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Feasibility of Administering an Oral Reproductive Inhibitor to Resident Canada Geese

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Abstract: We evaluated our ability to deliver adequate daily doses of the reproductive inhibitor, nicarbazin, to individually marked resident Canada geese (*Branta canadensis*). We also evaluated the efficiency of nicarbazin in reducing egg hatchability. The study was conducted prior to and during the egg-laying period at a wildlife sanctuary that has a large, problem-causing population of resident geese that were accustomed to being fed by people. Twenty-eight adult females were marked with individually identifiable neck collars, 24 of which were affixed with radio transmitters. Grit pellets and gelatin capsules containing nicarbazin were fed to these geese from March 17, 2001 through April 26, 2001. We attempted to deliver doses to geese each day. Doses varied among geese throughout the study and within geese daily because all geese were not present at the site each day, and even if present they accepted the bait to varying degrees. Seven of our target birds did receive what we believed to be adequate doses of nicarbazin. We documented that only about 11% of the resident population nested at the sanctuary, while the others nested in remote areas. We were able to locate 5 nests of birds that received adequate doses, but found no significant effect of nicarbazin on the hatchability of their eggs compared to untreated geese. We found that the biggest challenges to orally-fed reproductive inhibitors include the palatability of bait relative to other food sources, reduced feeding during the breeding period, and movements and territoriality associated with nesting.

Key Words: *Branta canadensis*, Canada geese, wildlife damage, nicarbazin, overabundant, reproductive inhibition, resident geese

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INTRODUCTION

Canada geese (*Branta canadensis*) are often welcomed and enjoyed, until they conflict with the interests and well being of homeowners, airplane travelers, and recreationists. As a result of their adaptability and reproductive potential, geese are as at home today in big-city suburbs as they are in agricultural regions or remote wetlands.

Urban and suburban development in the U.S. has increased dramatically during the last 20 years, resulting in the creation of ideal habitat for Canada geese. Geese thrive in large open areas with manicured lawns in proximity to open water, including parks, golf courses, airports, corporate complexes, and residential green-spaces (Smith et al. 1999). These geese can be a nuisance, threaten human health and safety, and cause damage to property. Geese denude lawns through their grazing while leaving large quantities of droppings and feathers behind. Heavy concentrations of droppings over-fertilize 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 they 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 (Dolbeer 2000). The greatest potential for strikes with geese that are airport residents is during takeoff and landing of airplanes. These strikes threaten human safety and lead to costly repairs.

Resident Canada goose populations have high reproductive and survival rates. The number of geese nesting in the U.S. is climbing very quickly, as are the complaints and problems associated with them. Throughout the U.S., resident populations of Canada geese increased at a mean annual rate of 13.1% from 1966 to 1998 (Sauer and Link 1999). In the central U.S., the breeding population increased from a few thousand geese in 1965 to over one million in 1996 (Wood et al. 1996). In the Mississippi flyway alone, the 1998 spring Canada goose population estimate exceeded 1.1 million birds, a 21% increase from 1997 (Tollefson 1999). In many cases resident geese do not need to migrate, or migrate only as far as the nearest source of open water. Small populations can grow quickly as locally breeding geese are provided with quality, unexploited habitat that is virtually devoid of predators. Humans do not represent predators in these areas, but good neighbors, 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.

The use of nicarbazin (NCZ) to reduce hatching success could aid in the stabilization of resident goose populations. Nicarbazin has been used since the 1950s to control the disease coccidiosis in broiler chickens. Researchers found that when fed to laying chickens, the hatchability of the eggs was reduced (Jones et al. 1990a,b). Nicarbazin affects the egg yolk, breaking down the yolk membrane and resulting in the mixing of the egg yolk and white, preventing an embryo from developing and the egg from hatching. When the feeding of NCZ is ceased, viable eggs are produced again in ~4 days (L. Miller, USDA NWRC, unpubl. data). NCZ is broken down within the body and is not transmittable through scat to non-target species.

The reduction of reproduction through the use of NCZ could be a valuable tool for an overall integrated goose management plan that incorporates other practices, such as discontinuance of feeding, habitat management, exclusion, harassment, egg addling, egg oiling, hunting, and trapping and removal. The goal of our study was first to evaluate the effectiveness of administering adequate daily doses of NCZ to free-ranging resident Canada geese. Second, we wanted to assess the effectiveness of NCZ in reducing egg hatchability.

STUDY AREA

We studied the Canada goose population at the Bay Beach Wildlife Sanctuary (BBWS) at the southern-most point of the Bay of Green Bay, Lake Michigan (44° 32' N, 87° 58' W). The BBWS is situated in Brown County, Wisconsin in the City of Green Bay (Figure 1). Being well situated on the Mississippi Flyway, BBWS is ideally located to serve as a waterfowl refuge, mainly for Canada geese, mallards (*Anas platyrhynchos*), and American black ducks (*Anas rubripes*) (Shine 1956). Other species of waterfowl use the sanctuary in fewer numbers, including lesser scaup (*Aythya affinis*), redheads (*Aythya americana*), canvasbacks (*Aythya valisineria*), common mergansers (*Mergus merganser*), northern pintails (*Anas acuta*), and bufflehead (*Bucephala albeola*).

The BBWS put forth great effort to establish the resident flock of Canada geese and mallards (Shine 1956, Jacobs et al. 1980). In 1938, 6 Canada geese were donated to the sanctuary, with an additional 3 the following year. The BBWS produced its first goslings in 1941 from the donated pairs and these are the presumed ancestors of the present goose flock (Jacobs et al. 1980). The BBWS became one of the first areas in the U.S. to establish a flock of resident Canada geese. Geese were banded for the first time at the BBWS during the summer of 1965 (*n* = 165) (Jacobs et al. 1980). Banding continued every year and, as the resident

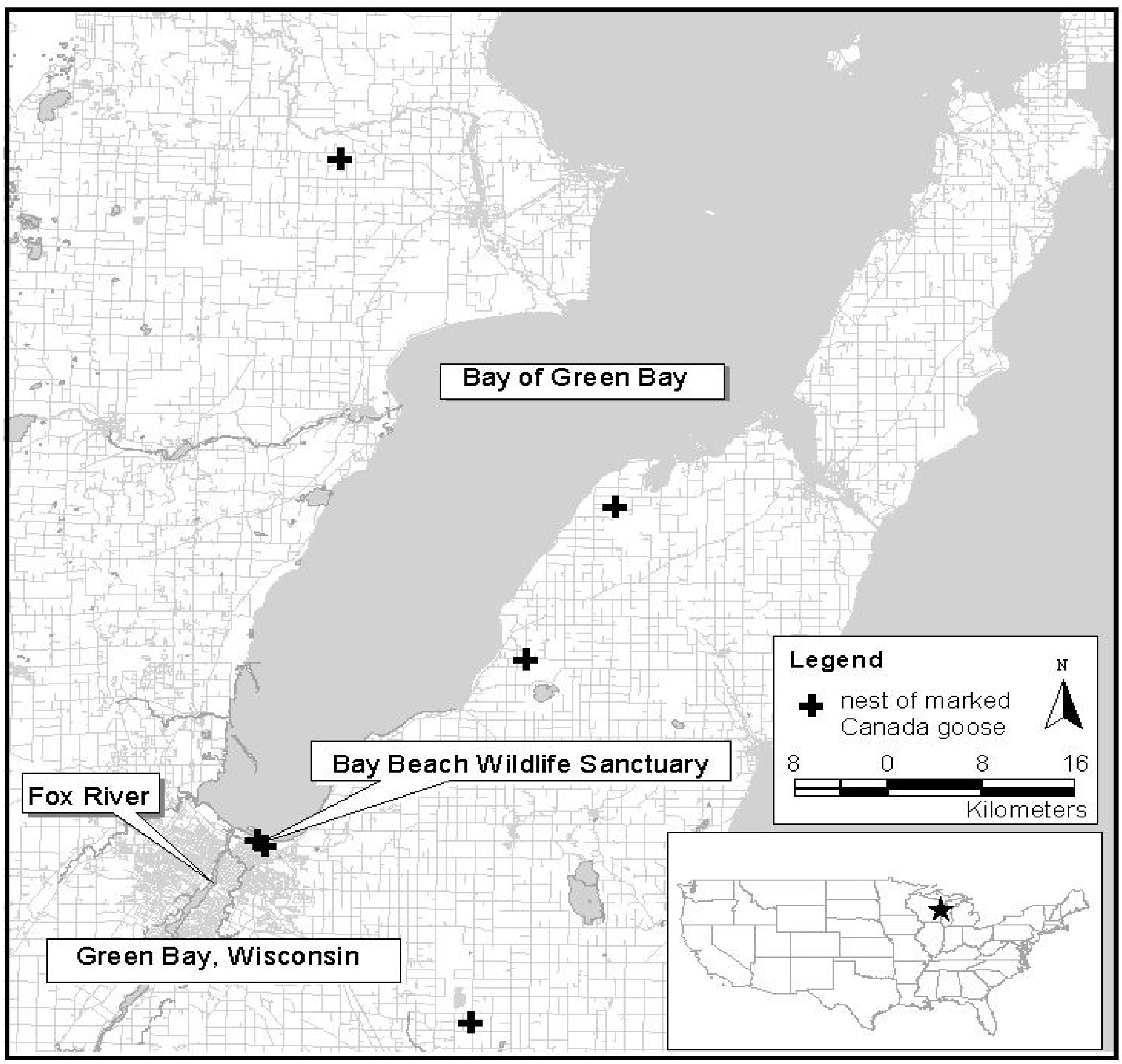

Figure 1. Location of study area and nests of marked Canada geese, Green Bay, Wisconsin, 2001.

flock increased in number, the goslings began to be shipped across the country to other refuges desiring to establish a resident goose flock. In 1999, for the first time, BBWS was unable to find any place in the country that would take their excess goslings.

The 285-hectare BBWS includes a series of contiguous lagoons with 4.83 km of shoreline and a main observation pond with 0.65 km of shoreline (Jacobs et al. 1980). The source of water for the lagoons is annual precipitation, snowmelt, run off, and groundwater from 3 wells. The lagoon water level can be manipulated by a whistle-tube and culvert drain system, which allows water to flow through a storm sewer system (via pumps) to Fox River where it ultimately flows into the Bay of Green Bay. The water quality at the sanctuary has severely declined because of the high numbers of waterfowl using the lagoons (T. Baumann, pers. comm.). Of the 9 fish species inhabiting the waters of BBWS in 1979, only the black bullhead (*Ictalurus melas*) and fathead minnow (*Pimephales notatus*) remain (T. Baumann, pers. comm.).

METHODS

Capture and Marking

Canada geese were arbitrarily selected and captured prior to and during the nesting period. Prior to the nesting period we captured 11 adult female geese with cannon nets on two separate occasions and locations within the sanctuary. Additional geese were caught prior to the nesting period by luring them close by feeding, and grabbing them by hand at the base of their wings (n = 17). Catching geese by hand proved to be quite efficient because we could target geese displaying female behaviors. Hand captures took place throughout several days and at different locations.

Once captured, we determined the sex of the each goose by cloacal examination (Hochbaum 1942). We placed 27 individually identifiable neck collars on adult female Canada geese from 5 February - 29 March 2001. Of these, 24 were equipped with radio-transmitters (Holohil Systems Limited, Carp, Ontario). The transmitters were necessary to track the geese and to locate their nests.

Of the 3 marked geese that were not outfitted with transmitters, one had a wing injury and was incapable of flight, so we felt confident we would be able to locate her nest. The other 2 were subadults, so it was not very likely that they would produce a clutch that season. One previously collared female goose was present at BBWS and was included in our study, bringing our sample to 28 adult female Canada geese.

Dosing

Marked geese were located daily prior to and during the baiting period using telemetry and visual observation. By keeping daily records on the presence of each individual bird at BBWS, we could determine the percentage of days marked geese were present and therefore available to be dosed with NCZ. Once a collared goose was located, we would approach and attempt to feed clean, untreated corn to it and the other geese in the area. When we were relatively close to the marked goose and it was feeding predictably, we started to lead the unmarked geese away from the target goose. We accomplished this by tossing corn on both sides of the target goose. The flock would part in the middle, leaving the target goose mostly isolated from the others. Next we offered doses of treated feed to the marked goose if the other geese were perceived to be not able to intercept. We recorded the dose received by each goose every day, as well as any failed attempts that were intercepted by other geese or rejected by the target female.

The NCZ was administered in the form of gelatin capsules and grit pellets. The capsules served as a bolus dose of NCZ, immediately being dissolved in the stomach and entering the blood stream. The grit pellets were designed to be retained in the gizzard for a few days and slowly release NCZ, providing a chronic dose to the goose. The concentration level of NCZ to be effective as a reproductive inhibitor was found to be ~1.0 ug/ml blood (VerCauteren et al. 2000). In order to achieve this concentration level, we designed a daily dose to be at least 1 capsule and 2 pellets daily, resulting in an approximated dose of 500 mg/day.

We originally planned on delivering the bait by hiding the pellets and capsules within dough balls of soft bread. However, the geese at BBWS were only accustomed to eating corn, which was fed daily by the public. It took several days prior to our baiting period to get the birds to recognize the bread balls as food. Most target geese did eventually accept bread balls, so our original baiting strategy could be implemented. One positive effect of this was that most unmarked geese did not recognize the bread as food and would not try to intercept. However, not every collared goose would readily feed on bread. Also, occasionally a bread ball would break apart when tossed to a goose or the goose would it break apart and reject the NCZ pellets and capsule before ingesting the bread.

Since hiding the NCZ in bread balls was not always effective, we developed another delivery method. As the geese fed on corn normally and readily, we disguised the NCZ pellets by inserting them in individual corn kernels. We found that by drilling a hole through the kernel and by keeping the pellet in place with a dab of peanut butter, the resulting product proved to be quite efficient. The baited corn did not break apart when tossed to target geese and they would swallow the kernel whole. The method also worked well when a target goose was feeding in water; the kernels would slowly sink and retain the NCZ, whereas as bread ball would sink quickly and break apart.

Each collared goose that was present at BBWS was treated daily, from prior to the nesting season (17 March), to the date on which that particular goose stopped laying eggs and started incubation (last goose dosed on 26 April). The time required to dose individual geese was highly variable. On some occasions, a goose would start feeding right away and receive a dose of NCZ within 1 minute. Other times, particularly for geese that were not always present at BBWS, it took up to 30 minutes for the goose to accept the bait. If a goose did not accept the bait within 30 minutes, it was left alone and we would return to try again later and repeat the process until it ingested the target dose or left the sanctuary.

Nest Monitoring

In mid-March the geese at BBWS began displaying mating behaviors and pairing. Pairs also began to isolate themselves from the rest of the flock and we began to observe more geese in the areas restricted to public access and less activity on the common feeding areas. At this point, we began to monitor breeding, nesting, and egg laying activity.

Daily observations became more difficult and telemetry was often required to locate transmitter-equipped geese. The majority of the lagoons at BBWS are not accessible to the public, and the shores were ideal for goose nesting. Shorelines were intensively searched for goose nests every day. Once a nest was found, whether it belonged to a marked goose or an unmarked goose, its location was recorded using a Garmin Model 12XL global positioning system (Garmin Corporation 1998). All located nests were coded and revisited throughout the nesting period to record their status, including data on male and female presence/ absence and behaviors, number of eggs in nest, condition of the nest, hatching date, viability (both expected via candling >14 days into incubation and the actual number hatched), and other notable observations, such as predation.

Egg Hatchability

As our study site was in an uncontrolled setting, predation occurred at several nests ($n = 7$) of both treated and untreated geese. Therefore, we could not simply compare the numbers of eggs that hatched for treated geese and untreated, or control, geese. To evaluate the efficiency of NCZ in reducing egg hatchability, we compared (A) the proportion of unhatched eggs/total eggs in the nest at the time of hatching using a Mann-Whitney test (Gibbons 1976). Also, geese occasionally ($n = 11$) ejected an egg from their nest during the incubation period. It is possible that geese can sense if an egg is not viable, stimulating them to eject the egg. To address this assumption, we also compared (B) the proportion of unhatched eggs/total eggs in the nest at the time of hatching, including the ejected eggs as unhatched.

Because predation rates were different for those nests within the WLS compared with nests off the sanctuary, we conducted three separate sets of Mann-Whitney tests: (1) comparing only nests within the BBWS, (2) comparing only nests found off the BBWS, and (3) comparing all the nests found, regardless of location. Each test used a dependent variable that expressed the proportion of unhatched eggs. Results were considered significantly different when $P < 0.05$. We used SYSTAT® Version 9 (SPSS Incorporated 1998) for all analyses.

RESULTS

Nest Locations

Because the majority of geese did not remain at BBWS as anticipated, finding nest locations of marked geese proved to be difficult. We were able to locate the nests of 33.3% ($n = 8$) of the transmitter equipped and 25% ($n = 1$) of the nests of geese without transmitters. The nest site selections of the geese were highly variable, ranging from pristine (e.g., middle of an extensive cattail marsh) to highly degraded (e.g., steep hillside of ash in an industrial area of the City of Green Bay). The distances of the nests from the sanctuary were also highly variable. Only 3 of the marked geese nested within the sanctuary (10.7%), 2 nested within the City of Green Bay (7.1%), and the remaining nests ($n = 4$) were 25-61 km from BBWS (Figure 1).

Dosing

Target geese were present at BBWS, and therefore available to receive doses of NCZ, to varying degrees throughout the baiting period (range = 0-36 days) (Table 1). This, combined with varying degrees of bait acceptance by the birds ($\bar{x}$= 72.2%, SD = 29.6) (Table 1), resulted in 3 categories of treatment levels for the geese. Seven of the marked geese (25%) were present at BBWS and accepted the bait consistently enough to reach the predicted blood concentration where NCZ would reduce reproductive success. Four marked geese (14.3%) received NCZ doses inconsistently, but often enough to possibly be effective. Seventeen geese (60.7%) were either not present or did not accept the bait consistently enough to reach the effective level (Table 2).

Egg Hatchability

We were able to locate the nests of 5 of the 7 geese that received adequate doses (Table 2); these geese represented our sample of treated birds (Table 3). All 3 marked geese that nested within the sanctuary received adequate doses of NCZ. We were unable to locate the nests of the 4 marked geese that received doses that may have been adequate (Table 2). Geese making up the untreated, or control, sample were marked birds that did not receive adequate doses of NCZ ($n = 4$) (Table 2) or unmarked BBWS resident goose nests ($n = 28$) (Table 3).

Though treated geese received doses that were presumably adequate, the proportion of unhatched eggs of treated geese was not significantly different than the proportion from untreated geese regardless of location (A: $U = 69.0$, $p = 0.689$; B: $U = 79.5$, $p = 0.429$). We also found no difference between the hatchability of eggs for nests within BBWS (A: $U = 29.5$, $p = 0.852$; B: $U = 32.0$, $p = 0.933$) or nests off the sanctuary (A: $U = 5.0$, $p = 0.480$; B: $U = 6.0$, $p = 0.273$).

DISCUSSION

Although other studies (VerCauteren et al. 2000; K. C. VerCauteren, unpublished data; C. Yoder, unpublished data) have demonstrated that NCZ does have the potential to reduce egg production and egg viability, it had no effect in our study. Our sample of treated birds produced viable eggs, despite being dosed with NCZ. One reason for this may be that the NCZ grit pellets were not retained in the gizzards as anticipated. If the gizzard of a goose we were attempting to dose already contained a sufficient amount of grits for normal breakdown of food, our NCZ grits may have simply passed

Table 1. Nest and nicarbazin (NCZ) dose data for 28 marked Canada geese, Green Bay, Wisconsin, 2001.

	n	%
Nest Located	9	32.1
Nest Not Located or Did Not Nest	19	67.9
Received Adequate Dose of NCZ	7	25.0
Possibly Received Adequate Dose of NCZ	4	14.3
Did Not Receive Adequate Dose of NCZ	17	60.7
Adequate NCZ and Nest Located	5	17.9
Possibly Adequate NCZ and Nest Located	0	0.0
Not Adequate NCZ but Nest Located	4	14.3
Adequate NCZ but No Nest	2	7.1
Possibly Adequate NCZ but No Nest	4	14.3
Not Adequate NCZ and No Nest	13	46.4

Table 2. Dosing of target geese at Bay Beach Wildlife Sanctuary, Green Bay, Wisconsin, 17 March - 26 April, 2001.

Goose ID	Days Available to Receive NCZ	Days Receiving Target Dose	Bait Acceptability (%)	Received Predicted Effective NCZ Level
05xm	0	0	NA	NO
06xm	15	3	20.0	NO
08xm	36	19	52.8	POSSIBLY
22xm	0	0	NA	NO
24xm	16	15	93.8	YES
26xm	0	0	NA	NO
28xm	2	2	100.0	NO
29xm	1	0	0.0	NO
31xm	2	1	50.0	NO
32xm	1	1	100.0	NO
33xm	0	0	NA	NO
35xm	0	0	NA	NO
36xm	0	0	NA	NO
37xm	32	20	62.5	POSSIBLY
41xm	15	15	100.0	YES
42xm	5	5	100.0	POSSIBLY
43xm	0	0	NA	NO
45xm	7	7	100.0	POSSIBLY
47xm	28	23	82.1	YES
49xm	0	0	NA	NO
50xm	0	0	NA	NO
53xm*	30	22	84.6	YES
55xm	7	4	57.1	NO
57xm	0	0	NA	NO
61xm*	26	8	88.9	YES
63xm	13	12	92.3	YES
70xm	2	1	50.0	NO
51hk*	35	17	65.4	YES
$\bar{x}$	9.8	6.3	72.2	
SD	12.6	8.0	29.6	

*Marked geese without radio-transmitters

Table 3. Nest and egg data for treated and control geese on and off Bay Beach Wildlife Sanctuary (BBWS), Green Bay, Wisconsin, 2001.

	Treated Geese									Control Geese								
	On BBWS (marked)			Off BBWS (marked)			Total			On BBWS (unmarked)			Off BBWS (marked)			Total		
	n	$\bar{x}$	*SD*	*n*	$\bar{x}$	*SD*	*n*	$\bar{x}$	*SD*	*n*	$\bar{x}$	*SD*	*n*	$\bar{x}$	*SD*	*n*	$\bar{x}$	*SD*
Nests	3			2			5			28			4			32		
Eggs Laid	20	6.7	0.6	10	5.0	1.4	30	6.0	1.2	138	4.9	2.2	20	5.0	0.8	158	4.9	2.1
Eggs Predated	4	1.3	2.3	0	0.0	0.0	4	0.8	1.8	19	0.7	1.6	0	0.0	0.0	19	0.6	1.5
Eggs Ejected	2	0.7	0.6	0	0.0	0.0	2	0.4	0.5	12	0.4	0.8	2	0.5	1.0	14	0.4	0.8
Unhatched Eggs	3	1.0	1.0	0	0.0	0.0	3	0.6	0.9	30	1.1	2.0	1	0.3	0.5	31	1.0	1.9
Eggs Hatched	11	3.7	2.1	10	5.0	1.4	21	4.2	1.8	77	2.8	2.4	17	4.3	0.5	94	2.9	2.3

through. It is also possible that the geese were regurgitating the NCZ grits before they were completely dissolved, not allowing enough time for the proper amount of NCZ to enter their system.

If the NCZ grits were not functioning as planned, our geese were not receiving a chronic dose of NCZ. In the VerCauteren et al. (2000) study, the geese were confined in pens and the NCZ (in powder form) was mixed in with their only food source. Therefore, these geese had no other choices but to receive a chronic dose of NCZ or starve. But because of the many non-target species present at BBWS, our geese had to be individually dosed.

There were many challenges to using NCZ as a Canada goose management tool in a natural setting. The most significant hindrance was our inability to deliver adequate daily doses to individual geese. It would be more feasible and less time consuming if the reproductive inhibitor required only 1 or 2 doses prior to the nesting period to be effective, as opposed to a daily dose from $\geq$ 5 days before the first egg is laid until incubation is initiated.

By late March into early April the snow began melting and exposing patches of fresh green grass. At this time, very few geese would accept corn from the public, and instead they grazed on the newly available grass. During this period (around 3 weeks), the geese would feed on corn during colder days and in the mornings, but when the sun was out and it was warmer, they preferred to graze. Also, as the nesting period drew closer, the pairs moved to the areas restricted or inaccessible to the public. If a single dose could be administered prior to this period, it would make no difference whether geese were only eating grass or could not be found at the time of nesting.

In order for NCZ to be more effective, we would also recommend further research in the palatability of the drug. In the previous study as well as in this study, there was an obvious taste aversion to NCZ by the geese. Hiding the NCZ in bread balls and corn kernels was successful as long as geese swallowed the bait whole. The corn kernel method was found to be more effective because it was swallowed whole more often, but it did require more time to prepare and could not be used to deliver the capsules. If the taste of the drug could be modified so the geese would readily ingest it by itself, NCZ could be molded and dyed to resemble corn kernels. These alternative delivery methods would save time, labor, and money, making the use of NCZ as a reproductive inhibitor more practical and realistic. If an alternative bait was developed that would be effective in one dose and could be fed without preparation, it would be more feasible that managers of parks, golf courses, and airports could use NCZ to control their resident Canada goose population.

We captured all of our birds during late winter and early spring, assuming they were true residents of BBWS. However, this was clearly not the case. Every goose seemed to have a different story, in terms of its movement patterns. Further research is needed to better understand the ecology and behaviors of urban Canada geese.

MANAGEMENT IMPLICATIONS

Reproductive inhibition via NCZ has the potential of playing an important role in goose management programs. NCZ has several advantages over traditional management methods such as egg addling and oiling, where the nests have to be found in order to be successful. We documented that the individual geese comprising the Canada goose flock at BBWS changed frequently throughout the season, and many that were present during the dosing period did not nest within the sanctuary. Even if every goose did nest on site, finding Canada goose nests is difficult and time-consuming. Also, because the embryo never develops in a NZC treated egg, it is a non-lethal alternative to the other methods, which kill the developing chick within the egg.

The use of a reproductive inhibitor such as NCZ is another tool to manage urban Canada geese and could be used in combination with other management tools. Every resident flock should be managed depending on the behaviors of the geese, size of the flock, desired results, and other factors such as predation rates and habitat availability. More research is needed on the movements, demographics, and ecology of urban Canada geese so managers can make more efficient decisions on which management tools to utilize.

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LITERATURE CITED

DOLBEER, R. A. 2000. Birds and aircraft: fighting for airspace in crowded skies. Proc. Vertebr. Pest Conf. 19:37-43.

FRIEND, M. (EDITOR). 1987. Field Guide to Wildlife Diseases, Volume I. General Field Procedures and Diseases of Migratory Birds. U.S. Fish and Wildlife Service, Res. Publ. 167, U.S. Department of the Interior, Washington D.C.

GARMIN CORPORATION. 1998. GPS 12XL Operator's Manual and Reference. Olathe, KS. 60 pp.

GIBBONS, J. D. 1976. Nonparametric Methods for Quantitative Analysis. Holt, Rinehart and Winston, New York, NY. 463 pp.

HOCHBAUM, H. A. 1942. Sex and age determination of waterfowl by cloacal examination. Trans. North Am. Wildl. Conf. 7:299-307.

JACOBS, J. P., J. A. BRUE, and A. A. BADEAU. 1980. Bay Beach Wildlife Sanctuary Master Plan. Unpubl. report. 169 pp.

JONES, J. E., B. L. HUGHES, J. SOLIS, D. J. CASTALDO, and J. E. TOLER. 1990a. Effect of nicarbazin on brown-egg layer-breeders. Appl. Agric. Res. 5:149-152.

JONES, J. E., J. SOLIS, B. L. HUGHES, D. J. CASTALDO, and J. E. TOLER. 1990b. Production and egg-quality responses of white leghorn layers to anitcoccidial agents. Poult. Sci. 69:378-387.

KEAR, J. 1963. The agricultural importance of wild goose droppings. Wildfowl 14:72-77.

MANNY, B. A., W. C. JOHNSON, and R. G. WETZEL. 1994. Nutrient additives by waterfowl to lakes and reservoirs: predicting their effects on productivity and water quality. Hydrobiologia 279:121-132.

SAUER, J. R., and W. A. LINK. 1999. Regional analysis of population trajectories from the North American breeding bird survey. Die Vogelwelt 120:31-38.

SHINE, H. E. 1956. Bay Beach Wildlife Sanctuary. Wisc. Conserv. Bull. 21:21-24.

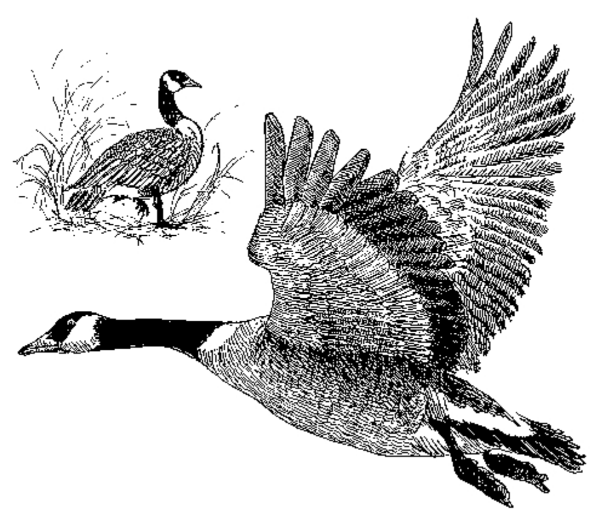
SMITH, A., S. R. CRAVEN, and P. D. CURTIS. 1999. Managing Canada geese in urban environments. Jack Berryman Institute Publication 16, and Cornell Cooperative Extension, Ithaca, NY. 42 pp.

SPSS INCORPORATED. 1998. SYSTAT Version 9, User manual. Chicago, IL.

TOLLEFSON, C. 1999. USFWS to explore Canada goose management strategies. USFWS press release, 3 August 1999.

WOOD, J. C., D. H. RUSCH, and M. D. SAMUEL. 1996. Results of the 1996 spring giant Canada goose survey in the Mississippi flyway. Wisconsin Cooperative Wildlife Research Unit. Unpublished report. 8 pp.

VERCAUTEREN, K. C., M. J. PIPAS, and K. TOPE. 2000. Evaluations of nicarbazin-treated pellets for reducing the laying and viability of Canada goose eggs. Pp. 337-346 *in*: Proc. 9th Wildl. Damage Manage. Conf., State College, PA.



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