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RANGING BEHAVIOR OF THE RED FOX (*VULPES VULPES*) IN RURAL SOUTHERN JAPAN

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Six red foxes (*Vulpes vulpes*) were radiotracked from May to September 1989 in central Kyushu, on the southern slopes of Mt. Aso. Size of home range was 357–631 ha (minimum-convex polygon) or 288–518 ha (95% harmonic mean), without apparent differences between sexes. Every night the foxes covered 29% of their ranges, moving about 6 km. Foxes spent from 18 to 50% of their activity time around houses, moving quickly from one village to another. A few scats collected in the area revealed that >50% of the diet is of human origin. The range overlap was substantial, both among females (as reported for urban foxes) and among males (not previously reported). The distribution of food scraps is therefore a likely factor influencing the ranging behavior of foxes not only in urban environments, but also in rural areas.

Key words: ***Vulpes*, Japan, home range, radiotelemetry**

The red fox (*Vulpes vulpes*) has been studied mostly in Europe and North America (Fox, 1975; Zimen, 1980), whereas few papers have been published on this species from its Asian range. Those papers deal with the activity rhythms (Eguchi and Nakazono, 1980; Eguchi et al., 1977), feeding ecology (Yoneda, 1982, 1983), age structure (Maekawa et al., 1980), and the patterns of den distribution and use (Nakazono and Ono, 1987). Nothing has been published on the ranging behavior of Asiatic red foxes. Because of the flexibility of behavior in this species (Voigt and Macdonald, 1984), as well as the possible genetic differences (foxes from southern Japan have been ranked as a subspecies, *V. v. japonica*), I hypothesized differences in behavior and ecology between Japanese and European foxes. In addition, knowledge about local variation in ranging behavior can be used in management, especially in the event of a rabies outbreak. The objectives of this study were to determine home range, movements, and degree of range overlap for a population of foxes in rural southern Japan.

STUDY AREA

The study was conducted in Yabe-Machi, Kumamoto-Ken, central Kyushu, a hilly area on the southern slopes of the volcanic Mt. Aso. Altitude ranged from 400 to 700 m above sea level. Vegetation was composed of woodland (occupying ca. 46% of the area, mostly cedar *Cryptomeria japonica* and cypress *Chamaeyparis obtusa* plantations), rice fields (25%, cultivated from May to October), cropland (15%), and grassland (8%). Villages (6% of the area, ≤20,000 inhabitants) were scattered throughout the area (Nakazono and Ono, 1987). During the study period, rainfall averaged 284 mm/month, minimum temperatures ranged from 7 to 24°C and maximum from 17 to 31°C, sunrise times ranged from 0508 to 0600 h, and sunset from 1821 to 1929 h. Snow (depth usually <1.5 cm) lasts from January to March. I observed that people in the area rarely shoot foxes, but often poison them.

MATERIAL AND METHODS

Six foxes (three adult males and two adult females captured March–May; one juvenile female captured in June) were captured in the proximity of four dens and radiotracked from May to September 1989. Since after 8 tracking days (from

0800 to 1700 h) I observed no activity during daytime, subsequent tracking was done almost exclusively at night (1800 to 0615 h; mostly between 1930 and 0530 h). Animal locations were recorded every 15 min during all-night tracking sessions (one animal per night). Activity was recorded on the basis of fluctuations in signal intensity. A microcomputer program for the analysis of animal locations (MCPAAL—M. Stuwe and C. E. Blohowiak, National Zoological Park, Smithsonian Institution, Front Royal, VA 22630) was used to evaluate the area of the home ranges. Two algorithms were used; minimum-convex polygon (hereafter MCP; Mohr, 1947) and harmonic mean (hereafter HM; Dixon and Chapman, 1980; the areas containing 95% and 50% of locations were calculated). For the calculation of the harmonic-mean areas, only one location per hour was used to reduce the dependency of the samples, which may produce sizable errors (Anderson, 1982). The resting locations were excluded to avoid overestimating the importance of resting sites in the use pattern of the home range. Fecal droppings of foxes were opportunistically collected and analyzed following Kruuk and Parish (1981). Data are presented as mean ± *SD*. Standard nonparametric tests were used (Siegel, 1956).

Results

Altogether 1,929 fixes were recorded (range, 177–521/animal). Sizes of home range (MCP) varied from 357 to 631 ha (288–518 ha for the 95% HM) for the adult foxes; the juvenile female ranged over a much smaller area (MCP: 67; HM: 55 ha). One of the males occupied two distinct, nonoverlapping ranges in the study period, one (HM: 462 ha) from June to July 1989, the other (359 ha) from August to September 1989. Core area (50% HM) was 5 ha for the juvenile, and varied from 11 to 65 ha for the adult foxes. Although males (average harmonic mean, 407 ha) did not appear to have substantially larger ranges than females (average harmonic mean, 380 ha), small samples prevented a statistical analysis. Indeed, the range size of the two animals with the greatest overlap (F2 and M2, Fig. 1) was similar. Also the distance between consecutive 15-min locations did not appear consistently different between females and males (range of individual averages, 160 ± 170–235 ± 250 m). The sum of the 15-min movements per night averaged 5.2–7.1 km. The juvenile female moved significantly less (85 ± 85 m; Mann-Whitney *U*-test, $z > -2.00$; $P < 0.01$; 3.6 km/night). Every night the foxes covered 29.3 ± 3.7% of their home ranges (convex polygon), with no significant individual differences (*U*-test, $z > -0.5$; $P > 0.20$). They spent a disproportionate part of the night near the houses (range of individual averages, 18–50% of the locations within 50 m; χ^2, $P < 0.001$). The observed pattern of movements often consisted of small-scale movements around villages, followed by quick displacements (up to 1,580 m in 15 min). Range overlap was substantial. M2 (an adult male), F2 (an adult female, lactating when first trapped) and F3 (a juvenile female) probably were members of the same social group (they also occasionally were seen traveling together), and their ranges were almost coincident (Fig. 1). Another adult male's (M1) range, although clearly separated from both the ranges of M3, extensively overlapped those of M2, F2, and F3 (Fig. 1).

Only 25 scats, mostly collected near the dens occupied by the study animals, could be positively attributed to foxes. Domestic animals constituted 31% of the volume of the diet, either from garbage dumps or actively predated. Amorphous material constituted 19.5% in volume of the feces examined, and was constantly associated with newspaper and human hair. This indicates an origin mostly from garbage. A few earthworm chaetae were found. Including cultivated fruits (1%), the human-related food amounted to >50% of the diet. Furthermore, radiocollared foxes occasionally were observed eating sweet corn cultivated in the area. Small mammals (20%) and beetles (12%) also were frequently eaten. Minor items were grass (8%), berries (7%), small birds (2.5%), and other insects (0.2%).

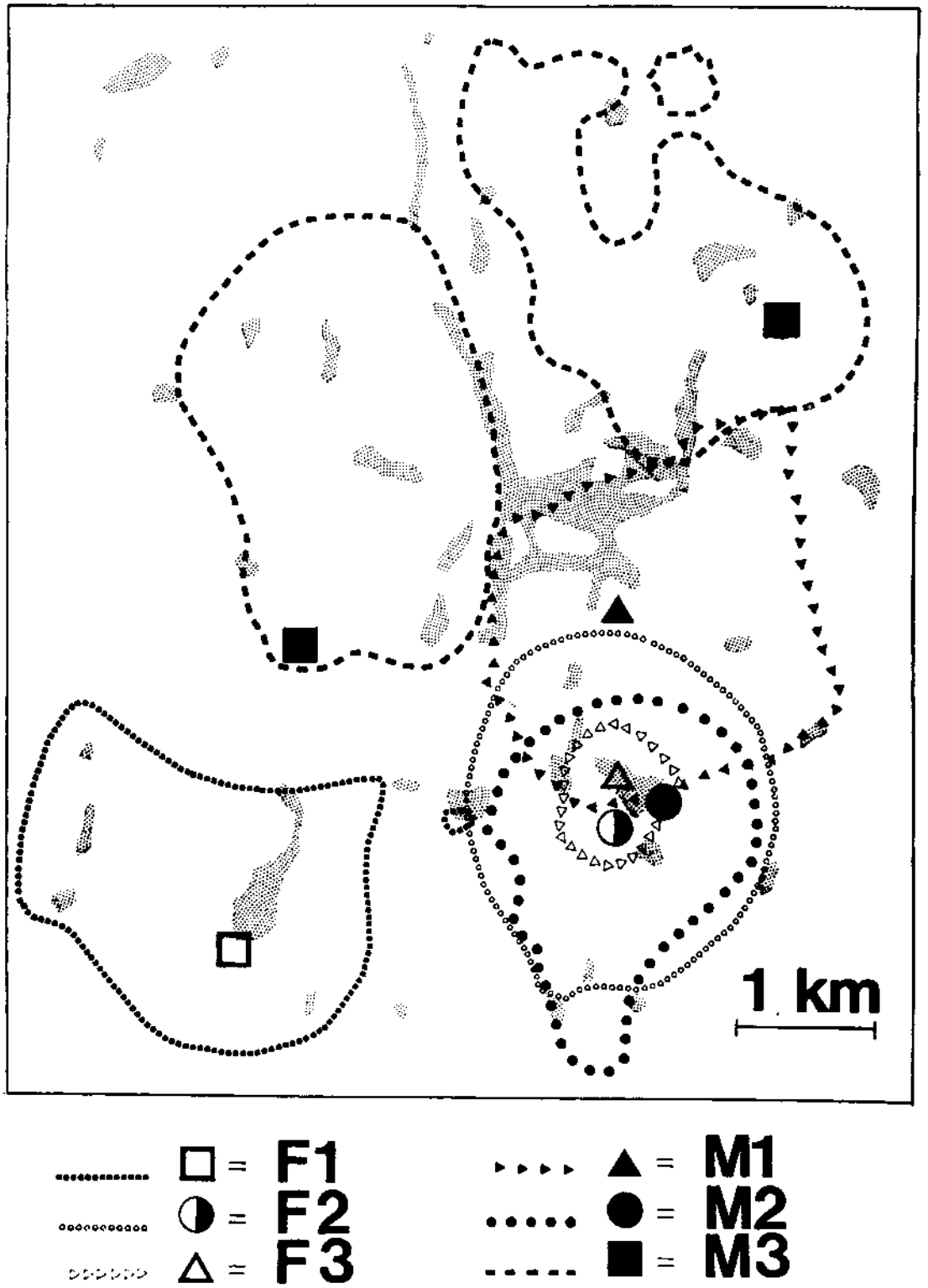

FIG. 1.—Home ranges of six foxes (95% harmonic mean) and harmonic centers of activity (Dixon and Chapman, 1980) in Yabe-Machi, southern Japan, May–September 1989. F are females, M are males. Villages are shaded.

Discussion

The sizes of home ranges observed in this study are consistent with the sizes found in other temperate farmlands (Voigt and Macdonald, 1984). The >2-fold difference in size of home range between Macdonald's (1981) farmland foxes (ca. 230 ha) and those in the present study can be accounted for by differences in home-range estimation techniques and in land-use characteristics (e.g., the paddy fields, 25% of my study area, are unsuitable for foxes for a large part of the year). However, my results fall within the range of sizes quoted in the literature (Maurel, 1980). Also the extent of movement is similar to that reported in other studies (4–12 km—Artois, 1985). In rural farmland and unmanipulated environments, foxes usually are strictly territorial, with exclusive family ranges (Ables, 1969; Sargeant, 1972). My findings, however, indicate a large range overlap, as often found for female foxes in urban environments (Harris, 1980; Kolb, 1986). More surprising is the overlap between adult males (to my knowledge the first report of this kind), since even in high-density areas, where adult females live in groups of up to five individuals, males maintain exclusive ranges (Macdonald, 1981).

From my small sample, little can be inferred about the diet of foxes in the area, however, human activities provide a major source of food for foxes in spring and summer. Furthermore, in winter, when insects and small mammals probably are less available, food derived from human activities might even increase. It is therefore likely that the complex distribution pattern of food scraps, temporally unpredictable and spatially patchy, influences the ranging behavior of foxes not only in high (human and vulpine) density cities (Macdonald, 1981), but also in a more rural environment.

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