The Impact of Hysterectomy in an Urban Colony of Domestic Cats (*Felis catus* Linnaeus, 1758)

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ABSTRACT

The easiness with which urban cats form colonies and the exponential growth of these populations are a challenge for all known population control methods. The zoological garden of Rio de Janeiro (RIOZOO) has been dealing unsuccessfully with the issue of stray cat populations for more than 10 years. For this reason, it was decided to investigate the structure and composition of the colony of cats populating the RIOZOO and to observe, during 36 months, the impact of hysterectomy of adults, with conservation of the gonads, as a means of population control. Hysterectomy was meant to be performed biennially, though at the beginning of the program, it was performed yearly for 2 consecutive years. The total size of the colony was estimated each year using the capture-mark-recapture technique. During the study's entirety, a total of 96 cats, 80 adults and 16 kittens, were caught. The yearly population estimate of cats showed that between the years 2001 and 2004, the population stopped to grow, strongly tending to decrease. The conservation of the gonads of all animals adding to the fact that no individuals were removed preserved the natural social behavior of the cats living in the colony. Thus, after 2 consecutive years of submitting captured adult females to hysterectomy, planned biennial interventions constitute an animal welfare-friendly, effective model for controlling the urban population of cats that can be proposed to public health authorities as an alternative to the traditional capture and culling in Brazil.

INTRODUCTION

Free-roaming domestic cats can live alone or in groups, depending on the population density and availability of food resources.[1-6] Under favorable conditions, cats form colonies of a generally matrilineal structure[3,6-11] in which the degree of descent, age, sex, and social status strongly influence the interaction between the components of the group and the hierarchic position of each animal inside the colony.[7,12] These colonies naturally will defend their territory, preventing new individuals from joining them.[13]

According to their living conditions, cats can be classified into the following: 1) confined - kept exclusively in households; 2) semi-confined - kept in households

but with free access to the streets; or 3) free - free-roaming cats not directly depending on humans.[4,14-17] While some cats receive care and protection from their owners, others are lost or abandoned (stray cats) and there are still those that have always lived on their own (feral cats). Studies carried out in the United States suggest the population of feral cats to be about 40% of the population of owned cats (confined and semi-confined).[18,19]

The few existing studies on the life expectancy of urban cats were carried out in developed countries (USA and Italy) and demonstrated that the animals held as household pets (in confined or semi-confined conditions) had an approximate life expectancy of 7 years while feral cats that had survived weaning lived for approximately 3 years.[8,20] At a first glance, feral cats may appear to be responsible for feline overpopulation in the urban centers. The growth of this population, however, is due more to owned cats whose owners do not provide appropriate care than to the feral population. The chance of turning themselves into immigrants with great survival capacity is higher for kittens born under human protection because they already passed the weaning period,[3,5,8,9,20-25] while kittens born in the streets hardly survive weaning to reach the reproductive age.[8,20]

Abundance of food and shelter available in urban areas facilitates the overpopulation with felines, which man historically tries to control by eliminating them.[4,18,26-30]

Capture and euthanasia was the most widely employed eradication method in the past and is still used in developing countries.[31] However, it is known that capture and elimination techniques do not reduce overpopulation. After removal of some individuals, new cats, possibly carrying new pathogens, migrate to the same place, occupy the empty niche, and may maintain or originate a colony.[2,4,32-34]

Historically, surgical sterilization with removal of gonads has been recommended as a form of population control of feral cats, although this lacks any scientific endorsement. On the contrary, there is evidence that sterilization with removal of gonads does not inhibit population growth.[10,35] Sterilization with preservation of the gonads is important for maintaining the sexual activity and consequently the social structure of the colonies. Animals submitted do ovarectomy or orchiectomy do not defend their territories, allowing new individuals to immigrate.[10,18,35]

The easiness with which urban cats form colonies and the exponential growth of these populations represent a challenge for all known population control methods. Exactly for this reason, the interest in research activities aiming at dimensioning the problem and at a better understanding of the characteristics of these populations is growing day by day. To employ population control methods efficiently, it is necessary to know the population dynamics of the colonies of free-roaming domestic cats in urban environments. The feline population to be controlled has to be exactly identified and defined. Previous knowledge of the parameters of the population structure (birth rate, age, distribution among sexes, and mortality) acting in its dynamics makes it easier to plan the population control method to be employed. The better the planning, the more efficiently time and labor can be employed among other factors for analyzing the impact of the employed method upon the population.

Zoos prevent the presence of domestic animals due to the possibility of transmission of pathogens to the wildlife in captivity. However, even in zoos where a maximum of measures are taken to prevent the presence of cats, it is almost unavoidable because the animals are attracted by the availability of food and shelter.[36] The zoological garden of the city of Rio de Janeiro (RIOZOO Foundation) cohabits for more than 10 years with a colony of feral cats that resisted different efforts of population control. It was therefore decided to study the urban colony of free-roaming domestic cats

(*Felis catus* Linnaeus, 1758) living at the RIOZOO to investigate its structure and composition and to assess during 36 months the impact of hysterectomy as a means of population control.

MATERIALS AND METHODS

Study Location

The work was carried out in the zoological garden of the city of Rio de Janeiro (RIOZOO Foundation), Brazil. The zoo occupies an area of 13.8 hectares in a municipal park situated at 23°54'S and 43°13'W, at an altitude of 44 masl.

Animals

The population of domestic cats, *Felis catus* Linnaeus, 1758, living in the RIOZOO was studied during 36 months, from June 2001 to June 2004. The cats identified in the RIOZOO when the work started and already known individuals later recaptured were called inhabitants, while new (unknown) cats were called immigrants.

In order to obtain information about deaths due to any cause, the employees of the RIOZOO were instructed to observe indications for changes in the health status of the cats and to report such changes as well as deaths. The deaths were registered in the individual records of the animals.

Abundance Estimate and Population Structure

Although the cats of the RIOZOO can usually be seen, most are wary of humans, making handling and identification of them difficult. Therefore, size and population structure of the colony of cats of the RIOZOO were established by means of abundance estimation techniques, such as those used for wild mammals. These methods were developed for estimating the population of a given place, where the individuals of the species under study cannot be counted and identified.[37]

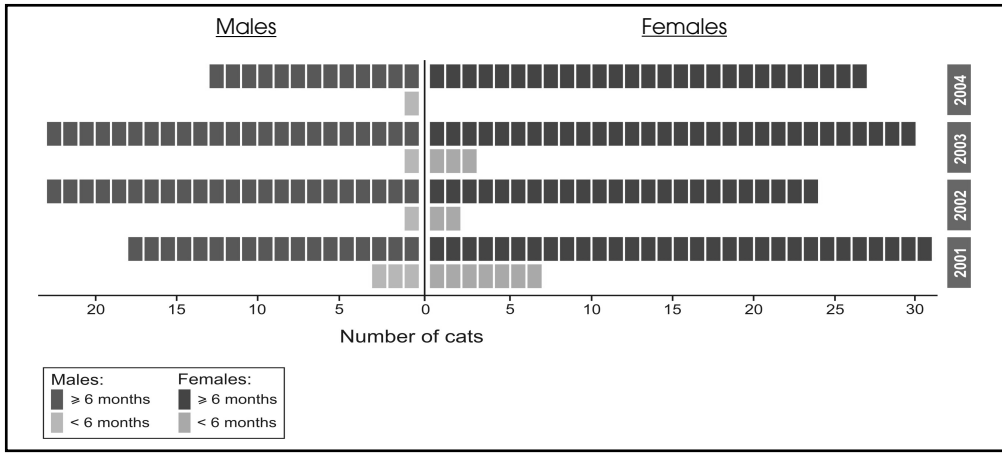
We used the mark-recapture method developed by Lincoln-Petersen (Lincoln 1930), modified by Chapman (1951). This method consists of marking all animals caught in a first capture and releasing them back into their population. In the second capture (recapture), the number of marked and unmarked (new) individuals is counted and recorded. The method is based on 2 combined and consecutive samplings.[38,39] The inferior and superior limits of the 95% confidence interval were calculated following the binomial method.[38]

This method however relies on 3 assumptions: Firstly, the population during the capture-recapture period should be closed, that is, there should be no additional animals through births and immigration and no losses through death or emigration. Therefore, the interval between the first and second capture, considering the studied species, should be of only a few days. The second assumption is that there should be equal chances for all animals to be trapped in both samplings. Finally, the marks should be permanent and incorrect records should be avoided.

We thus used the capture-mark-recapture method for performing a yearly population estimate and comparing the variations between the years. Six technicians performed the captures in the years 2001 to 2004, always in June, July, and August. In order to capture the highest number of individuals possible, the total area of the RIOZOO was divided into 4 sub-areas (Figure 1). This way, cats from 2 sub-areas were captured each week so that the interval between capture and recapture in each area was of 15 days. We established this interval based on the observation that the cats, principally the females trapped during the first capture and submitted to surgical sterilization, began to reappear after 10 days. In addition, this time is sufficient for captured and released individuals to mix again with the others without occurrence of migrations, births, or deaths.[39]

To be more effective, captures were performed in the morning (600h-1000h) or in the afternoon (1700h-2000h) when the animals are more active, using hand nets and

Figure 1. Structure of the estimated domestic cat (*Felis catus* L, 1758) population living in the Zoological Park of Rio de Janeiro, Brazil, from 2001 to 2004.



1-door Tomahawk-traps. The animals were attracted with small portions of commercially available wet food, chopped beef, or fish containing 2 mg flunitrazepam (Rohypnol; Roche Química e Farmácia, São Paulo, Brasil) for reducing their psychomotor performance and consequently facilitating the capture with hand nets. The animals captured with the hand nets or in the traps were transferred to transport boxes by technicians using leather gloves and sent to the veterinary department of the zoo.

Procedures

At the veterinary department, the animals were sedated intramuscularly with a combination of 10 mg/kg ketamine (Vetaset; Fort Dodge Saúde Animal Ltda, São Paulo, Brasil) with 2 mg/kg xilazina (Rompun; Bayer do Brasil S.A., São Paulo, Brasil). As soon as sedation could be observed, sex and age of the animals was determined. The age was estimated based on dentition, considering that the permanent incisor teeth erupt between 14 and 22 weeks of age and the permanent canines between 22 and 26 weeks of age.[40] The animals less than 24 weeks of age and consequently not sexually mature were considered kittens and those more than 24 weeks of age adults. Kittens and adults received 1 dose of polyvalent vaccine against panleucopenia, calicivirosis, rhinotracheitis, and chlamydiosis (Felocell CVR-C; Pfizer, Lincoln, Nebraska, USA), anti-rabies vaccine (Rabisin; Merial Saúde Animal, São Paulo, Brasil), and application 50 µg/kg of endo- and ectoparasiticide (Ivomec; Merial Saúde Animal, São Paulo, Brasil) and 6 mg/kg fipronil (Frontline Spray; Merial Saúde Animal, São Paulo, Brasil) or selamectine (Revolution; Pfizer, Lincoln, Nebraska, USA).

To ensure permanent marks would last for 36 months, the sedated animals were marked by subcutaneous implant of microchips (Friendchip; AVID, California, USA) in the interscapular region and had the tip of one ear amputated (males right ear and females left ear) so they could be identified at distance.[41] The biological data of each animal were registered in individual numbered record sheets containing the number of the microchip. Photos of all animals were attached to their individual records.

Adult females were submitted to hysterectomy in 2001, 2002, and 2004 after sedation and epidural anesthesia with 7 mg/kg lidocaine (Xilestesin; Cristalia Produtos Químicos e Farmacêuticos Ltda, Rio de Janeiro, Brasil). All animals received anti-inflammatory medication (Ketofen 1%; Merial Saúde Animal, São Paulo, Brasil) in a dose of 1 mg/kg and antibiotics (penicillin + streptomycin 30,000 UI/kg; Agropen LA; Virbac do Brasil Indústria e Comércio Ltda, São Paulo, Brasil).

The cats were always released back to the same place where they were captured. All males and not hysterectomized females (kittens and adults already submitted to surgery) were released, while females submitted to hysterectomy were kept confined for 24 hours.

Population Dynamics

For studying the dynamics and the impact of hysterectomy in the course of the 36 months of the study, we considered the total population of the RIOZOO as a single colony.

For assessing the population growth, we compared the estimated number of individuals year by year. The real number of individuals, classified according to sex and age, distributed between the years of the study allowed assessing the impact of hysterectomy on the population structure.

RESULTS

During the 36 months of the study, a total of 96 different cats, 80 adults (44 females and 36 males) and 16 kittens (11 females and 5 males) were captured. In the first year, we captured 47 animals; 25 females were submitted to hysterectomy. In the second year, 48 animals were captured and 12 submitted to hysterectomy, and in the third year, we captured 52 animals and no female was submitted to hysterectomy. At the end of the third year, 40 animals were captured and 7 females were submitted to hysterectomy. The population structure varied in the course of the 36 months, showing a trend to a stable male/female ratio of 1:3 and decrease of the number of young animals. In 2001, the relation between males and females was of approximately 1:3 and in 2002 1:2. In 2003, the number of males began to decrease in relation to the number of females until in 2004 the relation returned to 1:3. The initial proportion of 17% of kittens decreased to 7% in 2002 and to 6% in 2003 until reaching only 2.5% in 2004, suggesting that fewer kittens were born (Table 1 and Figure 2).

The number of immigrations diminished gradually. In the second year of the study (2002), 54% of the population was composed by immigrated individuals; in 2003, 34.6%; and in 2004 only 15% of the population was composed of immigrating cats. It is interesting to note that during the entire study, the migration rates of adult males were proportionally higher than those of adult females. The rate of adult male immigrants was 59% (13/22) in 2002, 33% (7/21) in 2003, and 15% (2/13) in 2004, while the rate of immigrating females was 43% (10/23) in 2002, 26% (7/27) in 2003, and 11.5% (3/26) in 2004 (Table 2).

A total of 22 cats died in the course of the study and their bodies were found and identified. In 2001, 2 females died (1 adult and 1 kitten) and in 2002, 7 animals died (2 adult females, 4 adult males, and 1 female kitten). The greatest number of deaths occurred in 2003, when 9 animals died, 7 adults (4 females and 3 males) and 2 kittens (females). In 2004, 4 animals died (1 adult female and 3 adult males).

The yearly estimate showed that between 2001 and 2004, the population did not grow and that the obtained results range within the maximum and minimum limits accepted by the population estimate method used (Table 3 and Figure 2).

DISCUSSION

Before we started this work in 2001, the population of cats of the RIOZOO suffered constant interventions but without a preestablished methodology and only with the simple objective of eliminating the population. Therefore, the population of cats fluctuated, the animals showed weak social relations and behavioral interactions reflected by weak individual territorial defense, and this probably opened the way for high migration rates.

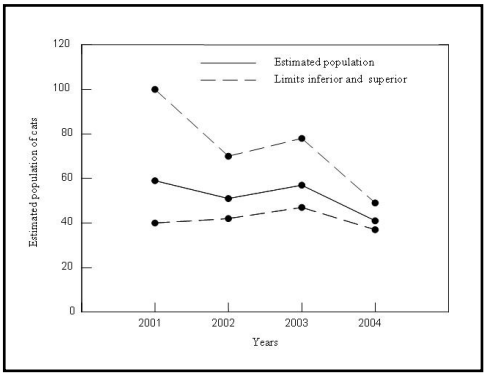
Between 2001 and 2002, the population structure showed variations, with an increased number of males in relation to the number of females. This variation may have occurred at random, merely as a result of

Table 1. Structure of the Population of Domestic Cats (*Felis catus* L.1758) Living in the Zoological Park of Rio de Janeiro, According to Gender and Age, From 2001 to 2004.

		2001		2002		2003		2004	
Gender	**Age (months)**	**N**	$\widehat{N}$	**N**	$\widehat{N}$	**N**	$\widehat{N}$	**N**	$\widehat{N}$
Female	<6	67	2	2	3	3	0	0	
	≥6	25	31	23	24	27	30	26	27
Male	<6	2	3	1	1	1	1	1	1
	≥6	14	18	22	23	21	23	13	13
Total		47	59	48	51	52	57	40	41

N=total population captured; $\widehat{N}$=estimated population of cats.

Figure 2. Estimated domestic cat (*Felis catus* L, 1758) population living in the Zoological Park of Rio de Janeiro, Brazil, from 2001 to 2004.



disorganized migration, or additional males could have been attracted by the higher number of females in estrus, given that after hysterectomy the females do not get pregnant but present estrus more times a year.[42,43]

The number of births decreased significantly after the first intervention using hysterectomy. Half of all kittens born during the study were born in the first year, when all females were actively reproducing. After that, the number decreased to only 1 kitten in 2004, when 90% of the females of the population had been submitted to hysterectomy.

The impact of hysterectomy on the population living in the zoo met our expectations. Between 2001 and 2004, the estimated population became stable, showing a trend to decrease. The behavioral effects of hysterectomy, however—sexually active females and males, increased sexual activity in the colony due to a higher number of estruses per female/year,[44-46] and territorial defense by dominating males and females—should not be underestimated because they contributed to the continued decrease in the number of kittens. This trend reached its peak in 2004, when only 1 kitten was found in a population of 7 females of reproductive age (hysterectomized) but probably inactive due to competition.[34]

The non-removal of individuals and preservation of the gonads of all animals adding to the fact that all captured individuals were released back to the same places where they were captured at maximum 24 hours later made it possible to maintain the natural social behavior of the cats. It should be emphasized that young females that reproduced were not very successful in keeping their offspring alive, probably due to their marginal condition inside the

Table 2. Distribution of Domestic Cats (*Felis catus* L.1758) Living in the Zoological Park of Rio de Janeiro, According to Age, Gender, and Population Status, From 2001 to 2004.

Age		2001		2002		2003		2004	
(months)	**Gender**	**i**	**im**	**i**	**im**	**i**	**im**	**i**	**im**
<6	Female	6	0	0	2	0	3	0	0
	Male	2	0	0	1	0	1	0	1
Subtotal		8	0	0	3	0	4	0	1
≥6	Female	25	0	13	10	20	7	23	3
	Male	14	0	9	13	14	7	11	2
Subtotal		39	0	22	23	34	14	34	5
Total		47	0	22	26	34	18	34	6

Population status = i (inhabitants; already known captured cats), im (immigrants; new cats).

colony.[34] This indicates that, besides the importance of females sharing core territories,[7,12] the activity is mainly dependent of the older, sexually active females; therefore, they are important elements in population control, perhaps more important than the territorial defense made by the males. It is known that dominant males spend more time taking care of the territory than involved in sexual activity.[6]

It was not possible to relate the yearly number of deaths to any cause, because finding the dead animals depended mainly on the cooperation of the employees of the park. It is noteworthy that the lowest incidence of deaths was registered in the first year, when the greater part of employees still did not give much importance to this work. After a while, the general comprehension (among other factors) probably increased, because fewer kittens were observed and the employees began to give more importance to the project and to report all observed occurrences.

Thus, after 2 consecutive years of performing hysterectomy in adult females, we conclude that programmed biennial interventions submitting all adult females to hysterectomy constituted an efficient measure for controlling the urban colony of free-roaming cats in the RIOZOO. Possibly, this model can be employed in other open or closed facilities, provided that the noise produced by the cats during mating and competition for females in estrus is not a limiting factor.

Table 3. Annual Estimated Population of Domestic Cats (*Felis catus* L. 1758) Living in the Zoological Park of Rio de Janeiro and Inferior and Superior Limits at 95% of Confidence, by the Binomial Method of Lincoln- Petersen, From 2001 to 2004.

Year	n_1	n_2	m_2	$\hat{N}$	IL	SL
2001	25	38	16	59	40	100
2002	35	42	29	51	42	70
2003	37	42	27	57	47	78
2004	36	30	26	41	37	49

n_1 = number of animals in the first capture; n_2 = number of animals in the second capture; m_2 = number of recaptured animals; $\hat{N}$ = total population estimated; IL = inferior limit; SL = superior limit.

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