

*Wildlife Damage Management, Internet Center for
Wildlife Damage Management Conferences –
Proceedings*

University of Nebraska - Lincoln

Year 2000

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Evaluations of nicarbazin-treated pellets for reducing the laying and viability of Canada goose eggs

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Abstract: The number of Canada geese (*Branta canadensis*) nesting in the United States is increasing rapidly, generating more complaints and problems associated with them. Overabundant geese can be a nuisance, threaten human health and safety, and cause damage to property. Nicarbazin (NCZ), a coccidiostat used in chicken production, has been documented to reduce egg production and viability. The reduction of reproduction through the use of NCZ could be a valuable aspect of an overall integrated goose management plan. We conducted studies at 5 sites in Nebraska in spring 2000 to evaluate the efficacy of NCZ-treated pellets for reducing the laying and viability of the eggs of Canada geese. For mated pairs of captive geese, none of the eggs ($n = 20$) laid by treated pairs were viable while 16 of the 20 eggs (80%) laid by control pairs were viable. At a site where resident geese did not accept the treated bait very well, there was no difference in clutch size (4.7 eggs/clutch, SE = 0.47, $n = 27$) when compared to a control site (4.9 eggs/clutch, SE = 0.49, $n = 14$, $t = 2.02$, $P = 0.70$). There was also no difference in the number of nonviable eggs/clutch at the treatment site (0.81, $n = 45$) when compared to the control site (0.45, $n = 40$, $t = 2.29$, $P = 0.19$). At a site where resident geese did consume the treated feed, only 4 eggs were laid by 55 adult females. None of these eggs were viable. Our results suggest that, when female geese receive an adequate dosage, NCZ may reduce egg viability. Further, when they receive a higher dosage, egg production can be reduced or eliminated. From this, we believe that NCZ may have the potential to be a valuable tool in the management of overabundant resident Canada geese.

Key words: *Branta canadensis*, Canada goose, damage, nicarbazin, overabundant, reproductive inhibition, resident

The voice of Canada geese (*Branta canadensis*) has historically symbolized wildness, and still does - at least in the right context. Recognized as a valuable natural resource, Canada geese are welcomed and enjoyed, until they conflict with the interests and well-being of homeowners, airplane

travelers, and recreationists. Their adaptability, reproductive potential, and other physical and mental attributes have made geese as at home in big-city suburbs as they are in agricultural regions,

Urban and suburban development in

the US has increased dramatically in the last 20 years, resulting in the creation of habitat that is ideal for Canada geese. Geese thrive in open areas with manicured lawns in proximity to small bodies of open water, including airports, parks, golf courses, corporate complexes, and residential green-spaces. These geese can be a nuisance, threaten human health and safety, and cause damage to property. Geese denude lawns through their grazing and in the process leave large quantities of droppings and feathers behind. Heavy concentrations of droppings overfertilize lawns, contribute to excessive algae growth in lakes that can lead to fish kills, and have the potential to contaminate municipal water supplies (Kear 1963, Manny et al. 1994, Smith et al. 1999). When protecting nests Canada geese can be quite aggressive, threatening or attacking people and pets. There is also potential for geese to transmit diseases to humans and other species (Friend 1987). Another major concern is the growing number of geese that are involved in aircraft strikes. The greatest potential for strikes is during takeoff and landing with geese that are airport residents. These strikes often threaten human safety and can lead to costly aircraft repairs.

Resident Canada goose populations have high reproductive and survival rates. The number of geese nesting in the US is climbing very quickly, as are the complaints and problems associated with them. In the Mississippi fly way, the 1998 spring Canada goose population estimate exceeded 1.1 million birds, a 21% increase from 1997 (Tollefson 1999). In many cases, resident geese don't have a need to migrate, or migrate only as far as the nearest source of open water. Local, suburban populations can grow quickly as resident geese are provided with quality,

unexploited habitat that is virtually devoid of predators. Humans don't represent predators in these areas and they tolerate high goose densities, as hunting is usually not permitted in urban and suburban areas. Wildlife managers need additional tools to regulate goose populations in areas where hunting may not be practical.

New and innovative strategies are needed to protect the public and to manage the geese over both short and long temporal scales. Further, strategies are also needed on both local and landscape spatial scales. The use of nicarbazin (NCZ) to reduce hatching success could help in efforts to stabilize resident goose populations.

Nicarbazin has been used since the 1950s to control the disease coccidiosis in broiler chickens (Chapman 1994). When fed to laying chickens, NCZ was found to reduce egg viability. Nicarbazin breaks down the yolk membrane and causes a mixing of the egg yolk and white which prevents the egg from developing and ultimately, from hatching. When NCZ is no longer fed to chickens, it clears from the system in a few days and the eggs again become viable. The reduction of reproduction through the use of NCZ could be integrated into a goose management plan that includes other practices, such as: discontinuance of feeding, habitat management, exclusion, harassment, egg addling, egg oiling, hunting, and/or trapping and removal.

Our initial studies were designed to evaluate the efficacy of NCZ-treated pellets for reducing the laying and viability of the eggs of Canada geese. We hypothesized that female geese fed a pelleted ration impregnated with NCZ would produce smaller clutches and

fewer viable eggs than other female geese. To test our hypothesis with varying levels of control over the geese, we worked with 2 flocks of captive geese and 2 flocks of pinioned, resident geese on private lakes.

Study areas

Our studies were conducted at 5 sites in Nebraska. Geese were fed NCZ-treated pellets at 4 sites and untreated pellets at the other.

Captive breeder pairs, sites 1 and 2

To assess the effects of NCZ on egg laying and viability in a semi-controlled setting, we used privately-owned, breeding pairs of captive Canada geese at two sites in Nebraska, one in Lancaster County (Site 1) and the other in Adams County (Site 2). Both landowners had been actively breeding and raising Canada geese for >8 years.

Resident goose, site 3

The site encompassed a 28-ha privately-owned lake in Madison County, Nebraska. The lake was a low-lying basin fed by drainage and seepage. It had been managed to be a very suitable area for resident Canada geese. The lake and its associated wetlands provided excellent loafing and nesting habitat for a flock of about 60 free-ranging resident Canada geese that were pinioned (they were the property of the landowner). The landowner had established the geese on the lake over the previous 15 years. The lake was also used by migrant Canada geese. Migrants were only present in the fall and late winter, but about 40 wild geese had become residents of the lake and some were mated with pinioned birds. The

landowner stated that there are about 20 successful nests on the lake each year.

Resident goose, site 4

The site was a privately-owned 1-ha lake in Buffalo County, Nebraska. In the early 1900s gravel was extracted from the site, leaving the steep-sided, deep bowl which became a lake in the 1940s. The shoreline is sandy and unvegetated. The lake is bordered by a 2 ha grass field to which the geese had access. The landowner began establishing geese at the site in about 1960, and he had purchased and pinioned geese intermittently until 1997. Migrant geese used the lake in the fall and late winter, with numbers approaching 5,000 in March. The landowner stated that there were about 13 successful nests on the lake each year.

Resident goose control, site 5

To collect data from untreated geese for comparison with the results from the 2 treated- resident populations, we established a control site. The control site was located in Lancaster County, > 193 km from the resident-geese treatment sites. It consisted of portions of 2 state-owned lakes, one area encompassed about 32 ha and the other about 20 ha. Both lakes had nesting populations of resident Canada geese.

Methods

We conducted the study from January 2000 through May 2000. Geese at the treatment sites were fed extruded pellets produced by J. Brent, Department of Grain Science and Industry, Kansas State University. The pellets were approximately 7 mm long with a diameter of about 3 mm. Untreated

pellets consisted of about 43% corn, 29% soybean meal, 15% porcine meat and bone meal, 10% whole oats, 3% soybean oil, and 0.3% salt. Treated pellets consisted of the same proportions of ingredients plus 3% NCZ premix. Nicarbazin gave the treated pellets a pale yellow hue, so Yellow 5 and Blue 1 dyes were added to the untreated pellets to make them look similar to treated pellets.

We quantified the amount of feed consumed by individual geese by video taping them each day as they fed. Results from this aspect of the study will not be presented here.

Captive breeder pairs, sites 1 and 2

At each site, we randomly assigned pairs to treatment or control groups. Site 1 had 12 treatment pairs and 8 control pairs, and Site 2 had 3 treatment pairs and 1 control pair. The landowners primarily fed their geese Purina® Duck Grower (PDG). To acclimate the geese to our extruded feed, in January we began feeding them our untreated feed mixed with PDG. At both sites, all geese were penned together until 1 March. On 1 March, pairs were put in mating pens separate from other geese. Mating pens were 4 m x 4 m; about half of each pen was in standing water and each contained a nesting location. For the first 3 days (1-3 Mar) after being placed in mating pens, each pair was fed 60 g untreated feed and PDG ad libitum. From these data we determined that pairs required about 300 g feed/day. On 4 March we began feeding treatment pairs 60 g treated feed mixed with 240 g PDG. Treatment geese were fed the treated mix until they began to incubate or until 15 May, the end of the study. Control pairs received 60 g untreated feed mixed with 240 g PDG until the end of the study. Feed (treated and untreated) acceptance was poor

initially (geese selected for PDG and against our feed), so on 27 March we began crushing the feed before mixing it with the PDG. Geese consumed the feed more readily after it was crushed, probably because it was more difficult to distinguish and separate from the PDG.

The 300 g mixture was offered to each pair from 0800 one morning to 0800 the next. Any remaining mixture was weighed and the amount of feed consumed by each pair over the 24 hr period recorded. In April, we noticed that intake requirements increased for most pairs, so to be sure each pair got the amount of food it required, each afternoon we offered more PDG to those that had consumed the entire 300 g mixture. When any of the mix remained in the feeding dish the next morning it consisted only of the treated feed. By weighing the amount of treated feed remaining, and subtracting this amount from the initial amount (60 g), we determined the amount of feed ingested/pair/day. We divided by 2 to estimate the amount of feed ingested by the female.

To evaluate the palatability of NCZ, we compared the amount of treated feed ingested/female/day to the amount of untreated feed ingested/female/day. To assess the impact of NCZ on egg laying, the percentage of treatment pairs that laid ≥ 1 egg was compared to the percentage of control pairs that laid ≥ 1 egg. The average number of eggs/clutch was also compared between treatment and control pairs. To assess the impact of NCZ on egg viability, we candled each egg approximately two weeks after all the eggs in a clutch were laid. We then compared the percentages of nonviable eggs/nest for treatment and control pairs. We used a *t*-test to perform the above

comparisons. To gain insight into NCZ levels in the geese, we collected blood samples and eggs from some of the treated females. Data from the blood sample analyses will be compared to those found in other, more controlled studies (Clark et al. unpublished data, Miller et al. unpublished data) and will be reported in future publications.

Resident goose, site 3

Capture and Marking. Sixteen female, pinioned geese were captured with a cannon net and 11 were captured in a drive trap. They were fitted with #8 blue plastic tarsal bands (Haggie Engraving, Crumpton, Maryland, USA). Each band was engraved with a unique three letter code.

Feeding Site and Consumption. Through years of being fed by the landowner in same manner, the flock was accustomed to feeding at the same site each day. To get the geese acclimated to our feed, we began feeding untreated feed, mixed with their usual ration of corn, on 20 January. From 3 March-17 April we fed NCZ-treated feed. We observed feeding geese from a parked vehicle, using a spotting scope and binoculars to identify marked birds. The feeding site was monitored daily during peak feeding periods, for 1-1.5 hrs in the morning and 2-2.5 hrs in the evening. Early in the study we monitored the site throughout the day, but ceased doing so because few geese visited the site during mid-day.

Egg laying and viability . To assess the effect of NCZ on clutch size, we compared the average number of eggs/clutch at the site to the average number of eggs/clutch at the control site. There was a possibility that NCZ would delay egg laying, so we also compared

the number of clutches that had hatched by 2-3 May between this site and the control site. We also compared the percentage of nonviable eggs/clutch at the site to the percentage of nonviable eggs/clutch at the control site. T-tests were used for these comparisons. To test for relationships between the distance from nests to the NCZ feed site and the two variables, number of eggs/clutch and percentage of nonviable eggs/clutch, we used a Pearson correlation analysis (SAS 1996).

Throughout the study we located nests and monitored them, recording numbers of eggs in each clutch and the date of incubation initiation. On 3 May, we candled each remaining egg in every nest to assess egg viability. If the clutch had already hatched, any remaining eggs were deemed nonviable. Some eggs were collected and submitted to the Chemistry Section at the National Wildlife Research Center in Fort Collins, CO and tested for the presence of NCZ.

Resident goose, Site 4.

Capture and marking. The last time the landowner had banded and pinioned geese on the site was in the fall of 1997. We, therefore, could be sure that any banded-female goose we captured was at least 2 years 9 months old and was a permanent resident of the lake. These were the geese we targeted. Geese were captured in a 3.6 m x 10.9 m catch pen constructed of 1.2 m x 2.4 m fence panels and topped with netting. Upon capture, the geese were fitted with individually-coded #8 tarsus bands (Haggie Engraving, Crumpton, Maryland, USA¹).

Feeding site and consumption. The landowner had been feeding the geese for

several years, and they were already habituated to feeding at a specific site. In mid-January we began feeding untreated feed mixed with the usual ration of corn the geese were currently being fed. A larger percentage of our feed was progressively fed, so that by 28 February the feed ratio was about 90% pellets and 10% corn. The geese soon relied on our feed for a major portion of their daily food intake (they had previously been fed in a manner very similar to this). On 3 March, we continued to follow the same protocol, only substituting treated pellets for untreated pellets. We continued feeding treated feed daily until 14 May. To document which banded females visited the site, we monitored the site for >2 hrs after the initial feeding each day.

By 27 March, geese had virtually ceased ingesting the NCZ-treated pellets. Birds would sort through the broadcast mixture of treated pellets and whole corn, effectively selecting for whole corn and against the pellets. Often they would pick up and manipulate a pellet in their bill before rejecting it. On 28 March, in an attempt get geese to ingest treated feed, a known amount of treated pellets were crushed and mixed with cracked corn. The mixture was divided and offered in 5 feed pans. The following morning the amount of treated feed remaining was determined. Though geese selected for the cracked corn, when fed in this manner, they also inadvertently ingested some of the crushed, treated pellets. After 24 hrs there were always pellets, but seldom any corn, remaining in the offered mixture. Geese could not be fed the bait exclusively because it was not nutritionally complete. The average number of geese that fed at the site each day was estimated by determining the number of resident geese on the lake and multiplying this

value by the average percentage of the banded population that visited the site each day. The amount of feed consumed/individual was estimated by dividing the number of geese that fed by the amount of feed consumed. We had to assume that each individual that visited the bait site ate its fill, and that all ingested the same ratio of feed to corn (that the first to arrive at the site each morning, and dominant individuals, did not ingest more corn than other geese).

Egg laying and viability. The resident geese historically nested either in floating nest structures or along the lake's perimeter. We had intended to follow the same procedure to assess the efficacy of NCZ as outlined for Site 3, but only 1 goose nest was established at Site 4. Even after the feeding of treated pellets ceased on 14 May, no nests were established.

On 15 May, to determine the level of NCZ in the systems of geese, as many marked geese as possible were recaptured in the catch pen and blood samples were collected. Samples were submitted to the Chemistry Section of NWRC to be analyzed for NCZ content.

Results Captive

breeder pairs, sites 1 and 2

At both study sites, the number of sample pairs available for assessing egg laying and viability was less than expected, due to uncontrolled reasons (i.e., selling of geese prior to study initiation, an abnormally dry spring that led to low water levels and resulted in a reduced number of breeding pens, landowners simply not having the number of established breeding pairs that they initially

portrayed). In the end, we obtained data for 7 treatment pairs and 4 control pairs that could be used for assessing egg laying and viability when we combined the data for the two sites. However, we were able to obtain data for 12 treatment and 8 control pairs for examining consumption data, because having true pairs was not as critical.

Geese preferred PDG to the feed (treated and control). Even when the feed was cracked and mixed with PDG, geese sifted through the mix and consumed mainly PDG. When there was <60 g of mix left in a feed pan, it was always the only feed left. To assess the palatability of NCZ, we compared consumption of treated and untreated feed. Geese on treated feed consumed significantly less than those on untreated feed ($t = 1.98$, $P = 0.00$), suggesting that NCZ has an off-flavor. The average amount of treated feed consumed/female goose/day was 18 g (SE = 1.5). The average amount of untreated feed consumed/female goose/day was 23 g (SE = 1.5).

Two of the 7 pairs of geese on the treatment feed laid no eggs, while all 4 of the control pairs laid ≥ 4 eggs. Clutch size averaged 2.9 eggs (SE = 0.88) for treated pairs and 5 eggs (SE = 0.41) for control pairs, but this difference in clutch size was not statistically significant ($f = 2.26$, $P = 0.12$). However, none of the 20 eggs laid by treated pairs were viable, while 16 of the 20 eggs (80%) laid by control pairs were viable. Sixteen eggs were collected from the 5 treated pairs that had laid eggs; NCZ levels in these eggs averaged 2.16 ug/g (SE = 0.97) and ranged from 0-10.2 ug/g. Blood samples were taken from 3 of the treated female geese; NCZ levels averaged 1.23 ug/ml (SE = 0.57) and ranged from 0.66-2.38 ug/ml.

Resident geese, site 3

Feeding site and consumption. The geese were offered ≥ 1.2 kg of treated feed/day from 7 March - 24 April. The amount offered was dictated by the amount of feed consumed the previous day. Initially, it was necessary to mix a small amount of corn with the feed to entice the geese into the feeding area. Marked geese would not visit the feed site every day, and as the study continued, fewer and fewer geese visited the feed site at all. When they did visit, they would feed in several short bouts over the course of about 5 min. From our estimate of the amount of NCZ feed necessary to impact egg laying and viability, no geese seemed to have visited the site consistently enough, or consumed enough feed, to have been affected. Though some geese may have visited the feeding site when observers were not present, we knew very little feed was being consumed because we weighed the feed at the site each morning and evening.

Egg laying and viability. We located 45 nests containing ≥ 1 egg. Most nests were established in man-made structures on shore, floating platforms, or on posts. Natural nests were found along the shore. Clutch size averaged 5.0 eggs (SE = 0.32, $n = 45$) and ranged from 1-9 eggs/clutch. Most of our banded birds seemed to have disappeared from the study site, even though they were pinioned. We only found nests of 3 of the banded females. These three nests had clutches of 3, 6, and 8 eggs. None of the banded females that occupied these nests had received an adequate dosage of NCZ.

Forty-four percent of the nests (20 of 45) were abandoned or suffered at least partial predation. Viability of the eggs at these nests

could not be assessed. Clutch size of abandoned nests was variable (\bar{x} = 3.6, SE = 0.19, range = 1-7).

There was no difference between clutch sizes of this treatment site and the control site ($t = 2.02$, $P = 0.70$). The treatment site averaged 4.7 eggs/clutch (SE = 0.47, $n = 27$) while the control site averaged 4.9 eggs/clutch (SE = 0.49, $n = 14$). There was also no significant difference ($t = 2.02$, $P = 0.75$) in the percentage of clutches that had hatched by 2-3 May. Sixty-two percent (SE = 0.14, $n = 13$) of treatment clutches had hatched compared to 56% (SE = 0.55, $n = 31$) of control clutches. The number of control nests in this analysis had to be reduced because the clutches that had hatched were not included. This was because we could not confidently determine how many eggs each nest had originally contained. We also did not include abandoned and predated nests in this analysis. Although the mean number of nonviable eggs/nest at the treatment site (0.81, SE = 0.23, $n = 45$) was greater than the mean number of nonviable eggs/nest at the control site (0.45, SE = 0.16, $n = 40$), the difference was not statistically significant ($t = 2.26$, $P = 0.19$).

We found a weak inverse correlation between the measured distance from feed site and clutch size ($r^2 = -0.38$, $P = 0.05$). We found no relationship between distance from feed site and percentage of nonviable eggs/clutch ($r^2 = -0.05$, $P = 0.82$). Evidence for the potential effectiveness of NCZ was provided at two nests that were <30 m from the feeding site. Only 1 of 7 eggs hatched at one nest and only 2 of 7 eggs hatched at the other. For the 8 unhatched eggs from these nests, our analysis indicated that 4 contained NCZ ($\bar{x} = 4.56$ ug/g, SE = 1.46 ug/g, range =

0.26-6.62 ug/g).

Resident geese, site 4

The total population of flightless-resident geese on the lake was about 105 birds, but the exact population fluctuated as individuals would occasionally leave the lake and return days later. Until mid-April, the lake was also used by migratory geese. Migrants occasionally numbered as high as 5,000. Though migrants were present during the experiment, they did not feed at the bait site, preferring to fly from the lake and feed in nearby agricultural fields.

Feeding site and consumption. Of the 47 banded female geese, on average 79% (SE = 0.01) visited the feeding site each day. Assuming the same percentage of unbanded geese visited the feeding site daily, of the 105 geese in the resident population, about 83 were on the site each day. The average amount of treated feed consumed each day was 3.78 kg (SE = 0.28). Therefore, the average dose/goose/day was about 45.5 g of treated feed. However, there were about 10 resident, nontarget birds (white-fronted geese, snow geese, mallards, and coots) that also consumed some of the feed each day. Assuming these non-target birds consumed about the same individual amounts as the geese, the corrected consumption/individual goose was 40.6 g/day.

Egg laying and viability. As of 14 May only 4 eggs had been laid by the entire population of resident geese. None of the eggs were viable. A domestic/Canada hybrid goose laid 2 eggs and began incubating them on 14 April; she abandoned the nest on 31 April. The other 2 eggs were laid approximately 2 weeks apart from each other

in the same nest structure, probably by the same goose.

Although the vast majority of geese did not lay any eggs, they did exhibit breeding and nesting behaviors. We observed pair-bonding, territorial, mating, and nesting behaviors daily from 20 March through 14 May, when we ceased daily monitoring. In fact, a pair was observed breeding on 14 May. Females were often observed in nest structures for hours at a time. It often appeared that they were incubating when in fact they had laid no eggs.

On 15 May, blood samples were taken from 16 of the marked female geese. Chemical analyses revealed that levels of NCZ in the geese averaged 1.09 ug/ml (SE = 0.26, range = 0.05-3.47). It should be noted that we had shifted the feeding site toward and into a catch pen a few days prior to our collection of blood samples. This could have had the effect of depressing the levels of NCZ at the time of sample collection.

Discussion

These studies represent our initial attempts to quantify the reproductive effects of NCZ on nesting Canada geese. Results from our study with captive Canada geese suggested that NCZ reduced egg production and egg viability. In one study with resident Canada geese, acceptance of the treated feed was poor. A rejection of the feed and green-up spring grasses, a preferred food, were the main reasons why the geese did not frequently visit the feeding site. No difference was found in the number of nonviable eggs/nest between this site and the control site. However, a weak inverse correlation was found between the distance of nests from the feeding site and the

number of viable eggs/clutch. In another study with pinioned residents, we were able to coerce geese to consume high doses of NCZ-treated pellets. Very few eggs were laid, suggesting that NCZ consumption may have been enough to eliminate egg laying for most birds. Further, none of the eggs laid at the site were viable.

Management implications and future directions

Results from our studies with captive and resident Canada geese suggest that NCZ may reduce egg production and viability. Also, no toxicity effects were observed in any of the studies. Reproductive inhibition via NCZ, therefore, has the potential of playing an important role in resident goose management programs. Further research is needed to more accurately determine NCZ impacts on egg laying and viability, to determine dosage requirements, to develop a more palatable feed, and to improve delivery methods. More research studies are also needed on the movements, demographics, and ecology of urban Canada geese. This would help in measuring the impact of factors such as predation and nest abandonment in efficacy studies.

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