Reproductive capacity of free-roaming domestic cats and kitten survival rate

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Objective—To determine reproductive capacity of naturally breeding free-roaming domestic cats and kitten survival rate.

Design—Prospective cohort and retrospective cross-sectional study.

Animals—2,332 female cats brought to a trap-neuter-return clinic for neutering and 71 female cats and 171 kittens comprising 50 litters from a cohort study of feral cats in managed colonies.

Procedure—Data collected for all cats included pregnancy, lactation, and estrus status and number of fetuses for pregnant cats. Additional data collected for feral cats in managed colonies included numbers of litters per year and kittens per litter, date of birth, kitten survival rate, and causes of death.

Results—Pregnant cats were observed in all months of the year, but the percentage of cats found to be pregnant was highest in March, April, and May. Cats produced a mean of 1.4 litters/y, with a median of 3 kittens/litter (range, 1 to 6). Overall, 127 of 169 (75%) kittens died or disappeared before 6 months of age. Trauma was the most common cause of death.

Conclusions and Clinical Relevance—Results illustrate the high reproductive capacity of free-roaming domestic cats. Realistic estimates of the reproductive capacity of female cats may be useful in assessing the effectiveness of population control strategies. (*J Am Vet Med Assoc* 2004;225:1399–1402)

The size of the free-roaming cat population in the United States is unknown, but overpopulation of free-roaming cats is considered to be an important problem because of concerns about animal welfare, wildlife predation, and zoonotic disease transmission.[1] Methods for controlling populations of free-roaming cats are controversial, in large part because of a lack of data needed to assess the various options.[1-3] Domestic cats are considered to be prolific breeders, with females capable of bearing their first litter before 1 year of age and able to have multiple litters each year thereafter.[4,a] However, estimates of the reproductive capacity of female cats and the consequences of unabated reproduction are often extrapolated beyond scientific reliability, as they typically fail to use realistic litter sizes or ignore kitten mortality rates.[5,6] The purpose of this study was to determine reproductive parameters of naturally breeding free-roaming cats. For purposes of the present study, free-roaming cats were considered to be cats that were not confined when outdoors. Feral cats were considered to be a subset of free-roaming cats.

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Materials and Methods

Data for the study were collected from 2 sources. Between May 1998 and October 2000, data were collected on 71 sexually intact female cats in 9 managed feral cat colonies in Randolph County, NC. The cats were being monitored to assess the impact of a **trap-neuter-return (TNR)** program on feral cat colony population dynamics. As each colony was enrolled in the population dynamics study, all cats in the colony were captured and pregnancy, lactation, and estrus statuses of the female cats were determined. Colonies were included in the study only if they had an established caretaker who provided food and water on a regular basis and either owned the land on which the colony resided or had the permission of the landowner to tend to the cats; cats in the colony had access to adequate shelter, such as a barn, storage shed, carport, basement, or crawl space; the colony consisted of at least 10 adult cats (ie, cats > 6 months old), with at least 3 adult male cats; the colony was located in a rural or suburban residential area at least 1 km from the nearest 4-lane road; and the colony caretaker agreed to random assignment of the colony to a treatment group (control vs surgical sterilization), ear-tipping of all cats for permanent identification, and regular visits to the colony by the investigators for data collection. At the time of inclusion in the study, cats in the colony were live trapped and anesthetized with an IM injection of ketamine, tiletamine, zolazepam, and xylazine.[7] Female cats in 6 colonies (n = 44) were surgically neutered. Female cats in the remaining 3 colonies (n = 27) were not surgically neutered. All cats in all colonies were vaccinated against rhinotracheitis, panleukopenia, calicivirus infection, FeLV infection, and rabies and treated with ivermectin. Food and water were provided daily. Cats were returned to their colony sites and monitored for a 2-year follow-up period. During that time, census data were collected on the colonies at least twice weekly by the caretakers or principal investigator. Data collected included parity, birth dates, litter sizes, and outcome of kittens. Parity was estimated on the basis of whether the caretaker had observed the cat to have been pregnant, lactating, or caring for a litter previously and the reproductive status of the cat at the time of enrollment in the study. Kittens that survived to 6 months of age were trapped and enrolled in the population dynamics study but were not enrolled in the present study. Litter size data were collected on 61 litters produced by the 27 control females during the 2-year study period. Data were available on time of birth for all 61 litters, on litter-specific mortality rates for 59 litters, and on litter size for 50 litters. All cats were trapped, neutered, and vaccinated at the end of the population dynamics study and again returned to their colony sites.

Data were also collected on a convenience sample of 2,332 free-roaming female cats trapped and brought by their caretakers to a monthly TNR clinic in Raleigh, NC,[b] between February 1996 and December 2001. Information on living conditions of these cats was not available; however, data on pregnancy status (ie, identification of embryos or fetuses visible without magnification), number of fetuses per pregnancy, lactation status (ie, ability to express milk from teats), and estrus status (ie, ovarian follicle development and uterine status) were collected by veterinary technicians and assistants at the time of neutering and recorded on a standardized recording sheet. Pregnancy status was recorded for 2,281 of the 2,332 cats, and 608 cats were confirmed to be pregnant on the basis of identification of embryos or fetuses in the uterus. Fetus counts were recorded for 317 of the 608 pregnancies. Lactation status was recorded for 2,205 cats, and estrus status was recorded for 2,227.

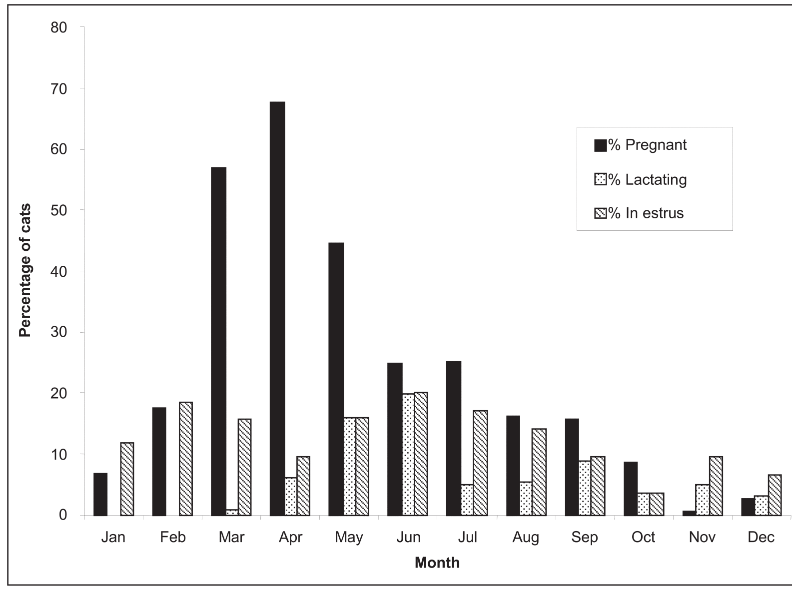

Figure 1—Percentages of free-roaming cats found to be pregnant, lactating, or in estrus as a function of month of examination. Data are based on 2,332 free-roaming female cats brought to a trap-neuter-return clinic for neutering and 71 female cats in managed feral cat colonies.

Data from the population dynamics study were used to determine litter sizes, litters per year, kitten survival rate, and causes of death for kittens that died. Descriptive statistics were calculated, and associations between parity, litter size, kitten survival rate, and litter order (first, second, or third per year) were assessed with *z* tests. Commercial software[c] was used for all calculations; values of $P < 0.05$ were considered significant. Distributions of fetus counts and litter sizes from live births were significantly different ($P = 0.008$; Kolmogorov-Smirnov test); thus, analyses were performed separately for each. Fetus counts and litter size were compared with the Mann Whitney *U* test. Distributions of pregnancy, lactation, and estrus statuses were not significantly different between cats in the population dynamics study and cats examined in the TNR program. Therefore, data were pooled for further analysis.

Survival time for 169 kittens was evaluated by means of the Kaplan-Meier product-limit estimate of the survivor function.[8] Observations were right-censored at the end of 6 months (180 days). Survival times were compared by parity of the queen, litter size, and litter order with the Peto and Peto generalized Wilcoxon test for k samples with censored data[8]; values of $P < 0.05$ were considered significant.

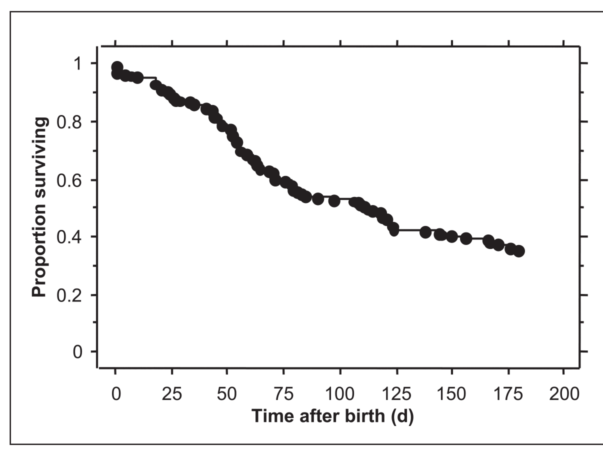

Figure 2—Kaplan-Meier survival curve for 169 kittens born to free-roaming cats. Kittens were observed for 180 days after birth.

Results

Six hundred twenty-five cats in the study (608 in the TNR program and 17 in the population dynamics study) were pregnant. Pregnancies were observed in all months of the year, but the percentage of cats found to be pregnant was highest in March, April, and May and lowest in November **(Figure 1)**. Distributions of the percentages of cats in estrus and the percentages of cats lactating had similar pattens, with the peak in percentage of cats in estrus preceding the peak in percentage of cats found to be pregnant and the peak in percentage of cats lactating following. Overall, 149 of 2,276 cats (131/2,205 cats in the TNR program and 18 of 71 cats in the population dynamics study) were reported to be lactating, and 295 of 2,298 cats (277/2,227 cats in the TNR program and 18 of 71 cats in the population dynamics study) were in estrus.

Information on fetus count was available for 317 cats in the TNR program and 17 cats in the population dynamics study (1,401 total fetuses), and information on litter size was available for 50 litters produced by cats in the population dynamics study (171 total kittens). Fetus count (median, 4; interquartile range [25th to 75th percentile], 2 to 6; range, 1 to 10) was significantly ($P < 0.001$) higher than litter size (median, 3; interquartile range, 2 to 4; range, 1 to 6). Cats in the population dynamics study produced a mean of 1.4 litters/y, with a maximum of 3 litters/y.

Survival data were available for 169 kittens. Overall, 127 of the 169 (75%) kittens died (n = 87) or disappeared (40) before 6 months of age. Median litter-specific mortality rate was 75% (interquartile range, 20% to 100%; range, 0% to 100%). Kitten mortality rate was not significantly associated with maternal parity ($P = 0.19$), litter size ($P = 0.10$), or litter order ($P = 0.38$). Eighty-one of the 169 (48%) kittens died or disappeared before they were 100 days old **(Figure 2)**. Median survival time was 113 days (10th to 90th percentile range, 24 to 180 days). Survival time was not significantly associated with maternal parity ($P = 0.12$), litter size (P = 0.11), or litter order (P = 0.58). Causes of death were determined for 41 of the 87 (47%) kittens reported to have died. Thirty-seven of the 41 (90%) died as a result of trauma, with attacks by stray and owned dogs (n = 18) and motor vehicle accident (10) being the most common types of trauma. Other types of trauma that resulted in > 1 death included falls from haylofts (n = 2), being stepped on by horses or people (3), and a suspected episode of infanticide (3). Cause of death was not determined for 46 of the 87 (53%) kittens reported to have died, but many reportedly had signs of disease, including upper respiratory tract disease and diarrhea, prior to death.

For 10 female kittens born into control feral cat colonies, ages at which they produced their first litters were recorded. Median age at first parity was 10.5 months (interquartile range, 8 to 12 months; range, 6 to 15 months).

Discussion

Results of the present study reinforce concerns about the high reproductive capacity of free-roaming domestic cats. Although cats are considered to be seasonally polyestrous with a defined anestrus period associated with day length,[9,10] pregnant cats were identified during all months of the year in the present study, and similar findings have been reported previously.[11] However, only 15 pregnancies were identified outside the spring and summer breeding season during the 6 years of the present study. This would support a hypothesis that seasonal births are dependent on optimal environmental conditions.[4]

In the present study, the proportion of pregnant cats peaked during the spring and late summer, which is consistent with reported patterns in Florida,[12] Australia,[13] and South Africa.[14] Proportions of the queen population in estrus and lactation followed similar seasonal patterns, with the percentage in estrus peaking prior to the peak in the percentage that were pregnant and the percentage lactating peaking after, as expected. The proportions of the queen population in estrus and lactation were lower than would be expected given the reported percentage that were pregnant, most likely because of the difficulty of identifying estrus and lactation, compared with identifying pregnancy. Also, estrus lasts a shorter time than either pregnancy or lactation, which would add to a bias for detecting pregnancy during monthly TNR clinics.

Reported values for mean litter sizes for free-roaming, laboratory-raised, and cattery cats vary from 2.1 to 5 kittens/litter, with ranges from 1 to 10 kittens/litter having been reported,[11,14-22] and litter sizes in the present study were consistent with these values. Litter size was significantly smaller than fetus count in the present study, which may be an indication of late gestational or early neonatal losses that were not directly observed. Litters of kittens could not always be located immediately after birth, and kittens were typically first counted at 3 to 4 weeks of age, when they began to visit the colony feeding site. This has been the only method used by some researchers to determine litter sizes[18] and, on the basis of our findings, results in conservative estimates of actual reproduction.

On average, cats in the present study gave birth to 1.4 litters/y, although 2 cats had 3 litters in a single year. Production of multiple litters a year has been negatively associated with survival of kittens in the first litter in other studies,[23,24] but we did not find a clear association between those variables in our data. However, the 2 females that each produced 3 litters in a single year did have 100% mortality rates for at least 1 of the first 2 litters in that year. This association makes intuitive sense but requires a larger data set to appropriately interpret the relationship. Of 10 female cats born into control feral cat colonies and closely followed to determine age at first parity, 9 produced their first litters at < 1 year of age, with 1 cat giving birth at 6 months of age. This young age at first reproduction combined with the potential to produce multiple litters a year contributes to the perception of cats as prolific breeders.[4,a]

High neonatal and juvenile mortality rates are widely reported for domestic cats. Reported percentages of kittens that die in the early neonatal period (ie, up to 6 or 8 weeks of age) range from 12.8% to 48%.[22,25,26] In 1 study,[26] up to 90% of kittens died before 6 months of age. Similarly, 81 of 169 (48%) kittens in the present study had died or disappeared before they were 100 days old, and 127 (75%) had died or disappeared before they were 6 months old. Trauma accounted for the death of most kittens for which cause of death was confirmed. Causes of kitten death may be highly dependent on a variety of environmental variables, and considerable variation in these data should be expected between study sites, making generalization difficult. Variations are also likely within causes of death. For example, single or multiple stray dogs were responsible for deaths of kittens in 2 colonies in the present study, whereas a caretaker's dogs were responsible for the deaths of multiple kittens in a third colony. It is likely that both motor vehicle accidents and dog attacks were overrepresented as causes of death in the present study because the noise or graphic visual evidence associated with these causes of death is likely to draw attention. Cats that become debilitated often seek hiding places, making it less likely that cats that die of illness or disease will be identified. Predation of kittens by other animals, such as raptors, foxes, and coyotes, likely resulted in the disappearance of some kittens in the present study but was not recorded as a cause of death, likely because the carcasses were consumed. Causes of kitten death and the relative rank of contribution to the overall mortality rate were reported in a study[24] of farm cats in Ithaca, NY; however, relative rankings were different from rankings in the present study, likely because of differences in study design and environmental conditions of the kittens, such as human population density, road density, road proximity, and climatic conditions.

Examined out of context, our data would tend to reinforce the popular notion that kittens born to free-roaming cats live a marginal existence and that their mortality rate is unreasonably high. However, reported kitten mortality rate was consistent with reported rates for similarly sized wild carnivores,[27,28] suggesting that the living conditions of free-roaming cats are comparable to those of other wildlife. It also suggests that the assessment and management of feral cat colonies with methods developed for studying other small wild carnivores are appropriate. Results of the present study provide information needed to develop reliable estimates of the impact of reproduction by sexually intact free-roaming domestic cats in rural and suburban regions of the southeastern United States.

[a]Liberg O. *Predation and social behavior in a population of domestic cats: an evolutionary perspective*. PhD dissertation, Department of Animal Ecology, University of Lund, Lund, Sweden, 1981.
[b]Operation Catnip Inc, Raleigh, NC.
[c]StatView 5, SAS Institute Inc, Cary, NC.

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