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**Short communication**

# Broad-leaved forest selection of the Japanese marten (*Martes melampus*) in central Japan revealed by camera trapping

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The Japanese marten *Martes melampus*, a small carnivore in the family Mustelidae, is endemic to Japan. Two endemic subspecies have been described: *M. m. melampus* of Honshu, Shikoku, Kyushu, and adjacent islands, and *M. m. tsuensis* of Tsushima islands located between Kyushu and the Korean Peninsula (reviewed by Masuda [2009]). Both taxa have been described as generalists with regards to their food habits; their primary or secondary food items consist of small mammals, fruit and insects (Yamagishi 1990; Tatara and Doi 1994; Nakamura et al. 2001; Arai et al. 2003; Zhou et al. 2010).

Tatara (1994) used radio-telemetry to investigate marten habitat selection, and showed that *M. m. tsuensis* preferred to forage and rest in deciduous and evergreen broad-leaved forests, and avoided coniferous plantations and open fields. For *M. m. tsuensis* forest edge was categorized as the most critical factor affecting home range size in relation to food and resting site availability. However, there is no information on the habitat selection of nominate *M. m. melampus*.

The topography of much of Japan consists of steep mountainous terrain. That topography, combined with Japan's intensely seasonal climate (which includes periods of high precipitation during the annual rainy season, typhoon season and very snowy winters), and the low density and wide ranges of Japanese carnivores makes studying those carnivores extremely difficult, even when using radio-telemetry (Ikeda 1985; Kaneko et al. 1998). Whereas radio-telemetry is difficult under these circumstances, the use of camera traps is ideal for research into such elusive species, such traps offer many advantages: they are not invasive, they detect multiple species, the photos serve as permanent records, and they require minimal labor (Kays and Slauson 2008). Camera traps have been in common use for surveys of American mustelids since the 1990s (e.g., Bull et al. 1992; Moruzzi et al. 2002, 2003). However, camera traps have not previously been used for studies of the Japanese marten.

In this paper, we used, for the first time, camera traps to record the presence or absence of Japanese martens in a mountainous region of central Honshu. We also examined whether data from camera traps were sufficient to reveal marten habitat preferences.

## Methods

*Study area and camera traps*

The survey was conducted in an approximately 10,000 ha government-owned forest known as Akaya, in the southern Mikuni mountains, on the border between Gunma and Niigata prefectures (36°40'N, 138°59'E at Minakami, Fig. 1). The elevation of the forest ranges from 560 m to 2,026 m, and 61% of the forest consists of primary and secondary stands of beech *Fagus crenata*. The subalpine meadows above the tree line in these mountains support a sub-alpine plant community consisting of alpine meadow plants and dwarf bamboo species (*Sasa* spp.) (Fig. 1b; Table 1). Conifer plantations of Japanese cedar *Cryptomeria japonica* and Japanese cypress *Chamaecyparis obtusa* occur at lower elevations. The mean monthly annual temperature ranges from –1.2°C (January) to 22.8°C (August), and annual precipitation is in the region of 1,733 mm (1981–2010, Japan Meteorological Agency) and falls mostly during summer

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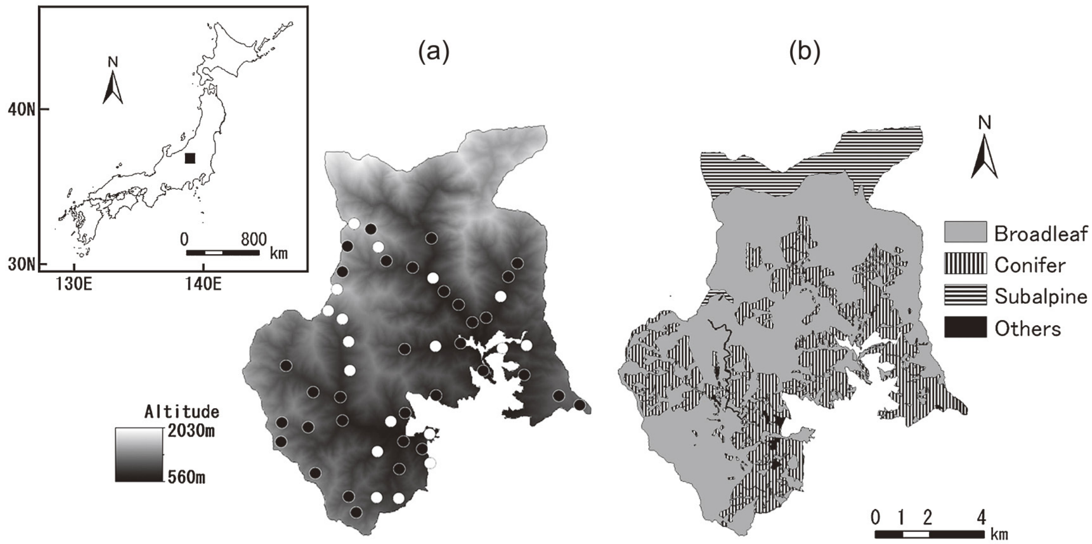


**Fig. 1.** (a) Altitude, and localities of camera traps operated to detect the occurrence of Japanese martens *Martes melampus*, 2008–2010, Akaya, central Japan. Black circles indicate cameras where martens were recorded, while open circles indicate where none were recorded. (b) Land use map of the study area. Definition of the land use types associate with Table 1 and the category "Others" include residential area, national road, farm grassland, ski slopes and waste land.

**Table 1.** Definition of land use in Akaya, Gunma Prefecture, Japan

| Land use | % of area | Characteristics |
|---|---|---|
| Broadleaf | 61.5 | Natural and secondary woodlands mainly composed of beech (*Fagus crenata* and *F. japonica*) and oak (*Quercus crispula* and *Q. serrata*) |
| Conifer | 27.6 | Artificial forest with Japanese cedar (*Cryptomeria japonica*), Japanese cypress (*Chamaecyparis obtusa*) and Japanese larch (*Larix kaempferi*) |
| Town and farmland | 0.3 | Residential area, national road and farmland |
| Grassland | 0.1 | Open habitat including grassland, ski slope and waste land |
| Subalpine | 10.5 | Alpine meadow and field of dwarf bamboo (*Sasa* spp.) generated by heavy snowfall |

and winter. Maximum snowfall has reached 150 cm in Minakami (10 km north of the study area, at 530 m in elevation). The study area contains few domestic residences, lodges, and some farmland.

Fifty-one camera traps (Field Note II, Marifu Co., film type) were set along mountain roads or trails, with consideration of accessibility for workers, and avoiding steep/rocky areas (Fig. 1). The study area was divided using a 1 × 1 km mesh from which we selected 51 squares crossed by mountain/forest roads as sites accessible by researchers. In each grid square, a camera trap was set at the nearest road from the centre of the square. At each camera trap site, we set a camera at a height of 1.3 m in a tree along the nearest animal trail.

The camera traps were set for four periods: in early October 2008, mid-August 2009, early October 2009, and mid-August 2010. Each film (ISO400; 36 frames) was collected one month after setting the camera. Animals of the same species photographed within 30 minutes of each other were considered to be the same individuals (Tsukada et al. 2006) and excluded from data records. The frequency occurrence of species photographed was examined according to the methods described in Tsukada et al. (2006).

*Data analysis*

We used ArcGIS software (version 9.3, Environmental Systems Research Institute, Redlands, USA) to identify each trap site geographically, and devised a vegetation map for the area based on the land use map of the Ministry of Forestry and aerial photos (Fig. 1b).

The generalized linear model (GLM), first introduced by Nelder and Wedderburn (1972), extended the concept of a linear model from normal response models to many

**Table 2.** The selected explanatory of the best model. The estimates and significance levels of the selected explanatry variables are shown

| | Estinate | Standard error | *z* value | *P* |
|---|---|---|---|---|
| Tree height | –6.954E–02 | 2.293E–02 | –3.033 | 0.00242** |
| Altitude | –8.808E–04 | 4.803E–04 | –1.834 | 0.06667 |
| Broadleaved forest | 8.479E–03 | 3.200E–03 | 2.65 | 0.00805** |
| Subalpine | –2.396E+02 | 2.123E+04 | –0.011 | 0.99100 |

Significant differences are represented as follows: ** for $P < 0.01$

other response distributions, such as the Poisson and the binomial. When analyzing the GLM for this study, we used a logarithmic link function.

As explanatory variables, we used: tree height, altitude, broadleaved forest, town and farmland, grassland, and subalpine. The tree height was estimated in comparison with a two metre standard tree with 0.5 m increments. The standard tree is the highest tree in each camera trap site. For 100 m buffer area from each camera location, area of the each land use types were calculated using ArcGIS. We did not use the coverage of coniferous forest, because it was strongly correlated with the coverage of broadleaved forest ($r = –0.094$).

The response variable was the number of photographs taken per 100 days.

Thus, the full model was:

The number of photographs per 100 days =
tree height + altitude + broadleaved forest + town and farmland + grassland + subalpine

We selected a best model for prediction using Akaike's Information Criterion (AIC). All statistical analyses were performed using R statistical software (version 2.13.0; R Core Development Team).

## Results

The study involved a total of 5,424 camera nights (CN), with 29–163 (min–max) CN per location (24.3 ± 14.2 (*SD*) CN in October 2008, 29.3 ± 13.2 (*SD*) CN in August 2009, 21.0 ±14.8 (*SD*) CN in October 2009, and 31.9 ± 12.6 (*SD*) CN in August 2010).

Japanese martens were recorded by 33 out of 51 camera traps and 92 records by martens in total, 1.8 ± 2.0 (*SD*) records/location (maximum eight photographs). Martens were recorded at a range of altitude from 609 m to 1,607 m. The selected model was as follows (AIC: 220.21, Table 2): the number of marten photographs per 100 days = tree height + altitude + broadleaved forest + subalpine.

Martens significantly preferred areas of broadleaved forest ($P = 0.008$) and areas with lower tree height ($P = 0.002$).

## Discussion

In this study, martens were recorded at elevations ranging from 609 m to 1,607 m, while camera traps were situated at elevations ranging from 609 m to 1,760 m, indicating that martens in the Akaya area were not affected by elevation. Zhou et al. (2010), who analyzed the food diversity of the genus *Martes,* involving five studies of the Japanese marten, found no altitudinal limitation affecting the marten's diet, as it adjusted its foraging strategy and was essentially a facultative generalist. We consider that the martens in Akaya are also generalists that find food at both low and high elevations.

Our camera trap results indicate that the Japanese marten prefers broadleaved forest as its primary habitat. Tatara (1994), who used radio-telemetry, found that the subspecies of the marten on Tsushima preferred broad-leaved forest. In this study using camera traps in different habitat types in central Honshu we found that not only did Japanese martens prefer broadleaved forest but also that they preferred areas with trees of low stature. Our results suggest that they rely on the complexity of the forest structure which provide cover and fruiting trees, whereas Tatara (1994) found that on Tsushima martens avoided areas with young trees and trees of low stature and preferred areas with mature and taller trees. The differences between these two studies may be the result of real differences between the two subspecies of *M. melampus* or the result of bias introduced by our protocol of setting camera traps along roads in a relatively open and artificial forest ecotone.

In conclusion, our survey revealed the primary habitat preference of the Japanese marten for the first time using non-invasive camera traps. As we set many camera traps along the forest edge ecotone (shown by Tatara [1994] to be preferred by martens on Tsushima) our results may have led to an over-estimation of the extent to which martens used this forest habitat. In future, we aim to set camera traps more randomly, in all types of habitat, in order to understand the habitat preference of the Japanese marten in Honshu more fully, thereby allowing us to consider conservation of suitable habitat for this subspecies.

Having proven the effectiveness of camera traps for surveying this taxon, we feel that a statistically well-designed trapping grid will be able to reveal more accurate information concerning the distribution of the Japanese marten. Moreover, further ecological information, such as seasonal variation in food availability, is necessary in order to understand the Japanese marten's habitat preferences.

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