Vocalizations of feral cats: sexual differences in the breeding season

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Abstract. The vocalizations of mature feral cats, *Felis catus*, were analyzed based on sound spectrograms and behavioral interactions, focusing on sexual differences. Both males and females produced three distinct types of loud vocalizations during the breeding season: rutting cry, yowl, and mew. The rutting cry could be distinguished from the other two types by behavioral contexts and spectrographic features. The rutting cry was heard only during the breeding season, whereas the other two types were heard throughout the year. These results suggest the existence of a loud vocalization specific to the breeding season in feral cats. Males produced rutting cries more often than females.

Key words: breeding season, *Felis catus*, feral cat, sound spectrogram, vocalization.

Sex-based behavioral differences during the breeding season include unique vocalizations. Understanding these differences is important for a complete understanding of breeding behavior (Alcock 1998). In mammals, males and/or females use vocalizations as mating signals between individuals or groups. For example, male red deer, *Cervus elaphus*, with its high roaring rate, attract and copulate with many females (McComb 1991), while female African elephants, *Loxodonta africana*, produce a chorus to attract males paired with other females (Poole et al. 1988). Vocalizations are also used as spacing mechanisms, such as the howling used by resident packs of coyotes, *Canis latrans*, between territories (Gese and Ruff 1998), and in the long calls of orangutans, *Pongo pygmaeus*, between males (Mitani 1985).

There is confusion, however, regarding which sex of feral cats, *Felis catus*, produces a loud vocalization specific to the breeding season. Many researchers studying the mating behavior of feral cats have argued that females produce loud vocalizations specific to the breeding season to advertise their receptivity to males (e.g. Moelk 1944; Leyhausen 1979; Bradshaw 1992). One of these studies mentioned nothing on the loud vocalizations of males during the same season (Leyhausen 1979). The other two studies reported that threatening vocalizations in the non-breeding season were also heard repeatedly in the context of sexual activity (Moelk 1944; Bradshaw 1992). Contrary to these reports, Dards (1983) observed that estrus female cats produced no call, while males often produced a high-pitched cry to attract females.

One major reason for such disagreement may be that previous studies have focused more

on copulatory behavior than on vocalization, thus limiting analysis in three ways. First, previous studies did not analyze the vocalizations objectively with a sound spectrogram or oscillogram, but rather by anecdotal descriptions of very small samples. "Mating-cry" by female cats (Moelk 1944), "female call" (Bradshaw 1992) and "characteristic cry" by males (Dards 1983) may or may not be the same vocalization. Secondly, previous studies did not compare vocalizations during the breeding season with those during the non-breeding season. Therefore, it is not clear whether each of the loud vocalizations was also heard during the non-breeding season. Finally, previous studies did not describe the frequency of each vocalization quantitatively. Therefore, it is unclear which sex produced what vocalizations specific to the breeding season. Even when both sexes produced vocalizations, earlier studies may have recorded only vocalizations by one sex if the sample sizes were small.

To clarify sex-based differences in calls during the breeding season, I gathered quantitative individual calling and other behavioral data on a daily basis. I then applied sound spectrogram analysis to recorded loud vocalizations to discriminate between male and female cats.

Materials and methods

This study was carried out on Ainoshima Island, 7 km offshore from Shingu, Fukuoka Prefecture, Japan (for a detailed area description, see Yamane 1998). Observations were made within a residential area of about 7 ha (Fig. 1). The main breeding season of the feral cat population on the island is from January to May (Yamane et al. 1994). From September 5 to December 29 in 1996, I visited the area for 22 days to observe the behavior of cats preliminarily. During this period, less than 20% of the males that I found courted females. I defined December 30, when more than 20% of the males first courted females, as the beginning of the breeding season and began observations thereafter. I observed cat behavior for 72 days from December 30 in 1996 to March 30 in 1997. After this period, the rate of courting males was not higher than 20% over any eight day period from March 31 to June 26 in 1997. I defined those days with 20% or less of the males courting as the non-breeding season.

In the study area, there were 68 mature cats (41 males and 27 females) and 24 immature cats in 1996–1997. Most of the cats could be easily identified individually by coat color and body features. Mature cats with all black coats (10 males and five females in 1996–1997), all gray coats (four males and two females in 1996–1997) or all white coats (four males and four females in 1996–1997) were fitted with collars for identification.

In the preliminary study, I measured baseline sound levels to distinguish loud vocalizations from other types of vocalizations. I defined "loud vocalizations" as those with a peak of over 70 dB when measured on a digital sound-level meter (Kagaku Kyoeisha, LM-9600, C weighting) at 1 m distance from the vocalizing cat.

As much as possible, I walked a fixed route (about 3 km, Fig. 1) three times a day, randomly between 7:00 and 19:00 every study day. I walked the same route once or twice a day in rough weather. Observations were not made at night because the use of a flashlight disturbed the behavior of cats. I made one observation out of three by the "route census method" and two out of three by the "tracing method" as follows. For the route census method, when I found a cat, I wrote down the name of the cat, the time, the calling behavior

(whether producing any loud vocalizations or not), and the location on a map. I also recorded the behavioral context of the cat producing a loud vocalization as follows: whether walking or not, whether any other actors (other cats or humans) were close to the cat, and the behavior of other cats or humans close to the cat. Using the route census method, I observed for 6,830 minutes in a total of 66 census periods and found an average of 35.5 mature cats per census.

In the tracing method, first I wrote down the same data as with the route census method. If the cat was mature, I started to follow it or stay with it as it called, making recordings of vocalizations with a microphone (SONY, ECM-672) and mini-disk portable recorder (SHARP, MD-MS100-B). If the cat did not produce any loud vocalization during the first five minutes from the beginning of the recording, I ceased recording, returned to the fixed route, and located another cat to observe. If the cat started loud vocalization within the first five minutes, the recording was continued throughout the vocalization and ended after five minutes of silence. Using the tracing method, I spent 7,712 minutes in a total of 54 census periods and found an average of 59.6 mature cats per census. In both methods, when I encountered the same individual twice within ten minutes, I did not use the latter observation for analysis.

Fig. 1. A map of the study area on Ainoshima Island (shaded area). The thick line is the fixed course for the route census. The polygons represent houses.

In addition to the above observations, I recorded vocalizations for 25 days from January 22 to March 31 in 2000, to describe the acoustic features of loud vocalizations spectrographically. During this sampling period, I recorded vocalizations on a digital audio tape recorder (SONY, TCD-D100) using a shotgun microphone (SANKEN, CS-3). The sound data obtained during this period were only used to present sound spectrograms of loud vocalizations and describe acoustic characteristics. Spectrogram analysis was made using Cool Edit Pro (Syntrillium) on a computer, VAIO PCG-861BP (SONY), with a sampling frequency of 22,050 Hz and a bandwidth of 21.5 Hz (1,024 pts). For calls recorded in 1996-1997, sound spectrograms were developed using SoundEdit 16 ver. 1.0 (Macromedia) on a Macintosh Performa 520 (Apple) computer.

Feral cats often produced loud vocalizations consisting of several vocal streaks. In this study, I refer to one vocal streak, such as one mew, as a "call," and note the duration of each call. Some of the calls of recorded vocalizations consisted of two different parts, *i.e.*, the amplitude profiles showed two discrete peaks. I refer to these calls as "two-part calls" and the local minimum of the amplitude profile within a call as the "boundary" between the two parts. For such calls, I measured the duration of the first part between the start and the boundary point of the call and calculated an "individual mean duration" for each cat.

To identify sex-based differences in the frequency of cries, I first calculated a "rutting cry rate" for each mature cat and compared these rates by sex. The "rutting cry rate" is defined by the number of times that a subject cat produced rutting cries at least once in a census, divided by the total number of times that the cat was encountered during the observation period. I calculated a "crying cat rate" for all mature cats pooled on each observation day, and also compared these rates between males and females on a daily basis. The "crying cat rate" is defined as the number of cats that produced rutting cries at least once, divided by the total number of cats that were encountered that day.

Results

Three types of vocalization

It was difficult to distinguish between male and female loud vocalizations aurally. However, three types of loud vocalization by both males and females could be distinguished by behavioral context and by spectrogram signatures (Fig. 2).

The first vocalization type was not heard during the non-breeding season (Fig. 2a; I refer to this as the "rutting cry"). The rutting cry resembled the crying of a human baby. Both males and females produced it as a series of several calls when walking or pausing. Mature males produced it repeatedly throughout the breeding season. The male rutting cry was not associated with any particular behavior of other individuals, such as other cats approaching or vocalizing or humans approaching with food. Females gave a rutting cry during the short receptive period of the breeding season. For the subsequent acoustic analyses, I defined the rutting cry as a vocalization specific to the breeding season, made without regard to the existence or behaviors of other cats or humans.

Two other types of loud vocalization could be heard during both the breeding and the non-breeding seasons (Fig. 2b, 2c). Threatening vocalizations (Fig. 2b) were lasting sounds, like a dog howling. The vocalization was produced by two mature males (or females) in turn when they were staring at each other. The vocalization continued until the

other cat left or the confrontation was interrupted. Because both the behavioral context and the sound spectrogram of this type of vocalization are similar to that of the “yowl” in lynxes as described by Peters (1987), it is hereafter referred to as a “yowl”. Yowls are defined as vocalizations alternately produced by two cats in confrontation.

Vocalizations associated with begging for food (Fig. 2c) were not always loud. This vocalization was produced by both mature and immature cats in response to the smell of food or sounds related to food, such as the rustle of plastic bags. It was continuously produced while the cats were within a confined area while a human fed them or until they gave up begging for foods. It is hereafter referred to as “mew” because its behavioral context and sound spectrogram are similar to those of the “mew” described by Peters (1987) in lynx. Mew was defined as vocalizations produced when a cat begged for foods from humans.

Spectral features

Rutting cries and yowls often included a boundary between two different parts with harmonics (Fig. 2a, 2b). A series of rutting cries sometimes had both two-part and one-part calls (Fig. 2a). In rutting cries, the duration of a call was shorter and the modulation of the

Fig. 2. Typical sound spectrograms of feral cat vocalizations. Calls on each sound spectrogram were produced repeatedly by the same male cats. (a) Rutting cry, (b) yowl, and (c) mew. The closed triangle indicates the boundary between two parts within one call. The open triangle is the end of a call which does not have a second part.

fundamental frequency in one call was relatively smaller than in yowls (Fig. 2a, 2b). On the other hand, yowls had very long duration and the modulation of the fundamental frequency often had several discrete peaks within one call (Fig. 2b). A mew call had short duration and consisted of one part (Fig. 2c). The fundamental frequency in a mew had a single peak and the frequency at the peak was relatively higher than that of the other two types (Fig. 2c).

Difference between rutting cry and yowl

Out of 41 observed males, rutting cries were recorded for 17 males and yowls for 13 males. Out of 27 observed females, rutting cries were recorded for only 2 females and yowls from 3 females. Because the sample sizes of both rutting cry and yowl by females were small, only the data from males were used to assess the duration of the rutting cry. I calculated the individual mean duration of twenty two-part calls chosen randomly from all the sound data for each cat. The mean yowl call duration across all individuals (2.391 ± 1.259 s, mean $\pm$ SD, $n=13$) was significantly longer than that of the mean rutting cry call (0.566 ± 0.288 s, $n=17$; Mann-Whitney U -test, $U=12850$, $P<0.0001$). Six males produced both of these vocalizations, allowing for the comparison of rutting cries and yowls produced by the same individual. The mean duration of the first part of a two-part yowl call was also significantly longer than that of the rutting cry for all of these six males (Wilcoxon signed rank test, $T=0$, $n=6$, $P<0.05$).

Difference in rutting cry rate and crying cat rate between males and females

The mean rutting cry rate of males (0.112 ± 0.099 , $n=41$) was higher than that of females (Fig. 3; 0.055 ± 0.041 , $n=27$; Mann-Whitney U -test, $U=397.5$, $P<0.05$). On 45 days during the observation period, I could observe both males and females. When the crying cat rates between males and females on each of the days were compared, the male rate was higher than the female rate during the breeding season (Fig. 4; Wilcoxon signed rank test, $z=-4.289$, $n=45$, $P<0.0001$).

Discussion

In many mammals one sex makes special vocalizations specific to the breeding season, usually as mating signals (Mitani 1985; Poole et al. 1988; McComb 1991; Gese and Ruff 1998). In the present study of feral cats, both mature males and females produced loud rutting cries, and males produced them more often than females. Feral cats also produced distinguishable yowls and mews, which were not specific to the breeding season.

Previous studies reported that all male loud vocalizations during the breeding season were comprised of threatening vocalizations ("yowl" in this study), and that these were also heard during the non-breeding season (Moelk 1944; Bradshaw 1992). The present study, however, demonstrates that mature males produce a rutting cry which is specific to the breeding season and different from the yowl.

Several previous studies have argued that loud vocalizations were produced only by female cats (Moelk 1944; Leyhausen 1979; Bradshaw 1992), while another study argued that it was produced only by males (Dards 1983). These are apparently inconsistent with the present result that the rutting cry was produced by both sexes. This disagreement may reflect behavioral variations of feral cats among different populations, or may be a consequence of

the small sample sizes in previous studies. Because the mean crying cat rate of males was very low in this study (about 0.152 per study day; Fig. 4, open circles), it is likely that previous studies simply missed the behavior. Even though both sexes may have produced a rutting cry, small sample sizes may have captured the cries of only one sex.

The intensity and duration of the rutting cry likely requires a substantial output of energy. Since male cats produced the rutting cry more often than females in the present

Fig. 3. Frequency distribution of rutting cry rate. Rutting cry rate was calculated for each cat during the observation period.

Fig. 4. Crying cat rate for all males or females pooled for each day of the observation period. Open circles show male rates; crosses show female rates.

study, there is likely some reproductive gain for this extra expenditure. In a follow-up paper, I will describe the relation between the male rutting cry and mating success in feral cats by means of playback experiments.

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