Impact of a trap-neuter-return event on the size of free-roaming cat colonies around barns and stables in Quebec: A randomized controlled trial

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Abstract

The objective of this study was to evaluate the impact of a trap-neuter-return (TNR) event on the size of free-roaming rural cat colonies in Quebec. This prospective randomized, controlled study included 18 cat colonies around barns and stables that were randomly assigned to either a TNR group (10 colonies of 7 to 27 cats; 14.3 cats on average) or a control group (8 colonies of 7 to 26 cats; 14.5 cats on average). The number of cats in each colony was calculated from the images obtained by camera-trapping at: baseline (T0), 7.5 mo (T7), and 12 mo (T12). At baseline, the TNR group was subjected to a TNR event. When taking into account adults only, a significant growth difference was observed in the number of cats between the TNR group and the control group at T7 ($P = 0.03$). When including kittens as well as adults, a trend towards a lower growth of the TNR group compared to the control group was noted at T7 ($P = 0.06$). There was no difference in the number of kittens between the 2 groups at T7 ($P = 0.49$) or at T12 ($P = 0.36$). There was a trend towards more emigration in the control group at T12 ($P = 0.095$). Isolated TNR events have a low and temporary impact on colony size in Quebec's rural cat colonies.

Résumé

L'objectif de cette étude est d'évaluer l'impact d'une intervention TNR sur la taille des colonies de chats en milieu rural québécois. Cette étude randomisée contrôlée impliquant 18 colonies de chats ayant accès soit à une écurie ou à une ferme. Les colonies ont été aléatoirement attribuées au groupe TNR (10 colonies de 7 à 27 chats; 14,3 chats en moyenne) et au groupe Contrôle (8 colonies de 7 à 26 chats; 14,5 chats en moyenne). Le groupe TNR a participé à un projet TNR au début de l'étude (T0). Par capture photographique, le nombre de chats et de chatons a été calculé, à 3 temps : T0, 7,5 mois (T7) et 12 mois (T12). Une différence significative de croissance des colonies du groupe Contrôle par rapport à celle du groupe TNR est notée à T7 lorsque seulement les adultes sont comptés (P = *0,03). Une tendance vers une plus faible croissance du Groupe TNR par rapport à celle du Groupe Contrôle est observée à T7 (*P = *0,06), lorsqu'on inclut tous les individus. Aucune différence n'est notée lors de la comparaison du nombre de chatons des deux groupes (T7* P = *0,49 et T12* P = *0,36). Un nombre plus élevé de disparitions tend à être observé dans le groupe Contrôle à T12 (*P = *0,095). Une intervention TNR isolée a un impact faible et temporaire sur la taille des colonies de chats en milieu rural québécois.*

(Traduit par les auteurs)

Introduction

Domestic cat *(Felis sylvestris catus)* overpopulation is a recognized problem worldwide (1,2). It is raising concerns not only because of the ethical issue of leaving numerous cats in poor living conditions without basic medical support (3), but also because domestic cats are a potential reservoir of infectious agents and represent a public health risk to humans and other animals (4,5). Domestic cats have endangered the survival of some species of wild cats by mating with individuals and creating hybrids (6). In addition to many threats from humans, domestic cats also threaten wildlife populations of small mammals, birds, and reptiles as they are skillful predators (7–10).

Free-roaming cats are widespread in rural areas, especially around barns and stables, which are ideal sites for domestic cat colonies. As cats are useful at controlling vermin at such sites, they are often provided with food and water and have access to many hiding places. Consequently, barns and stables have high carrying capacities for domestic cat populations and population growth is not controlled by attrition.

Several types of programs have been implemented in an effort to reduce feline overpopulation, but none has proved more effective than the others (11). Some theoretical models support the superiority of lethal methods over non-lethal ones (12,13), although their findings have not been proven *in-vivo*. It must be taken into account that lethal methods are extremely difficult to apply in populated areas,

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since humans develop compassion and affection for the free-roaming cats (14,15). In many situations, lethal methods are therefore not an option and are simply rejected as cruel (16).

Non-lethal methods, such as trap-neuter-return (TNR) programs, are an appealing alternative. Such programs have many advantages, such as decreasing reproductive rate, while increasing the well-being of individuals in the colony (15,17,18) and reducing the nuisance caused by cats (19,20). By improving the overall health of the cats, decreasing migration to other colonies (11,21), and providing a one-time vaccination, TNR programs could also decrease public health risk. Although some doubt the validity of such assumptions (22), such programs are perceived quite positively by the general public, which facilitates their implementation. On the other hand, some concerns have been raised as to whether TNR programs have a significant impact on the size of feline colonies (3,12,23). Hence, TNR programs increase survival and might enhance the carrying capacity by reducing intraspecies aggressive behavior (24–26). These programs also seem to promote the interest of the caretakers of the colony, making them more prone to dispense care to the cats (11).

Nevertheless, TNR programs have been used to control cat populations worldwide for at least the last 30 y (27). Substantial financial and human resources are allocated to run those programs. To our knowledge, the impact of a TNR event on the size of colonies around barns and stables has never been evaluated. Furthermore, no research has been published on the efficiency of TNR programs in a temperate climate with harsh winters, similar to Quebec. The results of only 13 field trials addressing cat population control have been published (14,23,28–38).

The objective of this study was to evaluate the impact of a one-time TNR event on the size of free-roaming cat colonies around barns and stables, by using a randomized, controlled trial. We hypothesized that implementing an intensive TNR event would significantly decrease the number of free-roaming cats in colonies around barns and stables over a 1-year period.

Materials and methods

Colony selection

The study took place from May 2014 to August 2015. Invitations were sent to colony caretakers through the bovine and equine ambulatory services of our institution. The first 20 colonies that met all inclusion criteria were included. Colonies had to be situated within a radius of 100 km of the Faculty of Veterinary Medicine in Saint-Hyacinthe, Quebec and they had to be composed of 3 to 20 cats at least 6 mo of age. Cats forming the colonies had to have access to a barn or stable, but have no known owner. Finally, the colony caretaker had to agree not to use any cat population control measures, other than what was prescribed by the study, until the end of the project. Colonies were excluded if they had previously taken part in a TNR event.

Study design

The protocol was approved by the Institutional Animal Care and Use Committee of the Faculty of Veterinary Medicine at the University of Montreal (FVM-UofM). The 20 colonies included in the study were randomly assigned to either the experimental group (referred to as the TNR group) or the control group. Data on the size and composition of each colony was collected by video camera at 3 time points: T0 (baseline), T7 (32 +/− 2 wk), and T12 (52 +/− 1 wk). Immediately after data were collected at T0, cats from the TNR group were subjected to a TNR protocol.

Data collection

The size and composition of the colonies were measured at each time point by using an adapted method of camera-based observations that was described in a previous study (39). Numeric recorders with 2 camera heads were placed 1 to 2 m away from the main feeding or resting area and were left to collect data for 72 consecutive hours. Recorders were motion-activated. Images were then viewed and analyzed so that all individuals were identified. The principal investigator (VB) carried out all these steps to prevent observer bias. To validate the methodology, videos of 5 colonies at one time point were randomly selected to be reviewed and analyzed by a second observer for comparison purposes.

Colony size was defined as the number of individuals in each colony. The data collected included the number of adults, the number of kittens, and the total number of cats in each colony. Young individuals with no permanent canines, thus less than 6 mo old, were considered kittens and cats older than 6 mo were considered adults. The number of spayed and neutered individuals following the TNR protocol application in the TNR group and the number of individuals that remained on site for the duration of the study were also reported.

TNR procedure

An intensive trapping effort took place for 48 h in each colony from the TNR group immediately after the size of each colony had been evaluated by camera. Social individuals were caught by hand and placed in carriers, while semi-feral and feral cats were caught using trapping cages with several baits. All captured cats were brought to the Faculty of Veterinary Medicine at the University of Montreal (FVM-UofM) where the surgical procedures were carried out by veterinarians only. Students of FMV-UofM were invited to participate, but only under the direct supervision of a veterinarian. Kittens that were too young at the time of trapping were left on site if weaned or otherwise brought with the mother to FMV, but were left intact. Cats weighing more than 0.5 kg and that were more than 8 wk of age were surgically spayed (mid-line approach, ovariohysterectomy) or neutered (scrotal approach, closed or open castration) and the distal third of the left ear was excised for identification purposes. The cats were vaccinated against feline herpesvirus-1, feline calicivirus, and feline parvovirus (Felocell; Zoetis, Montreal, Quebec) and against rabies (Defensor 3; Zoetis). They also received a topical anti-parasitic agent (Revolution; Zoetis) when recovering from anesthesia. Cats were released the day after their surgery, near the place they were first trapped. They were captive for a maximum of 72 h.

Statistical analyses

The comparability of the TNR and control group at randomization was evaluated by comparing the 2 groups at T0 using an exact bilateral Wilcoxon for 2 variables: the total number of cats and the

number of adult cats. To evaluate the impact of the TNR event on colony growth, the difference in colony size between T0 and T7 (ΔT7–T0) and between T0 and T12 (ΔT12–T0) was calculated for the number of adult cats, number of kittens, and total number of cats, respectively. These differences were then compared between the TNR and the control group using an exact unilateral Wilcoxon test, testing the hypothesis that the TNR event will result in a lower growth in colony size over time. Furthermore, the number of adults observed at T0 that left their colony at T7 and T12 was also counted in both groups and then compared using the exact unilateral Wilcoxon test. We concluded that there was a statistically significant difference when $P < 0.05$. A trend was considered when $P < 0.1$.

Results

The TNR group included 10 colonies of 7 to 27 cats, consisting of an average of 14.3 cats/colony, with a median of 13.5 cats/colony and a total of 128 adults and 15 kittens. For the control group, 2 of the colonies had to be excluded due to data loss at T0. Therefore, the control group included 8 colonies of 7 to 26 cats, consisting of an average of 14.5 cats/colony, with a median of 12.5 cats/colony and a total of 116 adults and 23 kittens at T0. At T0, the size of colonies in the TNR group was similar to the control group ($P = 0.78$ for all cats or $P = 0.95$ for adults only, exact bilateral Wilcoxon test). The data obtained by the second observer was similar to the principal investigator's observations.

Between 67% and 100% (median of 96%) of cats were put through TNR in each colony of the TNR group, for an average of 92% of cats per colony. Slightly more than half (53%) of the individuals sterilized were females. There was no perioperative death and only 1 minor wound infection in a female was reported. At T7, colonies in the TNR group consisted of 87% of spayed or neutered individuals on average (median of 90%). Similarly, at T12, colonies in the TNR group were composed of 87% sterilized individuals on average (median of 91%).

The median numbers of cats per colony at the different time points for each group are presented in Table I. When taking into account adults only, a significant difference in colony growth was observed at T7 (i.e., ΔT7–T0) between the TNR group and the control group ($P = 0.03$). On median, there was an increase of 2.5 adult cats per colony at T7 compared to T0 for the control group, whereas the same number of adult cats at T7 and T0 was observed for the TNR group. The TNR event had no significant impact on the growth of the colonies when comparing all individuals (kittens and adults), but a trend was observed ($P = 0.06$). On median, there was 0.5 more cats at T7 compared to T0 for colonies in the control group, whereas a reduction of 2 cats was observed in the TNR group. There was no difference in the number of kittens in the TNR group compared to the control group at T7 *versus* T0 ($P = 0.49$). No difference in colony growth was observed at T12 *versus* T0 (i.e., ΔT12–T0) for adults ($P = 0.25$), for kittens ($P = 0.36$), or for all cats ($P = 0.21$).

The number of cats that left their colony between T0 and T7 was not significantly different between the 2 groups ($P = 0.3$) (Table I). Nevertheless, there was a trend towards more disappearances in the control group than in the TNR group between T0 and T12 (median of 7.5 cats left colonies in the control group and a median of 3 cats left colonies in the TNR group, $P = 0.095$).

Table I. Median number of cats per colony for the control and TNR groups at different time points.

	T0		T7		T12	
	Control	TNR	Control	TNR	Control	TNR
Adult cats	10.5	11.0	12.0	11.0	11.0	12.5
Kittens	3.5	1.5	0.0	0.0	1.0	0.0
All cats	12.5	13.5	12.0	12.0	12.0	13.0
Baseline cats*	12.5	13.5	8.5	9.5	6.5	10.5

* Number of cats identified at T0 that were still seen later in the colonies.

T0 — baseline; T7 — 7.5 mo; T12 — 12 mo.

Discussion

We hypothesized that implementing a one-time intensive TNR event would significantly decrease the size of free-roaming cat colonies around barns and stables over a 1-year period. Our hypothesis was partially supported as we observed a significant decrease in the growth of the TNR group 7 mo after the application of the event when taking into account adults, but this difference was not significant at 12 mo or when considering all individuals (kittens and adults). The impact of our TNR intervention was therefore considered as low and temporary.

As this was the first project to study the impact of a TNR event on cat colonies around barns and stables over a 1-year period, it is not possible to compare it with other studies. A few studies in other contexts, however, have reported positive results of TNR programs in controlling cat populations. A study on the impact of a TNR program on rural cat colonies was conducted in North Carolina from 1998 to 2005 (28). Six cat colonies (consisting of an average of 14 individuals) were reduced by 36% after 2 y of participation in the program. All cats were sterilized and a vasectomy was carried out on the males of 3 of those 6 colonies instead of castration. The size of the colonies continuously declined over the years. By the end of the trial, 1 colony had dissolved, while the 5 others were reduced to 5 or less individuals (28). Unlike our project, trapping efforts were constant throughout the study and caretakers were relied on to bring in the cats progressively over the years. Use of vasectomy could also explain the success obtained since this procedure allows males to maintain their aggressive intraspecies behavior, their boldness, and their mating habits. In the case of mating habits, however, vasectomy was not proven more efficient than castration for population control (28).

One other study published results of their observations after the first year following the introduction of a TNR program. In 132 colonies from Florida, consisting of an average of 7 cats, a decrease of 27% was noted over a year (14). Our project resulted in a decrease of almost half (14% of decrease at T12) what this study obtained. Their trial was not controlled, however, and the caretakers were responsible for the cats participating in a TNR program and for calculating the number of cats per colony.

Field trials have had encouraging results in controlling cat populations with TNR programs after multiple years of effort. A population of 155 cats on a university campus in Florida was decreased to 23 cats in 11 y of TNR efforts combined with an intensive adoption

program (29). Studies in Rome and Rio de Janeiro were conducted over multiple years and populations decreased by 22% and 58%, respectively (30,31).

The success of a TNR program at controlling population is thought to strongly relate to the number of individuals that are sterilized. Some theoretical models suggest that it is possible to control population with TNR programs, but only with high proportions of sterile individuals, i.e., 51% to 94% (11,12,28,32,40,41). This contradicts the results of this study since no significant decrease was observed even with a high sterilization rate (average of 92% at T0 and 87% at T7 and T12). It was quite simple to trap most of the cats, probably because the colonies were already well-established, the cats received food regularly from the caretaker most of the time, and most individuals were not completely feral, with some even socialized. Our results are in accordance with a study using a mathematical model, which suggested that in colonies where immigration is possible, i.e., an open system, application of high treatment rates of TNR would result in a slight decrease or no change in the population size after a year (11). Indeed, this project was carried out in an open system in which cats were free to leave or enter the colonies and researchers had no control over people abandoning their pets on the colony territory.

In this trial, the number of adults in the TNR group decreased significantly compared to the control group at T7 only. One possible explanation for this short-term success would be that fewer kittens in the TNR group grew into adults. This would have happened for 2 main reasons: first, the intervention took place in early summer, which interrupted some gestations (62 fetuses were aborted) and prevented others from happening in the second peak of reproduction in late summer and second, that some unweaned kittens were inevitably left alone at the colony while their mother was being spayed. Even if lactating females were released as soon as possible after surgery, the absence of the mothers for several consecutive hours might have jeopardized the kittens' survival.

There was no difference in the growth of the TNR group compared to that of the control group after a year. The weather during the winter of 2014/2015 was the harshest in 20 y, with the coldest temperatures ever reported in Quebec in February. These harsh conditions could have affected the results of this study by having an impact on mortality and decreasing the reproductive rate of the control group. This would have made it harder to make a difference in population growth and the number of kittens.

Other factors that could partially explain the low impact of our intervention are frequency of implementation, failure to remove socialized individuals, and short follow-up period. Unlike the other studies discussed, our project involved only a one-time TNR event. Catching/trapping was carried out intensively over a 48-hour period. New members that integrated into the colonies during the year were not spayed or neutered. It would probably have been beneficial to continue the TNR effort throughout the year. Another option would have been to return 3 mo after the first trapping period to spay and neuter the kittens that were left intact at that time because of their young age. Removal of kittens and socialized adults with good potential for adoption would also have led to a faster decrease in population size, as indicated by the results of some successful TNR programs that joined their efforts with animal shelters (28,29,33,34,36–38,42). Finally, as the life expectancy of an adult in a free-range cat colony is less than 5 y (43), the population may have decreased in size over time due to age or accidents.

Another reason for the absence of statistically significant differences may be related to the low statistical power of a small sample size. Based on *a posteriori* analysis, the statistical power was estimated at 51% for the comparison of colony growth at T7 *versus* T0 between the 2 groups for the total number of cats. To reach a statistical power of 80% given the differences observed, 21 colonies would have been required in each group, for a total of 42 colonies. Limited resources and time contributed to restricting the sample size. Retrospectively, the authors consider it would have been unrealistic to double the size of the sample with the method of evaluation chosen, as the camera-trapping method was both time- and energy-consuming.

Several other interesting results were noted in our study. First, there was a trend towards more disappearances in the control group than in the TNR group between T0 and T12. These disappearances could have been due either to emigration or death. Female emigration is motivated by the search for a new source of food, while males leave in search of new mates. It therefore makes sense to observe more retention in colonies where the males are no longer influenced by sexual hormones (44). Most disappearances observed in the control group colonies occurred in the spring, between T7 and T12, which is when reproduction peaks. Moreover, the cold weather and the decrease in predation opportunities would make it more difficult to travel during fall and winter. More disappearances could also mean that there were more mortalities in the control group. Since gonadectomy decreases intraspecies aggression, which results in fewer wounds and blood-transmitted diseases, it is possible that cats in the TNR group had better survival rates. The TNR group was also vaccinated and received a dose of anti-parasitic agent, which could have improved the health of cats in this group.

Second, domestic cats generally live alone, with groups of females occasionally gathering around a food source (21). This was not observed in the present study, since both males and females were forming colonies around barns and stables and living close to each other. Third, we reported smaller growth in population than what was suggested in previous reports (28,32). This was expected as most other studies took place in more welcoming climates. It is also possible that the colonies included in this study were already close to their carrying capacity.

Finally, an unexpectedly small number of kittens was identified in all colonies. While theoretically cats are very fecund (25), this could have been diminished by the harsh winter climate in Quebec. It is also possible that the method of data collection was less efficient at counting kittens since the cameras were static and located in the main feeding or resting areas. Unweaned kittens are generally hidden from other cats in the colony, as well as from predators and humans, and would not usually be seen in the main areas.

Inevitably, we identified potential bias in this study. A selection bias could be present, since only colonies with motivated caretakers who answered the invitation took part in the study. Most of these caretakers were providing a regular food and water supply to their cat colony and some were even providing basic medical care, such as wound management and ocular topical treatments, to

the social individuals and kittens. As a result, most colonies were well-established and consisted of relatively social individuals and few feral ones. This might have facilitated the trapping, which enabled us to sterilize most of the cats in the colonies. Despite this, these motivated caretakers were increasing the carrying capacity of their territory, which could have reduced the impact of population control interventions.

Finally, we could not assess the precision of the use of cameras as a method for measuring the colony size. Although this is an objective method, the colony size could be underestimated if some individuals did not visit the main site of activity in the colony, as is probably the case for young kittens. Moreover, it can sometimes be challenging to identify all individuals when colors and patterns of coats and silhouettes are similar. Finally, data can easily be lost when the intensity and direction of natural light changes, the cameras accidently get displaced, or unsuccessful data transfers occasionally occur.

It was concluded that a one-time TNR event had a low and temporary impact on the size of cat colonies in this study. While these results do not discourage the use of TNR events in rural cat colonies, they strongly suggest that a one-time intensive TNR event might not be worth the effort if there is no possibility of a continuous trapping effort to counteract immigration.

This study is a first step towards a better understanding of the true impact of TNR events on cat colonies in rural environments in a temperate climate with harsh winters. Although many TNR programs are being carried out, their results are not being evaluated. More field studies should be conducted in different settings in order to gain a better understanding of the main factors influencing the impact of TNR events. Given the scarce resources available for cat population control, it is essential that efforts are deployed the most efficient way possible and this can only be achieved if we have a good understanding of the problem.

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