher for nests on ANS and beaver lodges than those on islands and the shorelines because of reduced predation pressure and protection from flooding. If increased productivity is an objective, additional ANS at ENWR may provide a greater number of safe nest sites and increase nesting success. However, the use of new ANS may be a delayed response. Although 15 additional ANS were placed in areas of high nesting density in 1981, only 3 were used in 1981 and 4 in 1982. The encouragement of landowners to construct ANS or nesting islands in farm ponds near ENWR might also increase recruitment. Water level fluctuations in farm ponds are less severe than in the reservoir, and flooding losses should be reduced.

A major factor reducing productivity at ENWR is the low survival of goslings. Some brood rearing areas at ENWR have larger broods and higher survival rates for goslings. Apparently these locations enhance brood rearing and gosling survival, but these and other survival factors are poorly understood and warrant further study.

The Canada goose flock at ENWR increased from 116 birds in 1968 to 500 in 1982. Low nesting success and gosling survival were probably offset by high adult survival. Canada geese are protected in the 4-country area surrounding ENWR, and adult mortality is probably less than 10%/year. Minimizing crop depredation by maintaining a small goose flock is a major objective at ENWR (D. Temple, pers. commun.). The low productivity should enhance this objective but will dictate a conservative harvest if the flock becomes large enough to sustain a limited hunting season.

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