The reproductive tactics and activity patterns of solitary carnivores – the Iriomote cat

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Abstract

Felids are generally considered to be crepuscular and nocturnal in their activity, but few studies have attempted to analyze the variability of activity patterns. We studied the daily activity of the Iriomote cat *Prionailurus iriomotensis* by radio-tracking on Iriomote Island, Japan. The general activity patterns of Iriomote cats showed slightly prevailing activity during dark periods of the day with particular peaks at dawn and dusk or early hours of the night. However, these patterns were clearly dependent on the sex and reproductive status of the cat. Peaks of cats' activity coincided with those of their main prey. On average, the cats were active for 13 h/day. During the mating season, the rhythm of activity in males followed that of breeding females, but not that of non-breeding ones. Males exhibited an 11% higher total daily activity and longer active bouts during the mating period than in the remainder of the year. Breeding females had an additional mid-day activity peak during nursing period, but their total time of activity per day was 16% lower than in the period of kittens' independence. Their active bouts were shorter and more frequent during nursing than in the other season. These results suggest that lactating females perform frequent movements to and from the den site to care for kittens. During the non-nursing period, females increased their activity, possibly in response to lowered prey abundance and the need of intensive foraging to recover after lactation. Seasonal and sexual variation of activity patterns in the Iriomote cats confirmed the existence of different reproductive strategies in males and females in these solitary carnivores.

Key words: *Prionailurus iriomotensis*, activity rhythm, breeding, mating, predator – prey relationships, reproduction

Introduction

Variation in mammal activity patterns is dependent on a range of environmental circumstances such as photoperiod (Kavanau and Ramos 1975; Beltran and Delibes 1994), temperature (Gębczyński 2006), predator-prey interactions (Cloudsley-Thompson 1961), and competition avoidance (Hayward and Hayward 2007), but they also can be affected by behavioral processes related to reproduction (Schmidt 1999; Zalewski 2001). Felids are generally considered to be crepuscular and nocturnal in their activity (Kitchener 1991), however, they are adapted to function in a wide range of light conditions (Sunquist and Sunquist 2002). On the other hand, detailed knowledge of activity patterns of many felid species and the factors that are shaping them is rather limited.

The Iriomote cat, *Prionailurus iriomotensis*, is a small (3-4 kg) felid endemic to Iriomote island, Ryukyu Archipelago, Japan. Whether it is a full species or a subspecies of the leopard cat, *Prionailurus bengalensis*, has long been debated, but recently it was proposed to be considered as a species with uncertain taxonomic position (*incertae sedis*) (Wilson and Reeder 2005). Its ecology has been studied since the early 1980s (e.g. Yasuma 1981; Izawa et al. 1991; Sakaguchi 1994; Okamura et al. 2000; Nakanishi et al. 2005), however, no data on their daily activity patterns have been presented until now.

The Iriomote cat forages on diverse prey, however it mainly takes key vertebrates available on the Iriomote Island, such as amphibians, reptiles and semi-aquatic birds, but it also takes insects on occasion (Sakaguchi and Ono 1994; Watanabe 2003). The amphibians on Iriomote Island show generally crepuscular and nocturnal activity, whereas some bird species dominating in the cat diet (such as *Rallina eurizonoides*, *Amaurornis phoenicurus* or *Turdus pallidus*) tend to be more active during the morning and late afternoon (Watanabe and Kobayashi 2006). According to the commonly accepted assumption that predators synchronize their activity with that of their main prey (Curio 1976) the Iriomote cats should show peaks in their activity in the twilight or at night, while foraging. Such a pattern was shown for the leopard cat *Prionailurus bengalensis* in Thailand (Rabinowitz 1990; Grassman 2000; Austin et al. 2007) the closest relative of the Iriomote cat (Johnson et al. 1999).

A study on the Iriomote cats' movement patterns (Schmidt et al. 2003) showed that it was highly variable as it changed between seasons and was dependent on the sex and reproductive status of the cats. These results suggested that distances moved, speed of travel and range of daily movements are shaped by reproductive strategies that are different in males and females. Males increased their mobility by covering larger daily ranges and moving faster during the mating period, thus indicating that movement was influenced by the need for contacting females. Females, in contrast, adjusted their behavior to the necessity of tending to kittens and to the abundance of food. Similar causal relationships were suggested by Sakaguchi (1994) for seasonal variation in the Iriomote cats' home range size. Thus, we predict that the daily activity pattern of this felid should be additionally shaped by sex and season.

In this study, our goal was to describe Iriomote cat activity patterns and test our predictions concerning its variation relative to sex, reproductive status, and seasonality. By comparing the daily activity among different cats and periods of the year, we aimed to find out if behavioral strategies related to reproduction that were responsible for variation in the cats' movement distances are also effective in shaping their daily rhythm of activity.

Materials and methods

Study area

The study was conducted on Iriomote Island, located at the southernmost end of the Ryukyu Archipelago of Japan (24º20' N, 123º49'E). The area of the island is 284 km^2 of which 83 % is covered by subtropical evergreen forest. The remaining area is occupied by human settlements and agricultural areas, which are restricted to the eastern and northern coasts. The main vegetation type is deciduous forest dominated by *Castanopsis sieboldii* and *Querqus miyagii*. Lowland wetlands are occupied by swampy forest, with *Pandanus odoratissimus*, *Barringtonia racemosa* and *Cerbera manghas* as the main species. Mangrove forests cover lowlands in estuaries. The interior part of the island is dominated by mountains with a maximum elevation of 469 m a. s. l. The climate is subtropical with a hot summer (April to October, mean temperature: 29°C in July) and a cooler winter (November to March, mean temperature: 17°C in January). The annual rainfall is 2500 mm. The Iriomote cats inhabit the entire island, however, they likely occur at higher densities in the lowland coastal area than in the mountains (Izawa et al., 2000).

Trapping and radio-tracking

Fifteen individuals (9 males and 6 females) were captured during two study periods: 1993 to 1996 and 1999 to 2001. We captured the cats in box-traps equipped with radio-alarm systems and baited with live chicks. Once captured, cats were anesthesized by a professional veterinarian with xylazine-ketamine mixture (ketamine hydrochloride 10mg/kg body weight and xylazine hydrochloride 1.2mg/kg body weight). The age of cats was determined based on tooth wear, body mass and signs of lactation in females. The males were considered adults when they weighed > 3kg. The females were considered subadults if they had no previous signs of lactation (Sakaguchi 1994). All animals were fitted with radio-collars (45-70 g; ATS Inc. Isanti, Minnesota, USA, and custom-made by the authors M.O. and N.N.). We radio-tracked cats in three separate study areas: Komi-Otomi on the eastern coast of the island, Funaura in the north, and Shirahama in the west (Fig. 1).

We located the radio-collared cats by triangulation (White & Garrot 1990) from the nearest accessible roads or trails either by car or on foot. The bearings were plotted on a map (1:10000 with a grid of 500 x 500m) and locations measured to the nearest 10 m. We didn't measure the exact accuracy of radio-fixes in the field due to the inaccessibility of the terrain. However, we could occasionally confirm the accuracy of our radio-locations by sightings of the tagged cats or finding their tracks at a radio-fixed site. Thus we are confident that our accuracy was below the level accepted to determine the cats' activity in this study (see below). To increase the reliability of locations we mainly used those for which three or more bearings intersected at approximately one point when plotted on the map (width of resulting polygon ≤ 10 m). In cases where locations were less accurate, we excluded those in which the longest side of the fixed triangle was longer than half the distance between the position of the observer and the farther apex of the triangle. In the remaining cases, we assumed the position of the animal as the middle of the triangle. When locating moving animals, taking three bearings in time was often not possible, so that such locations were less precise. However, this did not affect the reliability of recording the cat activity as movements were the main index considered in this study.

The range of the transmitters was between 0.1 and 1 km depending on the terrain. While radio-tracking, we tried to maintain a distance of at least 50 – 100 m from the focal animal to avoid disturbing its natural behaviour. On the other hand, occasional sightings of cats suggested that they did not pay much attention to the presence of humans.

We obtained a total of 3263 readings of the Iriomote cats' activity. We recorded the cats' activity during sessions of radio-tracking lasting from 2 to 24 h/day. These included 57 sessions of continuous radio-tracking that covered the entire 24-h cycle (Appendix). During shorter sessions, recordings were made in different periods throughout the 24-h cycle, so that each time unit (we pooled data into 2-h intervals) was represented by a comparable number of readings (mean ± SD numbers of readings per 2-h interval: 174.5 ± 14.0; 56.6 ± 5.0; 40.8 ± 5.4 for males, breeding females and non-breeding females, respectively). Consecutive locations were taken every 0.5-1 h. The activity of the cat was recognized based on the change of location from one record to another. We considered the cat active when it moved ≥ 50 m within a maximum of 1 h. Although we also noted the fluctuation of the strength of radio-signals as an index of animals' activity, we didn't use it for analysis, as we considered it less reliable than that based on actual movements.

For analysis of seasonal variation in the Iriomote cats' activity we used slightly different periods for males and females, based on the reproductive cycle of the cat (Okamura et al. 2000). The following periods were characterised for males: 1) mating – from November to April (increased rate of urine marking), 2) non-mating – from May to October, and for females: 1) nursing – May-August and 2) rest of the year – September-April. While the adjustment of analyzed periods separately for each sex allowed encompassment of their different reproductive activities, the periods distinguished for males and females still largely overlapped, allowing for inter-sexual comparisons in respective seasons. We recognized the reproductive status of females either by radio-tracking data or from photo-trapping. Radio-tracking indicated that a female was breeding when her movements were concentrated around specific sites, whereas photo-trapping provided information on presence of kittens and/or appearance of nipples (Okamura et al. 2000; Okamura 2002).

We tested for differences in patterns of daily activity between cats of different sex and reproductive status and between seasons with the use of the replicated goodness of fit *G* – test. We analyzed the sexual and seasonal variation of duration and number of activity bouts with the Kruskal-Wallis one-way analysis of variance, as the data were not normally distributed. In pair-wise comparisons between groups of cats and seasons, we used the Mann-Whitney *U*-test. For large samples ($N > 20$) we used the normal approximation by calculating the standardized Z - value of the normal distribution.

Results

General patterns of the Iriomote cat activity

The general activity patterns of Iriomote cats showed slightly prevailing activity at dark periods of the day with particular peaks at dawn and dusk or the early hours of the night. However, these patterns were clearly dependent on the sex and reproductive status of the cat (Fig. 2). The adult males showed an apparent bimodal pattern of activity with peaks at dawn and early hours of the night (at 20:00 - 21:00). The main phase of their reduced activity occurred during the day (from 8:00 till 17:00), whereas the second, shorter one was around midnight. In both low activity phases, however, they were still active ≥40% of the time. The adult breeding females had three clear activity peaks with the additional peak around noon (12:00 – 13:00) (Fig. 2). These patterns were generally not statistically different from each other (replicated goodness of fit test, $G = 10.9$, $P > 0.1$, $df = 11$), however females were significantly more active than males at 0:00-1:00, 2:00-3:00, 6:00-7:00 and 12:00-13:00 hours in pair-wise comparisons ($G = 4.3$; 8.3; 4.1 and 13.4, respectively; $0.001 < P < 0.05$, $df = 1$). The overall activity pattern of male cats was, however, significantly different from that of non-breeding females ($G = 36.8$, $P < 0.001$, $df = 11$; Fig. 2). The non-breeding females were also active generally at different times than the breeding ones ($G = 49.8$, $P < 0.001$, $df = 11$) with only the exception of the following hours: 0:00-1:00, 10:00-11:00 and 20:00-21:00 ($G =$ 1.8; 1.3 and 0.2, respectively, $P > 0.1$, $df = 1$).

The cats moved in 55.2% of radio-locations (pooled for all cats) that is 13.2 h/day. The males were active slightly shorter (12.7 h) than both breeding and non-breeding females (14.2 and 14.3 h/day, respectively) per day (Table 1).

Seasonal changes in activity patterns

Males

Adult male Iriomote cats showed significantly different activity patterns between the mating (November-April) and non-mating (May-October) seasons ($G = 28.7$, $P < 0.01$, $df = 11$) (Fig. 3). During mating they had two peaks of activity – at dawn and early night, whereas during the rest of the year they maintained only one distinct nocturnal peak. The males were active for 11% longer during the mating season (Table 1), however this difference was not significant ($G = 0.6$, $P > 0.1$, $df = 1$). The activity rhythm of males during the mating season generally followed that of breeding females in the same time of the year ($G = 16.1$, $P > 0.1$, $df = 11$) (compare Fig. 3a and Fig. 4b), but not that of non-breeding females ($G = 36.8$, $P < 0.001$, $df = 11$) (compare Fig. 3a and Fig. 2). In the remaining period (May-October), that included the nursing period in females, the activity rhythms of males and breeding females were different ($G = 32.9$, $P < 0.001$, $df = 11$) (compare Fig. 3b and Fig. 4a). Males were then particularly less active than females during nocturnal hours (from 0:00 till 7:00; G values in pair-wise comparisons from 12.2 to 18.3, $P < 0.001$, $df = 1$) and at the time of the females' additional midday peak (12:00-13:00; $G = 12.5$, $P < 0.001$, $df = 1$).

Females

Breeding female Iriomote cats showed different activity rhythms during the nursing period (May-August), as compared to the rest of year (kittens' independence: September-April) (G = 28.0, $P < 0.01$, df = 11) (Fig. 4). The activity rhythm during the nursing period had an additional conspicuous peak at 12:00-13:00, however the significant differences between periods occurred only in the morning (8:00-9:00; G = 34.6, $P < 0.001$, df = 1) and evening hours (18:00-19:00 and 20:00-21:00; G = 8.8, $P < 0.01$, and G = 41.5, $P < 0.001$, respectively, df = 1) with reduced activity during nursing (Fig. 4). Breeding females showed different activity patterns from that of non-breeding females during the period of kittens' independence (G = 65.1, $P < 0.001$, df = 11) (no activity data were available for non-breeding females in May-August). Breeding females were more active than non-breeding ones during the late night and morning hours (G from 5.0 to 65.6, $0.001 < P < 0.05$, df = 1), whereas they were less active in the afternoon (14:00-15:00 and 16:00-17:00; G = 7.9 and 8.2, respectively, $P < 0.01$, df = 1) and before midnight (22:00-23:00; G = 24.9, $P < 0.001$, df = 1).

The total duration of the breeding females' daily activity was 16% shorter (although not significantly: G = 1.5, $P > 0.1$, df = 1) during the nursing period than at the time of kittens' independence (Table 1). Non-breeding females, on the other hand, in September-April, had a 12% shorter (but also not significantly: G = 0.8, $P > 0.1$, df = 1) total daily activity than breeding females, which was comparable to that of breeding females in May-August (Table 1).

Variation in activity bouts

The activity of Iriomote cats was characterized by bouts of continuous movements ranging from 0.17 to 9.05 h, alternated with resting bouts (0.25 – 14.42 h) throughout the day (Table 2). The duration of activity bouts was, however, dependent on the cat's sex, reproductive status and the season of the year (Kruskal-Wallis one-way analysis of variance, $H = 21.36$, $P < 0.001$, $df = 4$). The same factors influenced the duration of resting bouts ($H = 12.65$, $P = 0.01$, $df = 4$), but not the number of bouts ($H = 8.85$, $P = 0.07$, $df = 4$). The longest average (± SD) duration of active bouts occurred in breeding females during the period of kittens' independence (3.4 ± 2.8 h), whereas the shortest activity bouts were with males during the non-mating season (1.5 ± 1.2). Males had generally shorter average movement bouts than breeding females (1.95 ± 1.7 h and 2.69 ± 2.31 h, respectively; Mann-Witney *U*-test, $Z = -2.79$, $P = 0.005$, $df = 1$). Males were also more frequently active per day than females (but insignificantly; $U = 240$, $P > 0.1$; 5.6 ± 1.8 and 4.9 ± 1.8, respectively).

During the mating season, the male active and resting bouts were significantly longer ($Z = 3.13$, $P = 0.002$, and $Z = 3.35$, $P = 0.001$, $df = 1$, respectively), and the number of active bouts was fewer ($U = 82.5$, $P = 0.02$, $df = 1$) than during other parts of the year (Table 2). The duration of active bouts of males was shorter than those of breeding females in respective seasons ($Z = -2.28$, $P = 0.02$, and $Z = -2.88$, $P = 0.004$, $df = 1$, for mating and non-mating period, respectively). In contrast, no difference in the duration of active bouts during the mating (= non-nursing) period was found between males and non-breeding females ($Z = -1.49$, $P = 0.14$, $df = 1$).

Breeding females moved in shorter and more frequent bouts during the nursing period than during other months, although these differences were not significant ($Z = -1.82$, $P = 0.07$, $df = 1$ and $U = 20.0$, $P = 0.08$, $df = 1$, respectively) (Table 2). On the other hand, their movement bouts during the non-nursing period were significantly longer than those of non-breeding females ($Z = 2.6$, $P = 0.009$, $df = 1$).

Discussion

Although the daily activity pattern of Iriomote cats varied greatly depending on sex, reproductive status and season, it can be generally characterized as crepuscular and nocturnal. When compared with available literature data on activity of the cats' main prey species, this pattern seemed to follow the periods of peak activity of prey. The evening peak in cat activity (19:00-21:00) coincided with one of peaks of vocal activity of several amphibian species recorded on the Iriomote island: *Rana supranarina*, *Rhacophorus owstoni* and *Microhyla ornata* as well as some orthopteran insects, which were found it the cat diet (Watanabe 2003; Watanabe and Kobayashi 2006). The morning peak in cat activity (at 6:00-7:00), however, occurred during a period of high activity of two *Rallidae* bird species that were often hunted by Iriomote cats (*Rallina eurizonoides*, *Amaurornis phoenicurus*) (Sakaguchi and Ono 1994, Watanabe 2003, Watanabe and Kobayashi 2006). No published data are available on the daily activity of reptiles, such as skinks, agamids and snakes (e.g. habu *Trimeresurus elegans*) on the island, that constitute an important part in the Iriomote cat diet (Watanabe 2003). Some reptiles, however, were nocturnal, as indicated by our field observations (Watanabe and Izawa 2002) and by the results of a telemetry study on habu *T. flavorodis* on Amami Island (Wada et al. 1970).

The relationship between the activity of predators and those of its main prey has been suggested by many authors (Curio 1976, Karanth and Sunquist 2000, Scognamillo et al. 2003), however the final outcome can be blurred by various factors, such as potential competitive or predatory interactions among coexisting carnivores (Cloudsley-Thompson 1961), hunting strategy or climate (Hayward and Hayward 2007). In complex ecosystems, detecting the relationship between the predators' and their prey activity rhythm may not be even feasible as it was for the pine marten *Martes martes* in Poland (Zalewski 2001). In some instances, the synchronization of predator and prey activity is not realistic, especially in the case of large carnivores, such as the Eurasian lynx *Lynx lynx*, feeding on ungulates, because the prey is more alert when active (Schmidt 1999). Also, the smallest carnivore, the least weasel *Mustela nivalis*, was found to be active independently of the activity of rodents (their principal prey) as they hunted them in their burrows (Jędrzejewski et al. 2000). The Iriomote cat feeds on small prey and is the only carnivore living on the island, thus it is likely that the coincidence of its activity pattern with those of its main prey is real, as it is not affected by neither competition nor predation.

Iriomote cats were active for a similar amount of time, as previously reported for several populations of another small felid – such as the leopard cat in the tropical environments of Thailand (i.e. from 47 to 52% of the recorded time: Rabinowitz 1990; Grassman 2000; Grassman et al. 2005; Austin et al. 2007). Also ocelots *Leopardus pardalis* showed a similar level of activity (40-58%: Ludlow and Sunquist 1987; Crawshaw and Quigley 1989). In contrast, other, larger cats, such as the Eurasian lynx were active for only 27% of records per day (Schmidt 1999). The lynx usually killed prey larger than themself (ungulates: Okarma et al. 1997) that provided them with food for several days, which allow long periods of inactivity. Yet lower duration of daily activity was found in feral domestic cats *Felis catus* (20%: Izawa 1983) in Japan, where their population was sustained on an artificial, rich and permanently available food resource. Thus, the amount of daily activity of predators seems to be related to the type and accessibility of food. A relatively high level of daily activity is likely characteristic for small felids that are dependent upon a variety of natural, yet smaller prey animals (from insects to small mammals: Rabinowitz 1990, Grassman 2000, Watanabe 2003, Ludlow and Sunquist 1987).

Our results showed that besides the effect of prey activity, the circadian rhythm of the activity of Iriomote cats can be explained by factors related to reproduction. It was conspicuous that male cats followed the activity patterns of breeding females only during the mating season, and were not active at the same time as non-breeding ones. This indicates that searching for receptive females could drive male cat activity. The seasonal variation in male activity pattern, including total duration of daily activity as well as the duration and number of single bouts shown in this research fits very well into the seasonal pattern of movements determined by us in an earlier study (Schmidt et al. 2003). Male cats apparently responded to the changes in their reproductive cycle (Okamura et al. 2000) by accelerating and expanding movements during mating season. The home ranges of male Iriomote cats' overlapped those of females to a similar extent during all seasons (Sakaguchi 1994), however their core areas overlapped extensively only during mating, which was when close encounters also occurred between them (Okamura 2002). These findings are in accordance with the prediction made by Sandell (1989) saying that the reproductive tactics in males and females of solitary carnivores should influence their use of space in different ways.

Peculiarities of female Iriomote cat activity pattern can be also clearly explained in light of Sandell's (1989) prediction. He predicted that, in contrast to males that rely on access to females, it is food availability and distribution that determines female reproductive success. This is because females are solely responsible for providing food for their offspring in solitary carnivores. Indeed, in this study, only the breeding female Iriomote cats showed an additional mid-day peak of activity. Moreover, this peak was only clear during the nursing period. It is reasonable to assume that during the day lactating females have to frequently move to and from the den site to nurse kittens and obtain sufficient food to sustain themselves, and at a later stage to provide solid food for kittens (Okamura 2002). This increased activity pattern was also seen in shorter, but more frequent activity bouts per day during nursing than at the time of kittens' independence. It may seem, however, surprising that the general level of breeding females' activity was lower during nursing than at other times. On the other hand, it must be noted that the nursing time coincides with the period of highest food availability on the island (Sakaguchi 1994, Watanabe et al. 2005). Thus, females may not need to go far from kittens to satisfy their energetic needs – they leave kittens often, but only for a short time. Indeed, the daily ranges of female movements were smallest during that period (Schmidt et al. 2003). Also, the high food availability could allow cats to forage very close to the dens, so that some movements within a radius of 50 m from the den may not have been detected. On the other hand, the overall longer time of females' activity during the period of kittens' independence may be due to two reasons. First, it's likely that a lower food abundance resulted in the necessity of traveling farther in search for prey – the daily movement ranges were then, indeed, larger relative to nursing time (Schmidt et al. 2003). The second reason, however, could be higher energetic needs by females to recover after the exhausting period of lactation. The fact that non-breeding females were less active than breeding ones at that time may also support this latter assumption.

Previous data on seasonal changes in activity levels of the closely related leopard cat (Rabinowitz 1990, Grassman 2000, Grassman et al. 2005, Austin et al. 2007) provided somewhat contradictory results to ours showing either a lack of seasonal change or lower activity during cooler (dry) season. It is, however, worth noting that in those studies the data for all cats were pooled for analyses and no information were given as to their reproductive status. Our research emphasized great variability in activity patterns related to sex and reproductive status of the cats.

Daily activity in small carnivores can also be considerably influenced by ambient temperature, as was shown by Zalewski (2000) for pine marten in Poland, which dramatically reduced their activity time during the non-breeding period (winter), despite a simultaneous decrease in food abundance. In that study, however, there were severe differences in average monthly temperatures between warm (22.5°C) and cold (- 8.5°C) seasons (Zalewski 2000). A significant negative influence of the temperature on activity patterns was also found in feral domestic cats (Izawa 1983). Due to relatively low amplitude of temperatures on Iriomote

Island, the results obtained in our research were more likely to discern the effect of reproductive status of the cat on its activity.

Since the publication of Sandell's (1989) theory on the influence of different mating tactics on the spacing patterns in male and female solitary carnivores, there has been an increasing amount of empirical evidence that reproductive strategies have an even wider influence on animal behavior. Besides its apparent effect on space use in various predators (Sakaguchi 1994; Schmidt et al. 1997; Kovach and Powell 2003; Baghli and Verhagen 2004; Herfindal et al. 2005), reproductive strategies have been found to influence the activity patterns in the Eurasian lynx (Schmidt 1999) and pine marten (Zalewski 2000, 2001). Such effects were also shown for movement patterns in the lynx (Jędrzejewski et al. 2002) and Iriomote cats (Schmidt et al. 2003). These studies documented that, indeed, different reproductive strategies of male and female solitary felids are clearly seen in their various life history traits. Our present study has contributed to this knowledge by providing information on the Iriomote cat activity that was not available to date and revealing its sexual and seasonal variability. However, due to a limited sample size our results should be treated as tentative and more research is still needed to provide further evidences on this issue.

Acknowledgements:

The field work was carried out using the facility of the Iriomote Station, Tropical Biosphere Research Centre of the University of the Ryukyus, through the courtesy of Prof. Tokushiro Takaso. We are greatly indebted to Prof. Hidetoshi Ota for his generous support during our study. We thank Prof. Masao Akuzawa and his assistants for tranquillising cats and care on animals when sedated. We are grateful to Dr. Lon I. Grassman and Dr. Matt W. Hayward for improving the English of the first draft and their valuable comments. We greatly appreciate comments by two anonymous reviewers. This study was partly supported by Grants-in Aid for Scientific Research from the Ministry of Education, Science and Culture of Japan (No.11480152) and by the 21st Century COE program of the University of the Ryukyus.

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Table 1. Total duration of activity per day in the Iriomote cats shown as a percentage of active radio-locations (%) and time active (in hours). Note, the number of individuals does not equal the total number of radio-tracked individuals as two breeding females (E18 and RR, see Appendix) were not reproducing for one year, and thus were scored as both breeding and non-breeding in different years. (-) lack of data.

Cat sex/reproductive status (number of individuals)	Mating/non-nursing season			Non-mating/nursing season			Whole year		
	%	hours	*N*	%	hours	*N*	%	hours	*N*
Adult males (n=9)	54.4	13.1	1484	49.0	11.8	610	52.9	12.7	2094
Adult breeding females (n=3)	64.4	15.5	264	55.9	13.4	415	59.2	14.2	679
Adult non-breeding females (n=5)	58.1	13.9	415	-	-	-	59.4	14.3	490

Table 2. Duration (hours) and number of activity bouts (mean ± SD) in the Iriomote cats. Minimum and maximum values are given in parentheses. Numbers of locations are in italics. No data were available for non-breeding females during the nursing period.

Activity parameter	Males		Breeding females		Non-breeding females
	Mating	Non-mating	Nursing period	Non-nursing period	Non-nursing period
Duration of active bouts	2.21±1.89 (0.33-9.05) *163*	1.49±1.20 (0.17-7.33) *93*	2.34±1.93 (0.50-8.00) *51*	3.36±2.83 (0.42-11.67) *26*	1.98±1.98 (0.37-7.92) *40*
Duration of inactive bouts	2.01±2.03 (0.25-14.53) *176*	1.46±1.85 (0.25-14.42) *94*	1.80±1.72 (0.25-9.00) *57*	1.56±1.46 (0.33-6.58) *32*	1.90±2.43 (0.28-10.80) *42*
Number of active bouts/day	5.17±1.54 (3-9) *29*	6.82±2.04 (3-9) *11*	5.67±1.37 (4-8) *6*	3.75±1.50 (2-5) *4*	6.00±2.89 (2-10) *7*

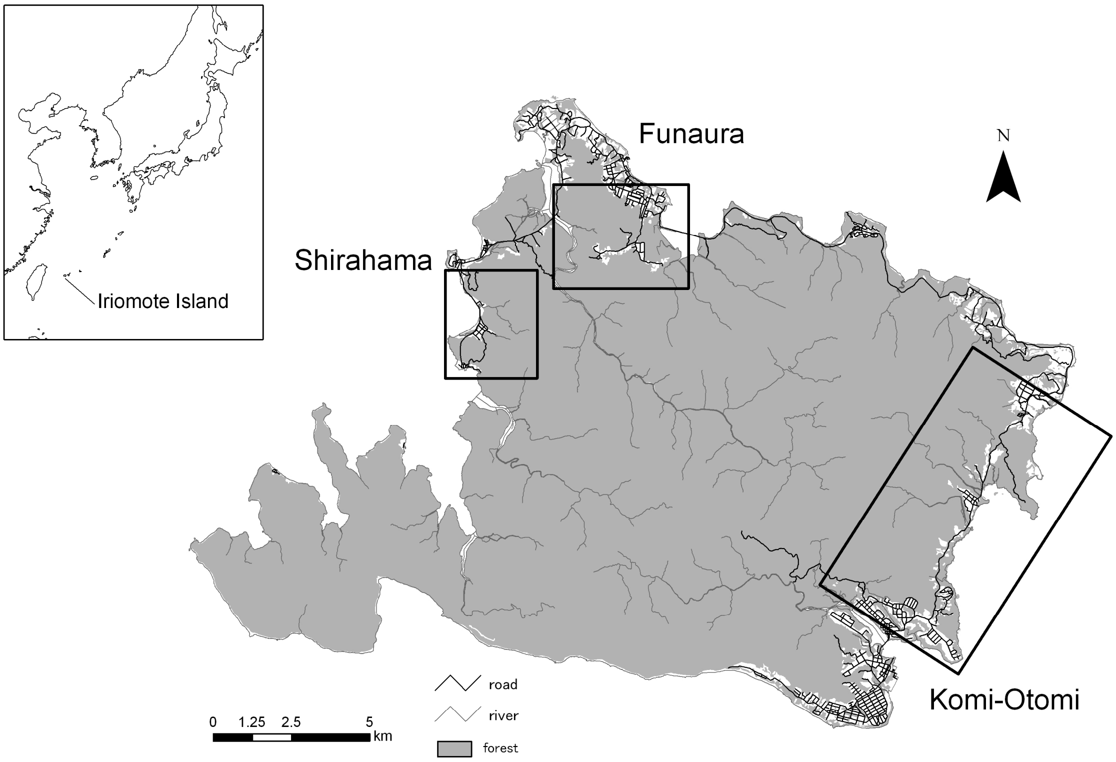
Figure captions:

Fig. 1. Map of the Iriomote Island (Ryukyu Archipelago, Japan) showing location of three study areas.

Fig. 2. The activity patterns of Iriomote cats with division of sex and reproductive status of females (adult males, $N = 9$, adult breeding females, $N=3$, adult non-breeding females, $N=5$). Data are pooled in 2-h intervals and expressed as percentages of activity readings recorded when cats moved ≥ 50 m from one location to another within a maximum of 1 h. Grey bars illustrate duration of night with ranges of sunrise and sunset times. Data for non-breeding females include only non-breeding season (September-April).

Fig. 3. Seasonal changes in activity patterns of adult male Iriomote cats. a – mating season (November – April); b – non-mating season (May-October). See Fig. 2 for other explanations.

Fig. 4. Seasonal changes in activity patterns of adult breeding female Iriomote cats. a – nursing season (May – August); b – non-nursing season (September – April)). See Fig. 2 for other explanations.



Iriomote Island
Funaura
Shirahama
Komi-Otomi
N
road
river
forest
0 1.25 2.5 5
km

Fig. 1

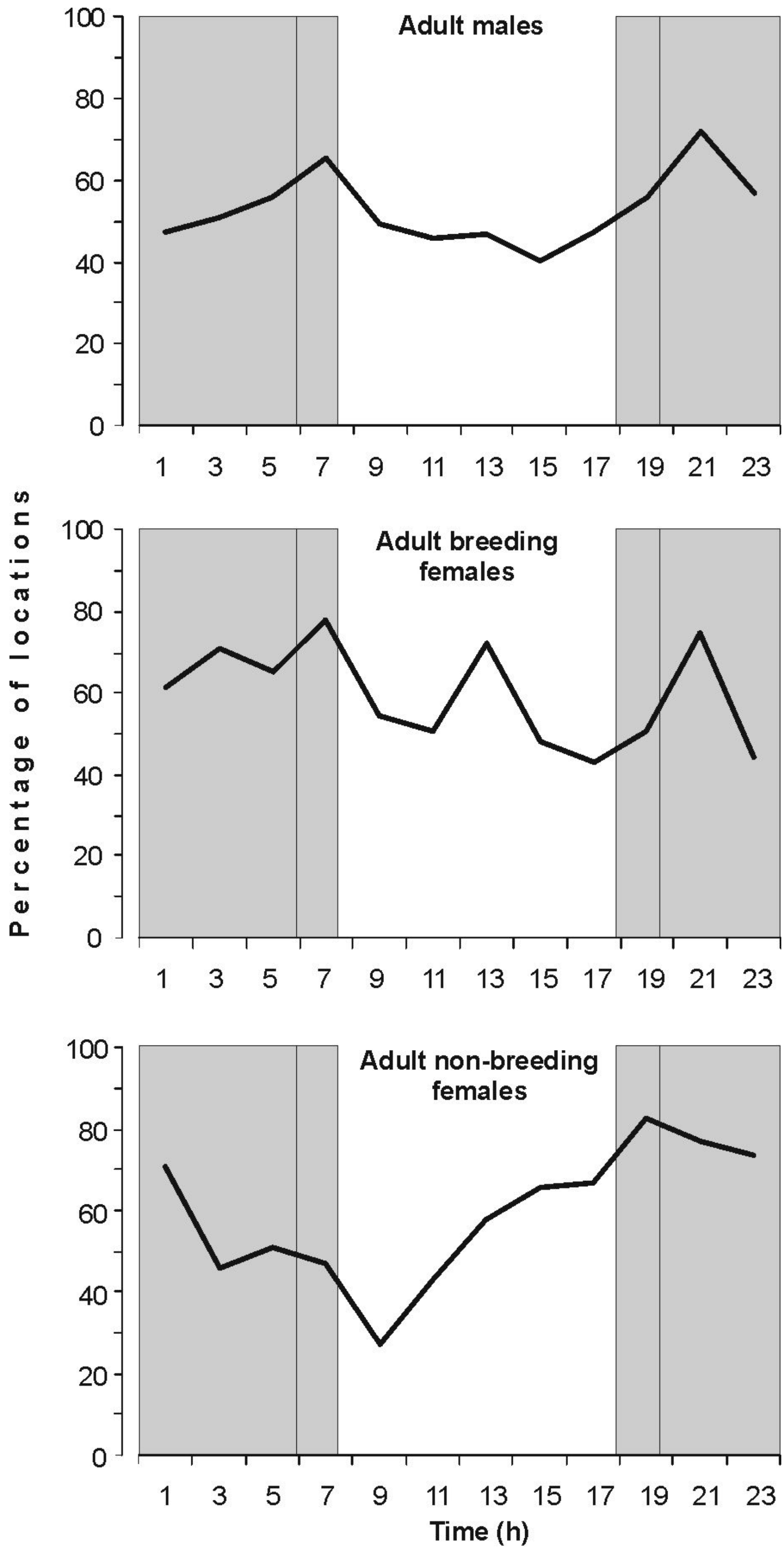
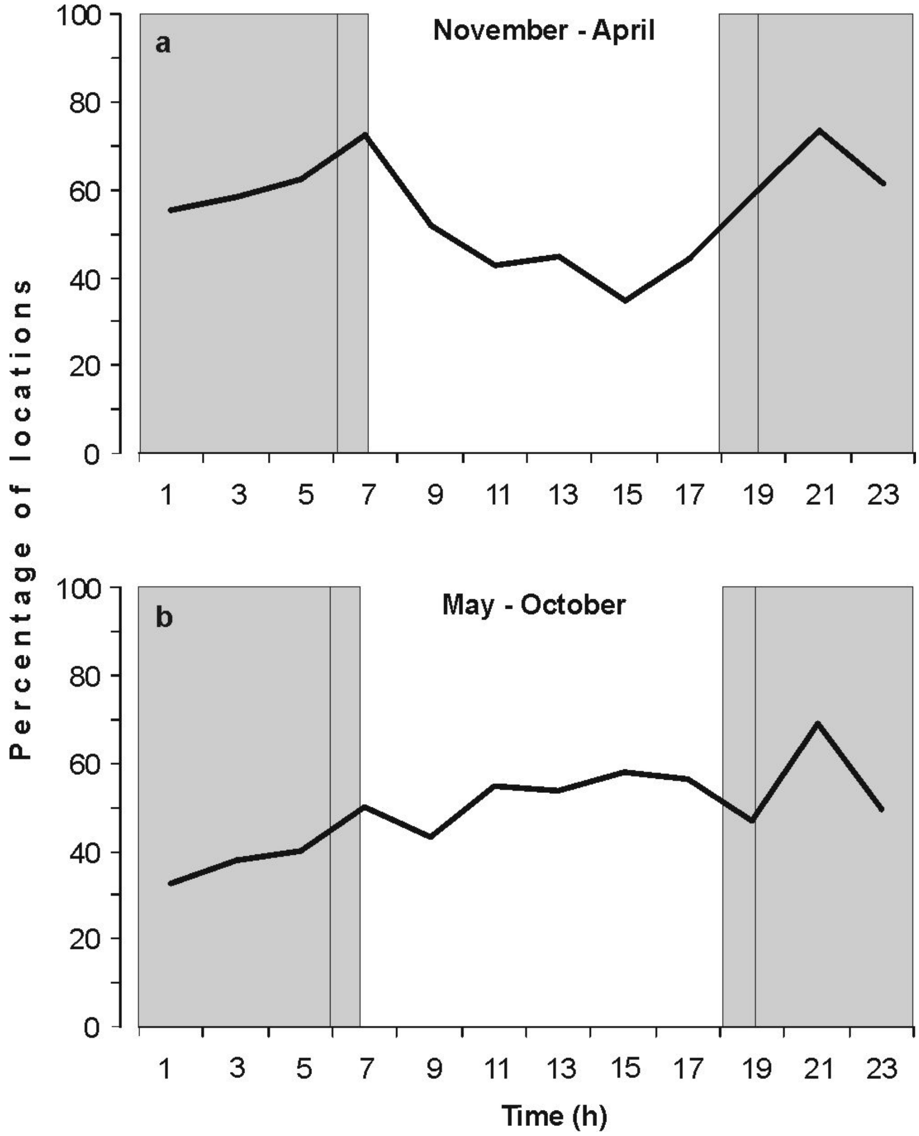
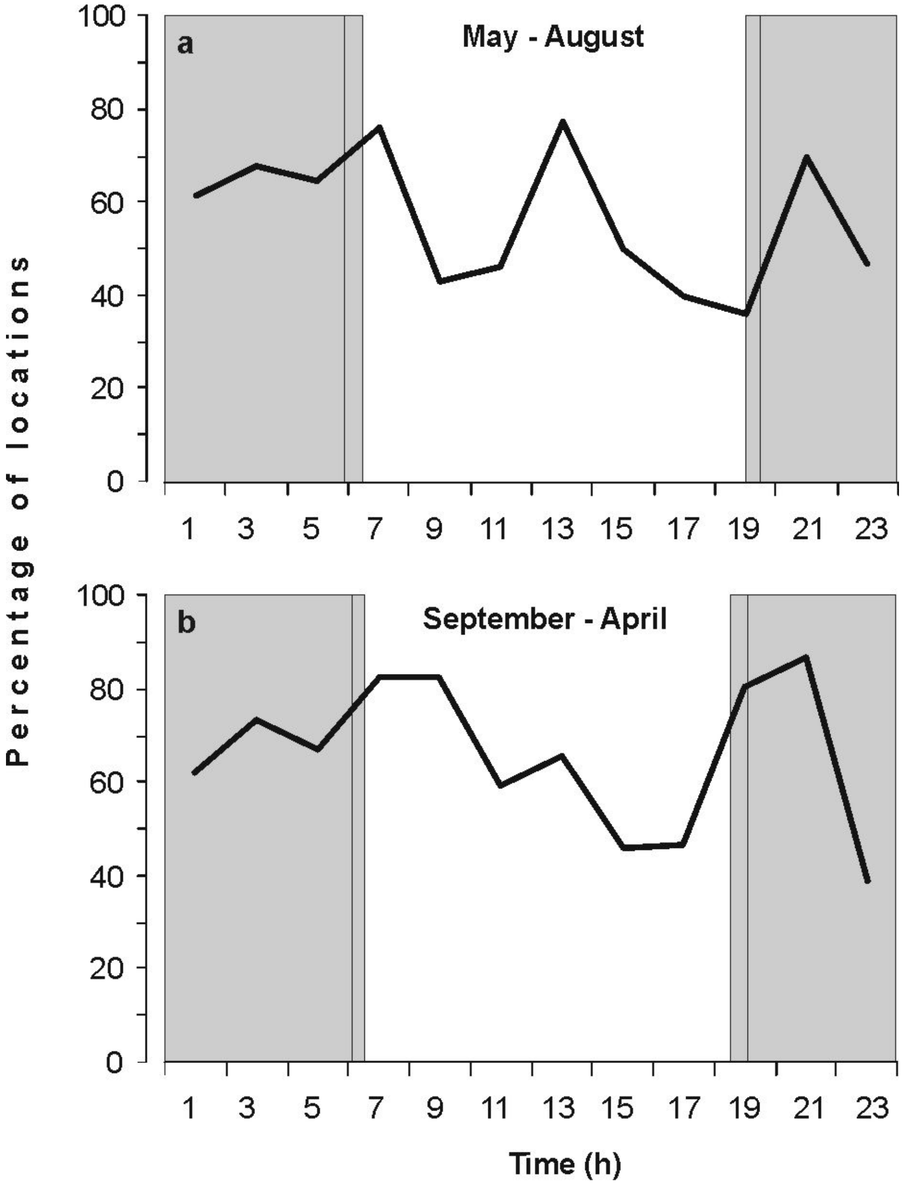

Adult males
Adult breeding females
Adult non-breeding females
Percentage of locations
0
20
40
60
80
100
1
3
5
7
9
11
13
15
17
19
21
23
Time (h)

Fig. 2



a
November - April
b
May - October
Percentage of locations
100
80
60
40
20
0
1
3
5
7
9
11
13
15
17
19
21
23
Time (h)

Fig. 3



a
May - August
b
September - April
Percentage of locations
100
80
60
40
20
0
1 3 5 7 9 11 13 15 17 19 21 23
Time (h)

Fig. 4

Appendix. Adult Iriomote cats radio-tracked for a study of activity patterns from 1993-2004, Iriomote Island, Japan. An asterisk indicates female reproducing during at least one year of the study period.

Cat's ID	Sex	Time of monitoring	Number of locations	Number of 24-h radio-tracking sessions
RR *	F	6 Nov 1993 – 21 Oct 1996	83	-
BB	F	6 Nov 1993 – 7 Nov 1995	61	-
SN	M	9 Mar 1995 – 17 Oct 1996	10	-
W-60	F	5 Mar 1999 – 6 Nov 1999	125	2
E-18 *	F	4 Jun 1999 – 22 Oct 2000	348	6
E-30	M	28 Aug 1999 – 9 Nov 2004	555	5
E-36	F	18 Oct 1999 – 22 Oct 1999	48	-
E-33	M	31 Oct 1999 – 22 Dec 2001	83	-
Omo	M	20 Jun 2000 – 29 Jul 2000	94	1
Oki	M	29 Jun 2000 – 2 Dec 2000	103	1
Yonku	M	15 Jun 2000 – 8 Mar 2001	1118	33
Nene *	F	26 Jun 2000 – 15 Feb 2001	504	9
W-89	M	21 Nov 2001 – 5 Mar 2002	39	
W-86	M	22 Nov 2001 – 31 Jan 2002	57	-
W-81	M	24 Nov 2001 – 6 Mar 2002	35	-