

Choice of resting sites by female foxes *Vulpes vulpes* in a mountainous habitat

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The resting sites of seven radio-tracked Red fox *Vulpes vulpes* (Linnaeus, 1758) vixens were determined in the Swiss Jura mountains. During their nocturnal active period, foxes rested above ground near their foraging areas. In daytime, some foxes always used dens in areas with little cover, while some other individuals often rested above ground when cover was abundant. Weather did not influence the choice of the resting place, except in extreme conditions. Each fox used several resting places, sometimes moving from one to another during the day, especially when lying above ground.

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Introduction

As in most habitats, foxes are mainly nocturnal in the Swiss Jura mountains (J.-M. Weber *et al.*, in prep.); only few short resting periods occur during the night and most of the rest occurs during the day. Underground dens are not regularly used as resting sites by foxes. The general opinion is that many individuals prefer to lie above ground outside the breeding season (Harris and Lloyd 1991) and that dens are used as resting sites only temporarily (Labhardt 1990) or even exceptionally (Artois 1989). But except for a study which showed that the use of dens by foxes changes according to the seasons (Weber 1985), only some scarce data concerning the resting sites of the Red fox could be found in the literature (i.e. Allan 1968, Dekker 1983, Artois *et al.* 1990, or Woollard and Harris 1990).

We present here data obtained from seven female foxes radio-tracked between 1989 and 1992.

Study area

The study area (altitude 1000 – 1290 m) is situated in the Swiss Jura mountains. The landscape is typically rural with many open or semi-open areas (pastures and meadows/wooded pastures), some spruce-dominated forests and several isolated farms. The area contains few arable fields. Most of the soil cover is thin and therefore the number of dens is low (Meia and Weber 1992).

Methods

Seven adult female Red foxes *Vulpes vulpes* (Linnaeus, 1758) were fitted with radio-collars (Wildlife Materials Inc., Carbondale, USA). They were caught between September 1989 and February 1992 (Table 1) using stopped neck snares. The transmitters were fitted with an indicator of activity. The foxes were monitored using two methods: (1) daily diurnal locations (1 fix/ animal/ day during the "diurnal resting period"), and (2) 24-hour tracking sessions (1 fix/ animal/ 15 minutes for 24 hours, every week during the month following capture, then every two weeks). The weather conditions (fine, cloudy, foggy, wet or snowy) were also recorded and presence or absence of snow cover noted. None of the radio-tagged vixens bred during the monitoring period.

Resting sites were ranked in six categories:

1. "den" – underground or above ground at the den site (≤ 25 m from den site),
2. "surface": 2.1. "forest", above ground in a forest, 2.2. "forest edge", above ground in a forest edge (within 25 m of the boundary between forest and open area), 2.3. "wooded pasture", above ground in a wooded pasture, 2.4. "pasture", above ground in a pasture, meadow or cultivated field, 2.5. "building", in a human construction.

The home ranges presented in this paper were calculated using the minimum convex polygon method (100 % of the fixes).

Table 1. Age of foxes (years), duration of radio-tracking and number of 24-hour tracking sessions (24HTS).

Vixen	Age	Tracking period	24HTS
F2	1	20.09.89 – 27.03.90	15
F3	4 (5)	08.11.89 – 03.12.89	3
F8	1	23.01.92 – 29.02.92	5
F10	1	11.08.90 – 23.01.91	13
F11	1	03.02.91 – 02.09.91	17
F12	4 (5)	09.02.91 – 21.12.91	24
F19	3	13.07.01 – 29.02.92	19

Results

Characteristics of resting sites

Nocturnal resting sites

During the night, foxes seldom rested at a den site (four cases out of 412 observed resting periods) and never in buildings. Usually they did not move from a present habitat to rest: they lay where they had been active. Four of the seven radio-tracked vixens (F3, F8, F10, F11) used the different habitats available to them in the same proportion either to rest or be active (Table 2, χ^2 , $p > 0.05$). The three others (F2, F12 and F19) showed differences in active/resting habitat preferences (Table 2, χ^2 , $p < 0.05$); this probably corresponded to a preference to rest near an edge rather than in totally open land.

Table 2. Comparison of the number of resting periods in the different habitats (rest) and the number of active radio fixes in the different habitats (activity) during the night, for each vixen, * – without “forest edge”.

Vixen	Behaviour	Number of locations (radio fixes)				χ^2
		Forest	Forest edge	Wooded pasture	Pasture	
F2	Rest	8	19	16	24	$p < 0.05$
	Activity	59	85	89	354	
F3	Rest	7	1	3	4	ns*
	Activity	39	3	12	56	
F8	Rest	4	6	11	3	ns
	Activity	32	47	62	52	
F10	Rest	15	11	12	15	ns
	Activity	139	72	88	155	
F11	Rest	11	12	14	33	ns
	Activity	65	62	112	247	
F12	Rest	30	44	4	39	$p < 0.05$
	Activity	160	134	11	336	
F19	Rest	3	9	37	10	$p < 0.05$
	Activity	32	36	323	245	

Diurnal resting sites

The diurnal resting sites were always hidden; resting in the “pasture” habitat corresponded only to areas with high grass or cereals and therefore it occurred from late spring to late summer. In the same way, foxes did not rest during the day in front of a forest edge but always in the cover; for this reason, we included the “forest edge” data in the “forest” category.

There were variations between individuals and seasons (Table 3, Fig. 1). The seasonal pattern of use of dens was examined by comparing the values of the “den” category with the total of the other categories. No difference between seasons was found for F2 and F3 (Fisher test, $p > 0.05$); these foxes rested always underground during the period they were monitored. Another vixen (F19) showed the opposite pattern: it seldom rested underground in autumn and winter (no difference between these seasons, Fisher test, $p < 0.05$) but we located it several days in a den in summer (Fisher test, $p < 0.05$). This result is related to the fact that it had reared cubs just before we caught it in mid-July. The other vixens (F10, F11, F12) used dens more frequently in autumn/winter than in summer (Fisher test, $p < 0.05$) but the rest occurred always partly above ground; the change is gradual by F12 – no difference between autumn and winter and between winter and spring (Fisher test, $p > 0.05$). The comparisons between individuals, for each season,

Table 3. Number of locations in underground (den) or "surface" resting sites during the day. Comparisons between seasons for each vixen.

Vixen	Season	Number of locations		Fisher test (comparisons between seasons)
		Den	"Surface"	
F2	autumn	61	0	$p > 0.05$
	winter	47	2	
	spring	17	0	
F3	autumn	21	0	$p > 0.05$
	winter	3	0	
F8	winter	29	8	
F10	summer	1	17	summer different from autumn/winter, $p < 0.05$
	autumn	57	26	
	winter	38	13	
F11	spring	2	73	winter different from spring/summer, $p < 0.05$
	summer	2	76	
	winter	9	12	
F12	spring	6	73	autumn different from spring/summer, $p < 0.05$
	summer	0	73	
	autumn	19	62	
	winter	4	25	
F19	summer	5	40	summer different from autumn/winter, $p < 0.05$
	autumn	2	80	
	winter	1	62	

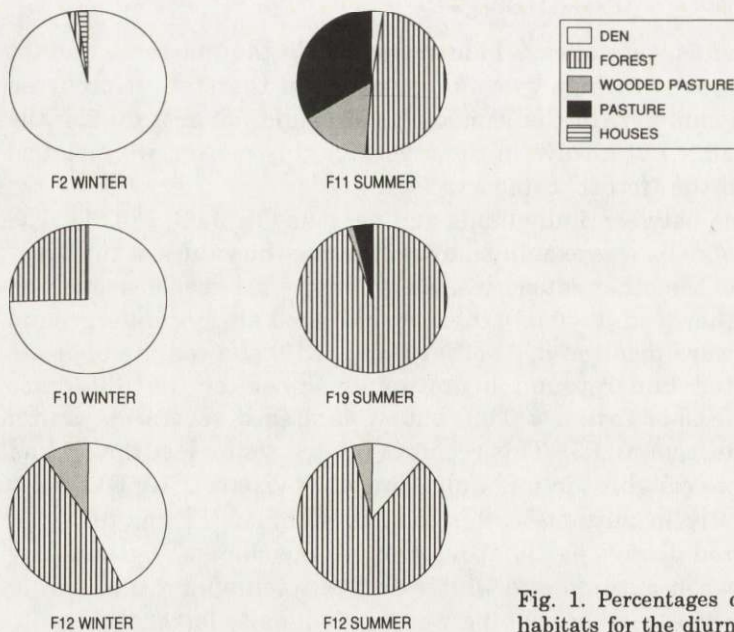


Fig. 1. Percentages of locations in the different habitats for the diurnal rest. Some examples.

confirmed the above mentioned results. No difference was found between F2 and F3 which rested always in a den (Fisher test, $p > 0.05$). In summer all radio-tracked foxes rested only exceptionally underground (Fisher test, $p > 0.05$), except for F19, but during the other seasons each fox had its own strategy: only the comparison between F8 and F10 in winter showed no significant difference (Fisher test, $p > 0.05$).

The location of "surface" resting sites varied with the individuals and the seasons. Only one of the monitored vixens (F11/ summer) was regularly located in the pasture habitat. The wooded pastures were always less used than the forests and only one fox (F2) rested once in a building. The foxes which used dens occasionally (F8, F10, F11, and F12) rested above ground also during cloudy, foggy, wet or snowy weather (Table 4). Only F12 rested less frequently above ground when the weather was bad and used a den (Table 4, Fisher test, $p < 0.05$). During winter, snow cover seemed to induce two of the same individuals (F10, F12) to rest underground (Table 4, Fisher test, $p < 0.05$). During the hunting season (September to February, 3 days/week), the use of a den by these foxes did not correspond to the hunting days (Table 4).

As we considered the percentage of open areas in the home range of the foxes, we could separate two groups. The vixens which used dens continually or almost continually (F2, F3, F8) had more open areas in their home range than the other vixens (Table 5, Mann-Whitney U -test, $p < 0.05$). A positive rank correlation could be found between the percent of locations of the fox in a den and the percent of open areas in the home range (Table 5). There was no correlation between the number of dens in the home range and the use of dens as resting sites (Table 5).

Use of diurnal resting sites

Movements between resting sites during the day

Using the results of the 24-hour tracking sessions (Table 1) we looked at the number of changes of resting sites (den or surface) during the day. Foxes could move to another resting site up to 4 times within a half day, but generally they did not change or moved once (no change – 122 cases, 1 change – 48, 2 changes – 11, 3 changes – 9, 4 changes – 1). The distances between two successively used resting sites varied from 50 to 2500 m (in metres: $\bar{x} = 330$, $SD = 400$) and the time used in moving was generally short (in minutes: $\bar{x} = 23$, $SD = 14$, range 15 – 75). When the foxes rested in a den, they left it for another site less frequently than when resting at a "surface" site (Fisher test, $p < 0.05$). Foxes moved generally to a "surface" resting site. Twelve of the 101 displacements were caused by disturbance, usually human.

Number and distribution of diurnal resting sites

In order to compare the number of resting sites used by all foxes, we have calculated an "index of utilization" ($n / r.s.$) which corresponds to the number of daily fixes (n) divided by the number of resting sites ($r.s.$) found during the seasons.

Table 4. Number of locations in underground (den) or "surface" resting sites according to weather, snow cover and hunting days.

Factor		Number of locations							
		F8		F10		F11		F12	
		Den	"Surface"	Den	"Surface"	Den	"Surface"	Den	"Surface"
Weather	fine	14	6	40	29	7	74	6	115
	cloudy, fog, wet, snowy	15	2	56	27	6	87	23	118
	Fisher test	ns		ns		ns		$p < 0.05$	
Snow cover	presence	8	4	34	7	7	11	4	7
	absence	23	2	4	6	1	2	0	18
	Fisher test	ns		$p < 0.05$		ns		$p < 0.05$	
Hunting day	yes	9	1	43	16	3	1	10	32
	no	11	2	62	23	1	3	11	44
	Fisher test	ns		ns		ns		ns	

Table 5. Relation between the underground rest and the surface of open areas or the number of dens in the home range, R_s - Spearman rank correlation coefficient.

Vixen	Percentage of locations in a den			Percentage of open area in the home range	Number of dens in the home range
	Autumn	Winter	Total		
F2	100%	96%	98%	79.7%	9
F3	100%	100%	100%	81.7%	13
F8	-	78%	78%	87.5%	5
F10	69%	74%	63%	71.8%	15
F11	-	43%	7%	78.0%	-
F12	23%	14%	11%	69.1%	15
F19	2%	3%	4%	64.1%	2

The results showed (Table 6) that the foxes which rested more often in a den than above ground (F2, F3, F8, F10 autumn and winter) used a lower number of resting sites than others (Mann-Whitney U -test, $p < 0.05$). The number of successive locations in the same resting site varied from 1 to 28 (Table 6). It was also higher for the foxes which rested more often in a den than above ground (Mann-Whitney U -test, $p < 0.05$). Fig. 2 illustrates these two patterns.

The home ranges of the monitored vixens covered between 127 and 292 ha except for F11 which travelled across an area of about 3400 ha but used regularly

Table 6. Index of utilization of the resting sites (*n/r.s.*) and average duration of utilization (expressed in successive radio fixes in the same site). Results are presented in bold when underground rest is the most numerous.

Vixen	Season	Number of fixes (<i>n</i>)	Number of resting sites (r.s.)	<i>n/r.s.</i>	Successive radio fixes in the same site			
					\bar{x}	SD	min	max
F2	autumn	61	3	20	5.5	8.3	1	28
	winter	49	5	10	7	10.4	1	5
	spring	17	1	17	17	—	17	17
F3	autumn	24	3	8	8	11.3	1	21
F8	winter	37	5	7	3.1	6	1	22
F10	summer	18	13	1	1.1	0.3	1	2
	autumn	83	11	8	1.6	1.4	1	7
	winter	51	8	6	3	3.5	1	14
F11	winter	21	7	3	1.2	0.4	1	2
	spring	75	37	2	1.1	0.3	1	2
	summer	78	34	2	1.3	0.8	1	6
F12	winter	13	7	2	1.4	0.7	1	3
	spring	79	21	4	1.3	0.6	1	3
	summer	73	17	4	1.3	0.9	1	6
	autumn	81	16	5	1.3	1.4	1	11
	winter	16	3	5	6.4	5.6	2	6
F19	summer	45	6	7	1.4	0.7	1	4
	autumn	82	6	14	1.7	1.1	1	4
	winter	63	6	10	2.2	1.9	1	9

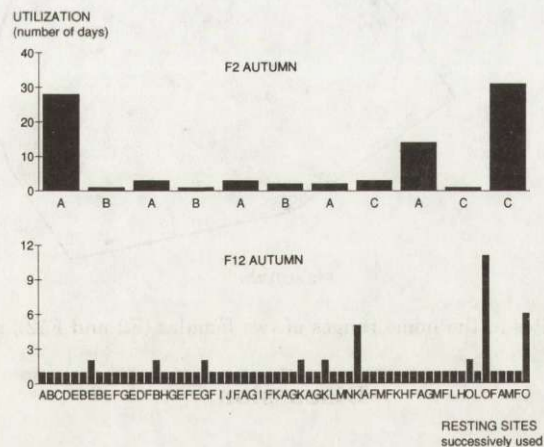


Fig. 2. Difference in use of resting sites by two females: F2 studied in autumn (89 consecutive days of underground rest) and F12 studied in autumn (86 consecutive days of rest above ground). Each resting site is represented by one capital letter.

only certain parts of this area. The resting sites were not distributed evenly in the home ranges and they could be very close to the borders (Fig. 3). They were not situated in the most travelled areas: no relation was found between the number of resting sites and the number of active radio fixes (24-hour tracking sessions) in equal size squares dividing the home ranges (Spearman rank correlation). The foxes used only a small proportion of the dens located in their home ranges. The number of used dens varied from one to three: 1 den in F11 and F19, 2 dens in F8 and F10, 3 dens in F2, F3, and F12 (Fig. 3).

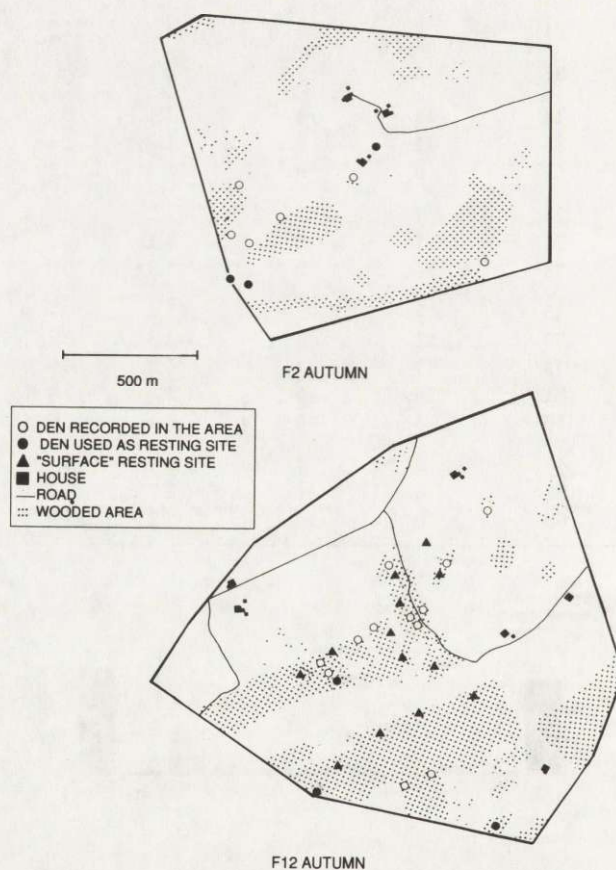


Fig. 3. Location resting sites in the home ranges of two females (F2 and F12), studied in autumn.

Discussion

Type of resting sites

Foxes show a great variability in their resting strategy; there are great intra- and interindividual differences. Dekker (1983) shows that in the same area, foxes

could lie above or underground. Poulle (1991) also observed that foxes use a large spectrum of sites to rest: in her study area, forest was the most commonly used habitat except in summer when foxes were mainly lying in cereals, and dens were rarely used. The type of available habitats seems then to have a great influence (cereals are not abundant in our study area). A constant feature is that foxes need a quiet place to spend the diurnal period; for this reason, they do not rest near buildings in our area. On that point, the conditions in the Swiss Jura mountains do not correspond to the "quiet gardens" used by urban foxes, for example in Britain (Harris 1977); hunting was very prevalent in the past and is still sustained in certain parts of the area.

The use of dens is noticeably more frequent in winter than in summer, but the annual variations observed by Weber (1985) are not applicable in all cases. In our area, some individuals rest all through the year in dens. Several months after the monitoring period, the vixens which had been regularly located in dens continued to rest underground and they were regularly observed going in or out of their habitual dens. This is probably due to the number of shelters in the area. The fox which never rested underground (F19) had at its disposal a very quiet, steep and undisturbed forest; this was not the case of vixens which continually used dens (F2, F3, F8) which all came from the same part of the study area where there is little cover and where hunters are particularly active. Lloyd (1980) also mentions that foxes lay below more often when cover is scarce or not secure.

The choice of the resting site was rarely influenced by weather, except in extreme conditions. Weber (1985), and Harris and Lloyd (1991) state that foxes prefer to lie in dens during bad weather. This pattern was not the rule in our area: during rain, foxes generally continue to rest above ground. We think that the current opinion that foxes avoid rain because it decreases the insulating power of the fur (Artois 1989) should be revised. We often observed foxes during the night which rested in totally open areas during heavy rain.

Number and location of resting sites in the home ranges

Although Capt and Stalder (1991) observed that foxes lie in the same place during the day, without moving, Artois *et al.* (1990), and Woollard and Harris (1990) show the use of several resting sites. We observed that there are few sites when dens are used probably due to the limited number of dens in the area. The larger number of sites used by foxes which rest above ground could be explained by three reasons. First, a fox lying above ground could be disturbed more easily (walkers). Second, in the areas with enough cover to rest above ground, foxes find many suitable sites to rest and could move from one site to another to patrol their home range. This survey function is supported by the great number of observed movements during the day without a visible disturbing factor and by the cases of foxes leaving a den to rest in another one or above ground. Finally, a "comfort" reason could explain some of the movements (change of the direction of the sun or arrival of another individual on the site). The fact that some dens (Ables 1969,

Eiberle 1975, Fabrigoule and Maurel 1982) or some "surface" areas (Artois *et al.* 1990) are preferred was confirmed in this study. Security and maybe comfort could explain this fact, but a social reason is more likely. We observed, as Harris (1980) did, that several individuals used the same resting sites and Poulle (1991) emphasized that the social interactions between foxes happen essentially during the resting period.

Like Artois (1985) who noticed that foxes could move a long way to reach their foraging areas, we observed that the daytime resting places and the nocturnal hunting areas do not overlap. This contradicts one part of the model of Weber (1985) which predicts that foxes try to reduce the travel costs between these two zones; we think that the small size of the home ranges could make these costs negligible. The often peripheral location of resting sites, mainly dens, emphasized the great part they probably play in the establishment of the home ranges.

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