Z. Säugetierkunde 59 (1994) 9–13

ISSN 0044-3468

Activity of foxes, *Vulpes vulpes*, in the Swiss Jura mountains

By J.-M. Weber, J.-S. Meia, and S. Aubry

Institut de Zoologie, Université de Neuchâtel, Neuchâtel, Switzerland

Receipt of Ms. 26. 1. 1993
Acceptance of Ms. 21. 9. 1993

Abstract

Studied the activity pattern of seven radio collared foxes in a mountainous habitat in Switzerland. Foxes were mainly nocturnal and their nocturnal activity pattern was acyclic. Activity periods varied according to seasons, being shortest during summer. On the other hand effective activity did not vary significantly throughout the year. Fox active period was generally interrupted by several inactive phases, most of which were short (< 15 min.).

Introduction

Red fox activity has been studied in different lowland habitats (Ables 1969; Artois 1985; Woollard and Harris 1990 amongst others), but little is known of red fox activity in mountainous habitats. In their study of fox habitat use in the Swiss Alps, Capt and Stalder (1988) emphasized the nocturnal pattern of fox activity. Most authors usually described fox activity pattern and its variations in general terms (e.g., Artois 1989). There are few quantitative data about activity level and time budget. Recently, Woollard and Harris (1990) recorded the duration of inactive and active bouts occurring during the active period of urban foxes.

Therefore, the objective of this study is to describe the activity pattern and to quantify the activity level of foxes in a mountainous habitat.

Material and methods

This study was carried out in a rural area of the Swiss Jura mountains (47°09′ N, 6°56′ E; altitude: 995 to 1288 m). This area is mainly composed of pastures and wooded pastures, as described by Weber and Aubry (1993).

Seven vixens (F2, F3, F8, F10, F11, F12, and F19) were tracked between September 1989 and May 1992. The foxes were snared, and then tranquilized with an injection of ketamin hydrochloride. Each fox was tagged with 1 or 2 colored eartags (Dalton Supplies, Ltd., Henley-on-Thames, UK). Adult-sized individuals were fitted with activity monitoring transmitters (Wildlife Materials, Inc., Carbondale, Ill., USA).

Radio tracking data were collected in two different ways. Radio tagged animals were located daily (1 fix/fox/day) to determine their diurnal resting sites. The collared animals were also tracked for one 24-h period (12.00 to 12.00; 1 fix/15 min.) one day per week during the first month following their capture. They were then tracked for 24 hours (1 fix/15 min.) once every two weeks. Radio tracking was made either by car or on foot using portable telemetry equipment.

Variations in radio signal pulse rate indicated whether foxes were moving (active) or not (inactive); hence fixes were recorded as either active or inactive. Two periods were distinguished within a day: the daytime/daylight (dawn to dusk) and the nighttime (dusk to dawn). The total active fixes (diurnal and nocturnal) constituted fox effective activity (EA). The activity period (AP) was determined by nocturnal active and inactive fixes as well as diurnal activity fixes. A prolonged inactive phase (> 1 min.) during the nocturnal activity period was considered as "rest during the active period" (RAP).

U.S. Copyright Clearance Center Code Statement: 0044-3468/94/5901-0009 $ 02.50/0

Results and discussion

Activity period and seasonal variations

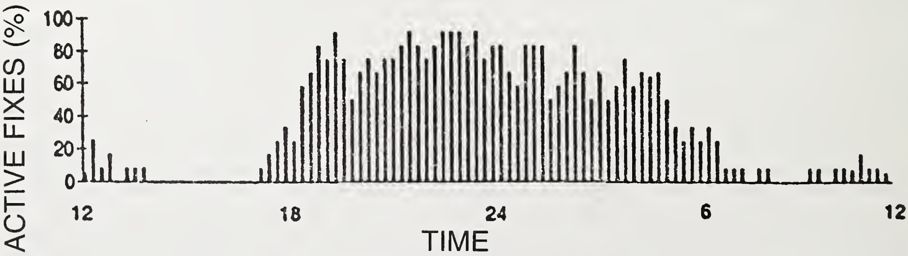
The activity period (AP) of all vixens was mainly nocturnal, but the individuals were also active to different degrees in daylight (Tab. 1). Two foxes (F2 and F3) were seldom or never active in the daytime (1.7 % (9/546) and 0 % (0/107) of diurnal active fixes respectively). Other vixens were significantly more diurnal (χ^2 test, $p < 0.05$). For F8, F10 and F19, the total proportion of diurnal active fixes did not exceed 9 %, whereas it represented 15.4 % and 11.7 % for F11 and F12, respectively. There was no significant trend in seasonal variations, but some individuals were more diurnal in one season than in another: F11 was more active during daytime in winter than in spring and summer (χ^2 = 108.89, d.f. = 2, $p < 0.001$).

Table 1. **Seasonal frequency (%) of diurnal active fixes recorded in foxes**
n: number of diurnal active fixes

	Spring		Summer		Autumn		Winter		Total	
	%	n	%	n	%	n	%	n	%	n
F2	–	–	–	–	0.4	288	3.1	258	1.7	546
F3	–	–	–	–	0.0	107	–	–	0.0	107
F8	4.8	209	–	–	–	–	5.9	169	5.3	378
F10	–	–	–	–	3.8	291	10.8	147	6.2	438
F11	13.5	244	11.8	340	–	–	38.4	73	15.4	657
F12	16.8	202	10.6	398	6.2	225	19.1	84	11.7	909
F19	7.1	227	14.1	191	9.8	225	4.1	267	8.4	910

Ables (1969) noticed that such variations could be influenced by climatological factors, for instance shorter diurnal activity in summer due to higher temperature and insolation. Eguchi and Nakazono (1980) emphasized human disturbance as a possible cause of fox diurnal activity, at least for individuals which were resting above ground during daytime.

Although we did not quantify the climatological factors, it seems that their influence was negligible, since there was no seasonal trend in diurnal activity. However, extreme weather conditions during the night could contribute to an increase of diurnal activity. This was observed for F11 during winter, when some nights were cold (ca. −25 °C.) On the other hand, we consider the human factor as very important. The high hunting pressure occurring in the region probably induced a nocturnal pattern of activity. In areas where cover was scarce, some foxes (F2 and F3) spent the day in dens and were strictly nocturnal most probably for safety reasons. For other foxes, diurnal activity was usually limited to movements between resting sites (Meia and Weber 1993). Foraging activity was uncommon in daylight, and even F8 did not show any increase of diurnal activity when rearing cubs during spring as described for another breeding vixen (Phillips and Catling 1991).



Example of fox activity pattern. F10: autumn and winter

The nocturnal activity pattern of the seven vixens was acyclic (Fig. 1). Most authors found a cyclicity in fox nocturnal activity pattern, being either bimodal (Ables 1969; Artois 1985) or trimodal (Eguchi and Nakazono 1980). According to Ables (1969), fox activity peaks were synchronized with those of the prey. In our study area, the main prey of foxes was the water vole, *Arvicola terrestris scherman* (Weber and Aubry 1993). Little is known about its activity pattern, but in Britain, no variation in activity was found between day and night (Boyce 1991). Our field observations indicated similar behaviour of water voles. No difference in trappability was found between day and night. Predators such as farm cats, *Felis catus*, and some raptors, regularly preyed on them in the daytime. This suggests a great variability in the activity pattern of water voles and could explain fox acyclic activity pattern in our study area to some extent.

There were seasonal variations in activity level of foxes (Tab. 2). Their activity period was shortest during summer and generally longest during winter (Mann-Whitney U test, $p < 0.05$). Besides, there were few variations between individuals. F12's autumn APs were longer than those of other foxes (Mann-Whitney U test, $p < 0.05$), and a similar trend was also observed in spring and summer.

Since fox activity period was mostly nocturnal in our area, the seasonal character of its duration was likely related to nighttime length (Eguchi and Nakazono 1980; Capt and Stalder 1988). Some intrinsic factors could explain the differences in the AP length observed between F12 and

Table 2. **Seasonal duration (min.) of fox activity periods, rest during the activity period and effective activity**
X: mean SD: standard deviation

	F2		F3		F8		F10		F11		F12		F19	
	X	SD	X	SD	X	SD	X	SD	X	SD	X	SD	X	SD
Activity period														
spring	-	-	-	-	557.1	147.6	-	-	717.8	107.9	741.4	81.6	617.5	70.6
summer	-	-	-	-	-	-	-	-	542.5	66.0	652.5	94.3	570.0	71.0
autumn	711.4	66.4	690.0	25.9	-	-	695.2	59.9	-	-	799.3	61.1	690.0	42.4
winter	797.5	68.9	-	-	753.0	144.7	795.0	114.2	622.5	289.4	690.0	207.8	762.8	64.5
Effective activity														
spring	-	-	-	-	454.3	168.1	-	-	527.1	104.4	443.6	93.6	547.5	73.3
summer	-	-	-	-	-	-	-	-	412.5	61.3	482.5	86.1	480.0	127.6
autumn	627.1	52.0	530.0	95.3	-	-	571.5	94.3	-	-	497.1	65.6	540.0	107.7
winter	602.5	133.6	-	-	506.0	144.7	525.0	199.4	461.3	198.8	410.0	233.5	574.2	61.1
Rest during AP														
spring	-	-	-	-	102.8	53.0	-	-	190.7	48.7	297.8	79.6	70.0	31.0
summer	-	-	-	-	-	-	-	-	130.0	32.4	170.0	114.9	90.0	61.5
autumn	84.3	40.6	160.0	110.6	-	-	123.7	54.2	-	-	302.1	95.8	150.0	96.3
winter	195.0	70.9	-	-	247.0	126.8	270.0	110.2	161.2	159.4	280.0	97.6	188.6	60.5

the other vixens. She was shot a few days before her capture, survived but never fully recovered. Because of her weak body condition, she probably needed to distribute her foraging effort over a longer period than other foxes.

Occurrence of rest during the activity period

Rest during the activity period (RAP) was related to AP length ($r_s = 0.69$, $n = 18$, $p < 0.01$). Longer activity periods led to more time spent resting. Variations between individuals also occurred. Compared to other vixens, and whatever the season was, F12 rested much longer during the activity period (Mann-Whitney U test, $p < 0.05$) (Tab. 2).

No correlation was found between foxes' effective activity (EA) and the length of activity period. Individual EA did not vary significantly throughout the year (Mann-Whitney U test, $p > 0.05$) (Tab. 2), but in some cases (e.g. F19) a 90 minutes difference could occur between the shortest and the longest EA.

Fox active period was generally interrupted by several inactive bouts. The average number of such breaks per night did not differ from one vixen to another, except F12 who used to take more breaks during her active period than F2, F8, F11 and F19 respectively (Student t-test, $p < 0.05$) (Tab. 3). The distribution of these breaks throughout the activity period did not follow any individual routine as also was observed in urban foxes (Woollard and Harris 1990). Their variable duration was classified into five groups (Tab. 3). For every fox, most of the inactive bouts were short (< 15 minutes) (Wilcoxon's signed-ranks test, $p < 0.05$), and on average occurred from 1.0 per night (F19) to 2.3 per night (F12). Intermediate (16–30; 31–45 minutes) and long resting periods (46–60; > 60 minutes) were less frequent. Only F8 and F12 used to rest on average once a night for more than 60 consecutive minutes, which was not surprising considering the presence of cubs to look after for F8 and the weak condition of F12.

Table 3. **Mean number of inactive bouts (IB) per night (X) according to their duration**
N: Total number of inactive bouts per fox, n: number of nights

	F2 (n = 13)		F3 (n = 3)		F8 (n = 12)		F10 (n = 12)		F11 (n = 17)		F12 (n = 23)		F19 (n = 25)	
IB	N	X	N	X	N	X	N	X	N	X	N	X	N	X
< 15	21	1.6	6	2.0	16	1.3	20	1.7	29	1.7	53	2.3	26	1.0
16–30	6	0.5	3	1.0	7	0.6	11	0.9	14	0.8	23	1.0	18	0.7
31–45	12	0.9	2	0.7	4	0.3	7	0.6	5	0.3	19	0.8	9	0.4
46–60	3	0.2	1	0.3	2	0.2	4	0.3	13	0.8	7	0.3	7	0.3
> 60	6	0.5	1	0.3	11	0.9	8	0.7	6	0.4	24	1.0	13	0.5
Total	48	3.7	13	4.3	40	3.3	50	4.2	67	4.0	126	5.4	73	2.9

The average duration of inactive bouts was shorter (except for F12) in our area than in an urban environment. Woollard and Harris (1990) recorded inactive bouts in Bristol averaging between 45.2 and 55.9 minutes, whereas our estimates ranged from 22.1 to 28.8 minutes (F12: 44.8 minutes). The comparatively higher diversity of potential food in the urban habitat as well as the smaller size of their home range (Harris 1980) could lead urban foxes to meet their daily energetic requirements more easily than mountain foxes, and accordingly to increase the duration of their resting periods.

Acknowledgements

We would like to thank Dr. R. Hewson for useful comments on the manuscript and Mr. N. Ferrari for help with the field work. We acknowledge the support received from Prof. C. Mermod. The study was funded by the Swiss National Fund, grant 31-27766.89/2.

Zusammenfassung

Aktivität des Rotfuchses, Vulpes vulpes, im Schweizer Jura

Die Aktivität von 7 weiblichen, mit Sendern versehenen Rotfüchsen wurde im Gebiet des Schweizer Jura studiert. Die Rotfüchse waren vor allem nachtaktiv und im allgemeinen azyklisch. Die Aktivitätszeiten waren in den Jahreszeiten unterschiedlich lang, die kürzesten fielen in den Sommer. Die effektive Aktivität erfuhr dagegen im Laufe des Jahres keine merklichen Veränderungen. Die Aktivitätsphasen der Rotfüchse wurden stets durch mehrere Ruhephasen unterbrochen. Die meisten davon waren kurz (< 15 Min.).

References

Ables, E. D. (1969): Activity studies of red foxes in southern Wisconsin. J. Wildl. Manage. **33**, 145–153.

Artois, M. (1985): Utilisation de l'espace et du temps chez le renard (*Vulpes vulpes*) et le chat forestier (*Felis silvestris*) en Lorraine. Gibier Faune Sauvage **3**, 33–57.

Artois, M. (1989): Le renard roux (*Vulpes vulpes Linnaeus*, 1758). Encyclopédie des carnivores de France No. 3. Paris: Société Française pour l'Etude et la Protection des Mammifères.

Boyce, C. C. K. (1991): Water vole. In: The Handbook of British Mammals (3rd Ed.). Ed. by G. B. Corbet and S. Harris. Oxford: Blackwell Scientific Publications. Pp. 212–218.

Capt, S.; Stalder, H. W. (1988): Untersuchungen zur Habitatnutzung von Rotfüchsen (*Vulpes vulpes* L.) im schweizerischen Alpenraum. Ph. D. Thesis. Univ. Bern.

Eguchi, K.; Nakazono, T. (1980): Activity studies of Japanese red foxes, *Vulpes vulpes japonica* Gray. Jap. J. Ecol. **30**, 9–17.

Harris, S. (1980): Home ranges and patterns of distribution of foxes (*Vulpes vulpes*) in an urban area, as revealed by radio tracking. In: A Handbook on Biotelemetry and Radio tracking. Ed. by C. J. Amlaner and D. W. Macdonald. Oxford: Pergamon Press. Pp. 685–690.

Meia, J.-S.; Weber, J.-M. (1993): Choice of resting sites by female foxes *Vulpes vulpes* in a mountainous habitat. Acta Theriol. **38**, 81–91.

Phillips, M.; Catling, P. C. (1991): Home range and activity patterns of red foxes in Nadgee Nature Reserve. Wildl. Res. **18**, 677–686.

Weber, J.-M., Aubry, S. (1993): Predation by foxes, *Vulpes vulpes*, on the fossorial form of the water vole, *Arvicola terrestris scherman*, in western Switzerland. J. Zool. (London) **229**, 553–559.

Woollard, T.; Harris, S. (1990): A behavioural comparison of dispersing and non-dispersing foxes (*Vulpes vulpes*) and an evaluation of some dispersal hypotheses. J. Anim. Ecol. **59**, 709–722.

Authors' address: Dr. Jean-Marc Weber, Jean-Steve Meia and Stéphane Aubry, Institut de Zoologie, Université de Neuchâtel, Chantemerle 22, CH-2000 Neuchâtel 7, Switzerland