

## GANG BROODING IN CANADA GEESE: ROLE OF PARENTAL CONDITION AND EXPERIENCE

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**Abstract.** Some Canada Geese (*Branta canadensis*) raise their broods by themselves (two-parent families), while others raise them in gang broods, defined as two or more broods amalgamated into a single cohesive unit and shepherded by four or more parents. From 1984 to 2005, I individually marked Canada Geese in New Haven County, Connecticut, so that I could compare the characteristics of adults that raise their goslings in gang broods to those of adults that raised their goslings in two-parent families. I wanted to determine if a parent's decision to form a gang brood was influenced by its age or body mass, its own parents (indicating either that the behavior has a genetic component or that the behavior is learned while a gosling), its prior experiences raising broods, or the loss of its mate. Parents tended to use the same brood-rearing approach from one year to the next: 61% of parents of gang broods (i.e., gang-brooders) during one year also were gang-brooders the next year they had goslings; likewise, 65% of parents in two-parent families during one year raised their next brood in a two-parent family. Geese that changed mates from the previous year were more likely to switch brood-rearing approaches than those that stayed with the same mate. As geese gained more years of experience raising goslings, their propensity to form a gang brood increased; only 29% of geese raising broods for the first time formed a gang brood versus 80% for geese with 5 or more years of experience. Geese raised in gang broods themselves were no more likely than geese raised in two-parent families to form gang broods once they became adults and had their own broods. These results indicate that gang brooding is a behavior learned as an adult. I tested the hypothesis that adult geese attending the same gang brood are members of the same extended family but found that geese were as likely to form a gang brood with unrelated individuals as with siblings or parents.

**Key words:** *Branta canadensis*, brood amalgamations, cooperative breeding, creching, Canada Goose, gang broods, geese.

### Nidada Grupal en *Branta canadensis*: Rol de la Condición y de la Experiencia Parental

**Resumen.** Algunos individuos del ganso *Branta canadensis* crían sus propias nidadas (familias con padre y madre), mientras que otros las crían en nidadas grupales, definidas como dos o más nidadas mezcladas en una única unidad cohesiva y custodiada por cuatro o más padres/madres. Desde 1984 hasta 2005, marqué individuos de *B. canadensis* en el condado de New Haven, Connecticut, para poder comparar las características de los adultos que crían sus polluelos en nidadas grupales con las de los adultos que crían sus polluelos en familias con padre y madre. Me interesaba determinar si la decisión de un/a padre/madre de formar una nidada grupal estaba influenciada por su edad o peso corporal, por sus propios padres (indicando que el comportamiento tiene un componente genético o aprendido durante la etapa de polluelo), por sus experiencias previas criando nidadas o por la pérdida de su pareja. Los padres/madres se inclinaron a usar el mismo método de cría de la nidada de un año al año siguiente: el 61% de los padres/madres que fueron criadores de nidadas grupales (i.e., criadores de nidadas grupales) durante un año también fueron criadores de nidadas grupales en el año siguiente que tuvieron polluelos. Del mismo modo, el 65% de los padres/madres que criaron en familias con padre y madre durante un año también criaron sus siguientes nidadas en una familia con padre y madre. Los gansos que cambiaron sus parejas del año anterior tuvieron una mayor probabilidad de cambiar el método de cría de la nidada, comparados con aquellos que permanecieron con la misma pareja. A medida que los gansos aumentaron su experiencia criando polluelos, la tendencia a formar una nidada grupal aumentó; sólo el 29% de los gansos que criaron nidadas por primera vez formaron una nidada grupal, versus el 80% de los gansos con cinco o más años de experiencia. Los gansos que fueron criados en nidadas grupales no tuvieron una mayor probabilidad de formar nidadas grupales que los gansos que fueron criados en familias con padre y madre, una vez que fueron adultos y que tuvieron sus propias nidadas. Estos resultados indican que la crianza en nidadas grupales es un comportamiento que es aprendido de adulto. Evalué la hipótesis de que los gansos adultos que formaron parte de la misma nidada grupal son miembros de la misma familia extendida, pero encontré que los gansos tuvieron la misma probabilidad de formar una nidada grupal con un individuo no relacionado que con un hermano/a o padre/madre.

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## INTRODUCTION

Birds with semi-precocial young can raise their offspring by themselves, or they can adopt some type of cooperative brood-rearing approach by joining with other parents. One such cooperative approach is creching, where young from several broods group together. Creching has been reported in penguins (Evans 1984, Seddon and van Heezik 1993), cormorants (Carter and Hobson 1988), and pelicans (Evans 1984), among others. In all of these colonial birds, young gather in a crèche while parents are foraging away from the colony. When parents return from their foraging trips, they feed only their own young, not any chick in the crèche. While the parents are away, creching may benefit chicks by providing protection from predators (Evans 1984, Carter and Hobson 1988, Seddon and van Heezik 1993) or from adult aggression (Seddon and van Heezik 1993). Creching may also result from crowding or the accidental mixing of broods (Carter and Hobson 1988, Seddon and van Heezik 1993, Kalmbach 2006).

Brood amalgamations also occur in many species of Anatidae when two or more families join together with their offspring, resulting in a cohesive group of young accompanied by two or more adult females (Brakhage 1965, Warhurst et al. 1983, Kalmbach 2006). Given that waterfowl do not leave their young to forage, gang brooding in waterfowl may arise for reasons different from those responsible for creching (Eadie et al. 1988, Kalmbach 2006).

Unlike most Anatidae, male and female geese care for their offspring together, and both parents, not females alone, tend gang broods (Gosser and Conover 2000). Many authors have assumed that gang brooding must provide some benefit to the goslings or otherwise the behavior would not occur, and several hypotheses have been proposed to explain why gang brooding is advantageous. For example, the numerous goslings in a gang brood may provide each gosling greater protection from predators through a dilution effect (Kalmbach 2006), or the multiple parents attending a gang brood may provide greater vigilance for predators (Lessells 1987, Forslund 1993, Sedinger et al. 1995, Fowler and Ely 1997). Goslings in gang broods also may gain better access to optimal foraging sites because large families are dominant over smaller ones (Raveling 1970, Lamprecht 1986, Loonen et al. 1999). Yet if gang brooding increases goslings' survival, all geese should raise their goslings in gang broods, but this is clearly not the case. In Connecticut, about half of all Canada Goose (*Branta canadensis*) goslings are raised in gang broods, and half are raised in two-parent families (Gosser and Conover 2000).

In this study, I examined the characteristics of Canada Geese as parents to determine why some raise their goslings in gang broods and others raise them in two-parent families. I wanted to determine if the brood-rearing approach employed by a parent was influenced by its age, body mass, years of brood-rearing experience, the brood-rearing approach it used during the prior year, or the brood-rearing approach its

parents used to raise it. I examined if naïve geese learn how to gang brood from experienced pairs of gang brooders (i.e., tutors) and tested the hypothesis that adult geese in gang brood are members of the same extended family.

## METHODS

I studied Canada Geese nesting in New Haven County, Connecticut, over 22 years (1984 through 2005). Most Canada Geese in the county built their nests on islands in scattered lakes and ponds but brought their broods to one of three brood-rearing sites, sometimes traveling several kilometers to reach them. Each brood-rearing site was located in a complex of two to four lakes. The three complexes were (1) Konold's Pond-Lake Dawson, (2) Whitney Lakes, and (3) Maltby Lakes. Adjacent to these lakes were golf courses, parks, shopping centers, and apartment buildings, and the broods usually foraged on the lawns associated with these areas. For instance, broods from Maltby complex spent most of their time on Yale University's golf course, which offered both rich foraging ground (lawns) and sanctuaries (water hazards and ponds). Such open sites also proved ideal for tracking individual geese and their goslings (Conover and Kania 1991).

In late June, adult geese molt their primary feathers and become flightless. This molt occurs about 2 weeks before the goslings gain the ability to fly. During the molt, I caught adults and goslings at the brood-rearing sites by driving them into funnel traps (i.e., the round-up). Most of the adults and goslings at these sites were captured (usually 100 to 200 annually), but some always managed to elude capture. When caught for the first time, each bird was sexed through a cloacal examination, weighed, and given a U.S. Fish and Wildlife Service band. Each bird was also given a large individually numbered leg band with letters and numbers 1.3 cm high or a neck collar with numbers and letters 3 cm high. Hence most geese nesting at my study site could be identified individually at a distance by their collar or large leg band. For this reason, I identified all broods at my study sites by their parents. I banded approximately 2300 geese during this 22-year study.

Each year, I located my individually marked geese at their nests and again at the brood-rearing sites. I noted which geese were paired and recorded weekly how many goslings they had in their broods. I also recorded whether each pair raised their goslings in a gang brood or two-parent family.

I examined whether a parent's brood-rearing approach in the prior year (year 1) influenced its selection of a brood-rearing approach the next year it raised goslings (year 2). The null hypothesis for this and all other tests was that the factor did not influence a parent's brood-rearing approach. These two years did not need to be consecutive, but year 2 had to be the subject's most recent brood-rearing experience after year 1. Sampling units were breeding pairs whose brood-rearing approach I had recorded for two years, and no pair was used more than once in this test. I divided the geese into two groups

based on which brood-rearing approach (gang brood or two-parent family) each pair used during year 1. I tested the hypothesis that a pair's brood-rearing approach in year 2 was the same as that used in year 1. I compared the proportion of gang-brooding pairs (i.e., gang brooders) in year 1 that were also gang brooders in year 2 to the proportion of two-parent families in year 1 that became gang brooders in year 2. For these and all other comparisons, I used a  $2 \times 2$  contingency test (Siegel 1956) unless otherwise noted; a difference was considered statistically significant if  $P \leq 0.05$ .

I also searched my data set for cases in which a parent had raised goslings in two successive years but had changed mates from one year to the next. Divorce was rare in my geese; usually a change in mates meant the death of the former partner. I examined whether a change from the previous year's mate increased the probability of a male or female switching to a different brood-rearing approach. The subjects were geese for which I had brood-rearing records for two years and I knew the identity of their mates for both years. I compared the proportion of divorced geese (those that lost a mate) that switched to a new brood-rearing approach to the proportion of non-divorced geese (those that were with same mate) that switched to a new brood-rearing approach. In this and all other tests, the experimental unit was an individual adult goose, and the same goose could not contribute more than once to the same category of data. If the status of an adult changed, however, it could contribute to more than one category. That is, the same goose could contribute a datum to both the divorced and non-divorced categories if during its life it experienced both. If an individual goose contributed to a data set, its mate could not.

Both sexes participate as a team in raising goslings, and it is unclear which sex has more influence in deciding how to raise the brood. To assess this, I asked whether males or females showed more fidelity to a particular brood-rearing approach. My sampling units were divorced males and females for which I had records of their brood-rearing approach for the year in question (year 2) and for the previous year (year 1). Whether the goose switched its brood-rearing approach from the previous year was the dependent variable, and the sex of that goose was the independent variable. Using these variables, I divided the geese into four groups: (1) female, same brood-rearing approach used in both years; (2) female, different brood-rearing approaches used in the two years; (3) male, same brood-rearing approach used in both years; and (4) male, different brood-rearing approaches used in the two.

To determine whether a goose adopted the brood-rearing approach under which it had been reared, I searched the data set for geese that I had banded as goslings and I knew whether they had been raised in a two-parent family (i.e., two-parent goslings) or in a gang brood (gang-brood goslings). Once these goslings matured and started raising their own young, I noted which brood-rearing approach they used to raise their own offspring. I compared the proportion of two-parent

goslings and gang-brood goslings that became gang brooders when they raised their own goslings.

Age or prior brood-rearing experience may influence a parent's brood-rearing approach. For age assessment, I used only those geese that I banded as goslings and whose age I knew exactly. Using unpaired Student's *t*-tests (Siegel 1956), I compared the parents of gang broods to parents of two-parent families in their mass and number of years of brood-rearing experience. Each year that a goose produced a brood was considered the sample unit; this is because each year the goose was one year older and had one more year of brood-rearing experience. Thus a goose could not contribute twice to the same category of age or experience.

I expected a parent's age and brood-rearing experience to be auto-correlated. To test the effect of age independent of experience, I conducted a second test examining what brood-rearing approach a parent used during its first year raising goslings. Once again, geese were divided by their age, and I compared the proportion of first-time parents that formed gang broods versus two-parent families.

A parent's body mass may influence its decision to become a gang brooder. To test this, I weighed all adults during the round-up and compared the mass of adults attending gang broods to that of those attending two-parent families.

Geese may need to be tutored by experienced gang brooders to learn how to gang brood. To test this, I located pairs of geese that were gang brooding for the first time and determined the number of years of brood-rearing experience and years of gang brooding of their gang-brood cooperators (other parents in their gang brood). For clarity, I excluded from this analysis any geese that had formed a gang brood with more than a single pair of gang-brood cooperators.

To assess whether geese form a gang brood with the same pair of brood-rearing cooperators from one year to the next, I searched the data set for pairs of geese that (1) formed a gang brood together in the first year and (2) the same two pairs of geese both cared for broods during year 2 at the same place and time. This last condition was imposed because if one of the pairs did not produce a brood during the second year or produced it somewhere else, there was no option for the two pairs to form a gang brood during the second year. I then determined what proportion of the pairs that had formed a gang brood together during the first year also formed a gang brood together during the second year. To determine if this proportion was higher than expected, I identified an equal number of pairs that both (1) raised a brood during the first year at the same place as gang brooders but did not form a gang brood with them and (2) raised a brood during the second year at the same place as the gang brooders. I then identified what proportion of the gang brooders during the first year formed a gang brood during the second year with one of these pairs. To avoid pseudo-replication, I used only one pair from a gang brood in this analysis.

I examined whether an adult goose was more likely to form a gang brood with its own sibling or with an unrelated individual. For this analysis, I defined siblings as goslings that had been raised in the same two-parent family or gang brood. This definition meant that many goslings, but not all, were genetically related to their siblings. Subjects were adult geese that (1) I had banded as goslings along with their siblings, (2) were raising their own goslings in a gang brood, and (3) had a sibling that was also raising its own goslings at the same place and time as the subject. I noted what proportion of the subjects formed a gang brood with a sibling. To determine whether more subjects formed gang broods with a sibling than would be expected by chance (i.e., through a random pairing of geese into gang broods), I identified for each subject another adult goose that both (1) had been a gosling at the same year and place as the subject but was raised by different parents (i.e., it was a “non-sibling”), and (2) was raising goslings of its own during the same year and place as the subject was raising its goslings. To avoid pseudo-replication, only one gosling per gang brood could serve as a subject for this test. Because one expected value was  $<5$ , I used a Fisher exact probability test (Siegel 1956) to compare the portion of subjects that formed a gang brood with a sibling versus a non-sibling.

I also examined whether an adult goose was more likely to form a gang brood with one of the geese that raised it when it was a gosling (parent in a sense including both genetic parents and the genetic parents’ gang-brood cooperators) than with an unrelated individual. For this analysis, a subject was defined as a goose that I had banded as a gosling that (1) had reached sexual maturity and was raising its own offspring in a gang brood and (2) one of its parents was raising goslings at the same time and place as the subject. To determine whether forming a gang brood with a parent occurred more often than would be expected by chance, I identified for each subject another adult that (1) produced goslings during the same year the subject was a gosling and at the same site, and (2) raised goslings during the same year and at the same site where the subject was raising its own brood. These geese were referred to as “non-parents.” I then used a  $2 \times 2$  contingency test to compare the proportion of subjects that formed a gang brood with a parent versus a non-parent. Values reported in the results are means  $\pm$  SE.

## RESULTS

### DO GEESE EMPLOY THE SAME BROOD-REARING APPROACH ACROSS YEARS?

I identified 80 pairs of geese that remained paired and raised goslings during two different years. During the first year, 28 pairs formed gang broods. Of these 28 pairs, 17 (61%) also formed a gang brood during the subsequent year. During the first year, 52 pairs raised their goslings in two-parent families; during the subsequent year, 18 (35%) of these formed a gang

brood. These proportions were different ( $\chi^2_1 = 5.03$ ,  $P = 0.02$ ), indicating that pairs of geese had a tendency to use the same brood-rearing approach from year to year. This tendency was not influenced by whether the pair raised goslings in two consecutive years or whether a year separated their brood-rearing years ( $\chi^2_1 = 2.79$ ,  $P = 0.09$ ).

I found 80 pairs that remained together and raised goslings during two different years (i.e., they did not switch mates). Of these, 64% stayed with the same brood-rearing approach for both years. I also located 63 geese that switched mates for the next year in which they raised a brood: 40% of them stayed with the same brood-rearing approach for both years. These percentages differ significantly ( $\chi^2_1 = 8.19$ ,  $P = 0.001$ ).

I identified 35 divorced females that produced goslings during two years but with different mates; during the second year 14 (40%) raised their goslings by the same approach they had employed during the first year. I located 28 divorced males that produced goslings with different mates; during the second year 11 (39%) of them raised their goslings by the same approach they had employed during the first year. This difference between the sexes was not significant ( $\chi^2_1 = 0.01$ ,  $P = 0.95$ ).

### DOES A PARENT’S BROOD-REARING EXPERIENCE, AGE, OR BODY MASS INFLUENCE ITS LIKELIHOOD TO FORM A GANG BROOD?

The number of years of prior experience a goose had raising goslings had a major effect on the probability that it would form a gang brood ( $\chi^2_5 = 30.98$ ,  $P = 0.0001$ ). Few (29%) geese raising goslings for the first time formed a gang brood (Fig. 1). In contrast, gang broods were formed by 80% of geese with

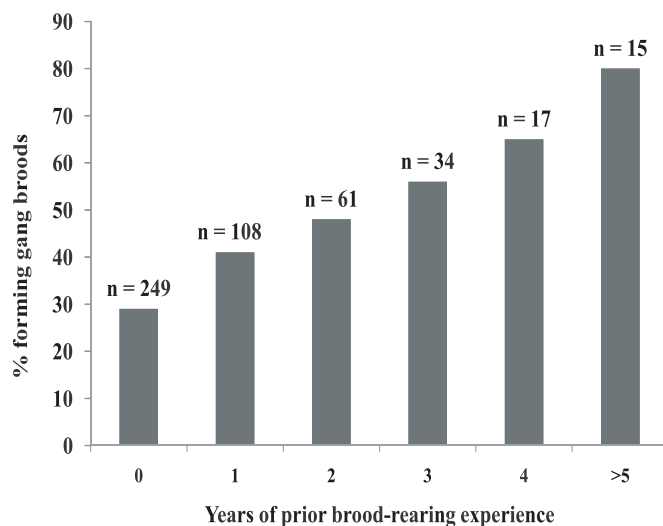


FIGURE 1. How a goose’s propensity to form a gang brood changes as it gains more years of experience raising goslings (numbers above each column are the number of parents with that amount of experience).

TABLE 1. Differences in age (years) and body mass (g) of male and female Canada Geese raising their first broods in either two-parent families or gang broods.

Sex	Variable	Two-parent families		Gang broods		df	<i>t</i>	<i>P</i>
		$\bar{x}$	SE	$\bar{x}$	SE			
Female	Age	4.8	0.4	4.2	0.4	60	0.88	0.38
Male	Age	4.3	0.8	3.4	0.7	69	0.83	0.41
Female	Mass	3695	48	3749	56	68	0.70	0.48
Male	Mass	4411	59	4578	82	69	1.59	0.12

$\geq 5$  years of prior brood-rearing experience. Given this relationship, it was not surprising that the mean ages of gang brooders ( $6.6 \pm 0.4$  years) and parents of two-parent families ( $5.5 \pm 0.3$  years) were different ( $t_{158} = 2.06$ ,  $P = 0.04$ ). After I factored out brood-rearing experience by looking at the age at which adults raised goslings for the first time, there was no difference between the ages of gang brooders and parents of two-parent families (Table 1). The body masses of parents of two-parent families and of gang brooders were similar for both females and males (Table 1).

I identified 60 pairs of geese forming a gang brood for the first time and whose past brood-rearing experience I knew, along with that of the other parents in their gang brood (gang-brood cooperators). Half of their gang-brood cooperators had no prior brood-rearing experience, 18% had 1 year of experience, 18% had 2 years of experience, 10% had 3 years of experience, 2% had 4 years of experience, and 2% had 5 years of experience raising broods. Most (76%) of their gang-brood cooperators had never formed a gang brood before, 18% had formed a gang brood during one prior year, 3% during two years, and 3% during three years.

#### IS A GOOSE RAISED IN A GANG BROOD MORE LIKELY TO FORM A GANG BROOD AS AN ADULT?

I identified 27 geese that were raised in gang broods as goslings and survived long enough to produce goslings of their own; 15 of these (55%) raised their first goslings in gang broods. I also found 33 geese that were raised in two-parent families; 13 of these (39%) raised their first goslings in gang brood. These proportions were not significantly different from each other ( $\chi^2_1 = 1.56$ ,  $P = 0.21$ ). Over their entire lives, gang-brood goslings raised 50% of their own 44 broods in gang broods, while two-parent goslings raised 43% of their own 60 broods in gang broods. These differences also were not significant ( $\chi^2_1 = 0.45$ ,  $P = 0.50$ ).

#### DO GEESE FORM A GANG BROOD WITH THE SAME GANG-BROOD COOPERATORS FROM ONE YEAR TO THE NEXT?

I identified 49 pairs of geese (the subjects) that formed a gang brood during year 1 and both they and their former

gang-brood cooperators raised goslings at the same site during the subsequent year (year 2). During the second year, 28 subjects (57%) formed a gang brood with their former gang-brood cooperators. I also identified 49 other pairs of geese that raised goslings at the same site as a subject during both years 1 and 2 but did not form a gang brood with a subject during year 1 (i.e., they were gang-brood non-cooperators). During the second year, 22 subjects (44%) formed a gang brood with these former gang-brood non-cooperators. These proportions did not differ from each other ( $\chi^2_1 = 1.47$ ,  $P = 0.23$ ), indicating that a pair was as likely to form a gang brood with a former gang-brood non-cooperator as it was to form a gang brood with its previous gang-brood cooperator.

#### DO GEESE FORM A GANG BROOD WITH THEIR SIBLINGS OR PARENTS?

I identified 58 adult geese (i.e., the subjects of this test) that were raising goslings at the same time and place as one of their siblings were raising its own goslings; none of the 58 subjects (0%) formed a gang brood with its sibling. To determine if this proportion was lower than expected, I concomitantly identified for each subject another adult goose that (1) was raising its own goslings at the same time and same place that the subject was raising its goslings and (2) had been a gosling at the same year and place as the subject but had been raised in another brood (i.e., it was a non-sibling). Two of the 58 subjects (4%) formed a gang brood with a non-sibling. The proportion of subjects that formed a gang-brood with a sibling did not differ from the proportion that formed a gang-brood with a non-sibling ( $P = 0.50$ , Fisher exact probability test).

I also identified 58 adult geese (i.e., the subjects) that were raising their own goslings at the same time and place that at least one of their parents was raising its own brood. Only three (5%) of the subjects formed a gang brood with one of their parents. To determine if this 5% was higher than expected, I concomitantly identified for each subject another adult goose that (1) had raised its own goslings during the same year when the subject had been a gosling and (2) was raising its goslings during the same year and at the place where the subject was raising its goslings (i.e., it was not the subject's parent). Twelve subjects (20%) formed a gang brood with a non-parent goose.

This proportion (20%) differed from the 5% of subjects that formed a gang brood with a parent ( $\chi^2_1 = 5.69, P = 0.02$ ). This difference suggests that geese avoided forming a gang brood with a parent.

## DISCUSSION

I took several precautions to ensure that my data were independent and to avoid pseudo-replication. First, no subject was allowed to contribute more than one datum to a single category of data. Second, only one individual for each pair of geese could be used as a subject, and if a pair of gang brooders contributed to a data set, their gang-brood cooperators could not. Although these precautions reduced my sample sizes, I felt they were necessary.

At my study sites, about half of all goslings are raised in gang broods and half by two-parent families (Gosser and Conover 2000); this raises a puzzling question about gang brooding. If gang brooding is advantageous, why do not all geese do it? If it is disadvantageous, why should any do it? One explanation is that the costs and benefits of gang brooding counterbalance each other, so that the net benefits of raising goslings in gang broods are similar to the benefits of raising them in two-parent families (Kalmbach 2006). I hypothesize that the benefits and liabilities of gang brood primarily result from an increase in brood size and affect primarily gosling survival. The liability of a large brood is intra-brood competition among goslings for food. The benefit of a large brood is a reduction in the risk that any one gosling might fall prey to a predator due to both the dilution effect and an increase in predator vigilance resulting from the presence of multiple parents. If this hypothesis is correct, then gang brooding should be common where food is abundant. At my study sites, broods foraged primarily on golf courses and lawns. Lawns are optimal foraging areas for goslings because after mowing, the young, growing leaves tower over older leaves, making young leaves easy for goslings to find and harvest. Because they are less fibrous these young leaves are more nutritious and easier for a gosling to digest than mature leaves (Conover 1991). Hence, I predict that gang brooding is more common among urban–suburban populations of Canada Geese where there are numerous mowed lawns than in populations nesting where mowed lawns are unavailable.

In this study, I investigated why some adult geese form gang broods and others do not. One explanation is that gang brooding results from the accidental mixing of broods (Eadie et al. 1988, Kalmbach 2006). If this were true, I would expect gang brooding to be more frequent among inexperienced parents than experienced ones. However, I found the opposite: gang broods were rare among inexperienced parents but common among parents with five or more years of brood-rearing experience.

Another possibility is that gang broods are formed among extended family members, and some parents are unable to

form gang broods because they do not have family members at their brood-rearing sites. However, I found that a goose was as likely to form a gang brood with a non-family member as it was to form one with a parent or sibling.

The third possibility is that first-time gang brooders (naïve pairs) require a tutor (geese with prior gang-brooding experience) to learn how to gang brood, and the absence of tutors may deprive some parents of the opportunity to form a gang brood. However, I found that at least half of naïve pairs formed a gang brood with gang-brood cooperators that were equally naïve.

A fourth possibility is that gang brooders differ in some way from those that raise their goslings in two-parent families. However, I found that gang brooders were similar to other parents in characteristics such as body mass and age. They also did not differ in parentage (either learned or genetic). Geese raised in gang broods were no more likely to raise their own goslings in gang broods than geese raised in two-parent families.

Geese that raised their goslings in gang broods or two-parent families, however, differed in their brood-rearing experience. First, geese tended to use the same brood-rearing approach from one year to the next. That is, if a goose was a gang brooder one year, it was more likely to be a gang brooder during the next year it bred. This tendency to use the same brood-rearing approach in successive years was stronger when the original pair of adults stayed intact. A change in mates from one year to the next made it less likely that the same brood-rearing approach would be used in both years. Second, the number of years of brood-rearing experience had a major effect on which brood-rearing approach a goose used. Few geese (29%) formed a gang brood during their first year of raising goslings. However, 80% of geese with 5 or more years of brood-rearing experience raised their goslings in a gang brood. Perhaps this shift results because experienced parents are less wary of other parents or better able to recognize the benefits of gang brooding. They may also be better able to communicate their willingness to form a gang brood to the other parents at their brood-rearing site and to recognize when other parents are so inclined. These findings suggest that gang brooding is a behavior that Canada Geese learn as adults.

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