Z. Säugetierkunde 59 (1994) 169–173
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ISSN 0044-3468

Placental scar counts in the Red fox (*Vulpes vulpes* L.) revisited

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Receipt of Ms. 8. 7. 1993
Acceptance of Ms. 28. 2. 1994

Abstract

Placental scars used for analyses of reproduction in the red fox (*Vulpes vulpes* L.) may fade throughout the season after birth. I report a method to calculate whelping frequency and mean litter size from placental scar analyses of 608 vixens shot during autumn and winter in three areas of Sweden. The material allowed 6-9 consecutive periods of calculation within the year in each area. By successively including scars of lighter shades in the counts, I established isopleths of constant whelping frequencies. The isopleth yielding the best estimate of mean litter size as derived from analyses of vixens in late pregnancy was accepted for calculations in each area. Although this method appeared to be adequate for each area, there were inter area differences. Therefore, reference material is needed for each specific area before this method can be used.

Introduction

Placental scars provide convenient measures of litter size and whelping frequency (proportion of females that give birth) in the red fox (*Vulpes vulpes* L.), and the method has been applied extensively (e.g. Sheldon 1949; Richards and Hine 1953; Layne and McKeon 1956; McIntosh 1963; Wandeler 1968; Fairley 1970; Englund 1970; Wandeler et al. 1974; Ryan 1976; Storm et al. 1976; Ulbrich 1977; Pils and Martin 1978; Kolb and Hewson 1980; Artois et al. 1982; Allen 1983; Harris and Smith 1987; Lindström 1988, 1989, 1992; Ansorge 1990). However, different shades of scars may originate at resorption sites, be persisting from old pregnancies or from cubs born the previous spring (Englund 1970). Hence, Englund (1970) based his calculations on the darkest scars only. Lindström (1981) showed that the shade of a scar may fade throughout the year following birth. Accordingly, I modified the method to account also for the fading, and in such a way that the scars of 4 vixens with known minimum litter sizes were correctly interpreted (Lindström 1981). Here, I report a new attempt to determine which scars should be counted at different intervals after birth, including new material and with a new approach.

Material and methods

Placental scars were counted in adult (≥ 1 year) vixens that showed no sign of fresh ovulation (an indication of a new pregnancy). The carcasses were collected from hunters in three parts of Sweden: Västerbotten (approximately 65 °N, 20 °E, n = 203, 1982–1990), Bergslagen (approximately 60 °N, 15 °E, n = 284, 1975–1990), and Småland (approximately 57 °N, 15 °E, n = 121, 1983–1990). The hunting season, i.e. the season of collection, lasted from early August to mid-March/mid-April (depending on area). Adult age was indicated by epiphyseal closure of the tibia. Placental scars were classified by shade of darkness from 1 (hardly visible) to 6 (completely black).

An additional 30 pregnant vixens with fetuses of a crown-rump length > 12 mm (i.e. at least halfway through pregnancy, see e.g. Englund 1970) were used for calculating mean litter size. For comparison of mean litter sizes, I used 95 % confidence intervals.

The exact date of death of the fox was not known in all cases. Hence, the week numbers were used

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as the time base; a year encompasses weeks 1–52 except every 5th or 6th year, which also includes week no. 53.

Mean litter size and whelping frequency were calculated for scars of shade 6, shade 6 + 5, shade 6 + 5 + 4, etc. until scars of all shades were included. This was done for consecutive periods throughout the season of collection in each area. At least 20 individuals were desired for each period, but especially in early autumn and late winter, this number was not possible to attain. The shades that had to be included during the different periods to obtain isopleths of constant whelping frequencies (40, 50, 60 and 70 %) throughout the season were noted, and the resulting mean litter size was calculated for each isopleth. This was then compared with the mean litter size as calculated from pregnant vixens and the isopleth giving the best fit was chosen for each area. To make a final adjustment I also checked the chosen isopleths for the best estimates of the mean litter size during each consecutive period.

Results and discussion

Mean litter size in late pregnancy

Mean embryonic litter size did not differ statistically among areas (means ± 95 % confidence intervals: Västerbotten 5.7 ± 1.2, n = 9; Bergslagen 5.1 ± 0.89, n = 15; and Småland 4.8 ± 1.6, n = 6). Thus, I pooled the materials and calculated an overall average of 5.2 ± 0.58 cubs. The confidence interval thus obtained covered the average of 4.8 cubs per litter (n = 489) noted by Englund (1970) in his total material of pregnant vixens from four areas of Sweden.

In five comparisons, embryo counts overestimated mean litter size as calculated from cubs at dens by an average of 18.5 % [range 0-63 %; data from McIntosh (1963); Wandeler et al. (1974); Storm et al. (1976); Pitzschke (1972) combined with Stubbe and Stubbe (1977); Pils and Martin (1978)]. Appling this figure to Englund's (1970) data would yield 4.1 cubs at dens. For different reasons, embryo counts are likely to overestimate the number born, whereas counts of cubs at dens are subject to the opposite. I have used a tentative estimate of 4.5 cubs born per litter in all three areas.

Selecting isopleths

The results did not vary much when scars of all shades were included in the calculations (Tab. 1). However, the darkest scars were primarily found early in the season. Thus, although dark scars faded, no scars seemed to disappear completely within one season.

Isopleths of constant whelping frequencies could be established by successively including scars of lighter shades (Tab. 1), and the corresponding mean litter sizes were calculated (Tab. 2). In Västerbotten the best estimate of the mean 4.5 cubs born was attained by the 60 % isopleth, whereas the 70 % isopleths yielded the best fits in Bergslagen and Småland.

Adjustments to obtain the best fit of mean litter size in single time periods yielded the finally accepted trajectories (series) of successive shades to be included in the counts: (shades counted early in autumn; subsequently included shade/week when first included) Västerbotten 6–4; 3/46; 2/5, Bergslagen 6–4; 3/41; 2/52, Småland 6–3; 2/1.

All previously counted scars were included in the new counts, but 22 % of the vixens with accepted scars had an increased number of scars as compared with the old method. Half of these vixens were previously considered as having had no cubs. The number of scars now counted in the uteri of the four vixens with known minimum (!) litter sizes (Lindström 1981) overestimated these by 1–3 cubs.

The series of shades to be successively considered in the scar counts presented above should not be applied in any other areas. However, the method of calculating these provides a possibility to analyze fading of the scars whenever a material large enough is available, and also to correct for fading if an independent estimate of mean litter size can be obtained. There is no limitation concerning species as long as the method of placental scar

Table 1. **Mean litter size and percent whelping females (left and right of slash, respectively) as calculated from placental scars of increasingly lighter shade and throughout the season of collection (week number 31–13) in Västerbotten (a), Bergslagen (b), and Småland (c)**

Periods indicated by vertical bars. Sample size indicated at the top of each data set

a.

Week	31–45	46–49	50–53	1–2	3–4	5–6	7–8	9–13
n	12	25	40	29	23	27	20	27
shade 6	2.0/ 8	1.0/ 4	3.0/ 3	-/ 0	-/ 0	-/ 0	-/ 0	-/ 0
5-6	5.0/25	2.0/12	2.0/10	-/ 0	4.0/ 4	6.0/ 4	-/ 0	-/ 0
4-6	5.2/42	2.3/56	3.1/30	1.7/10	3.8/22	3.0/19	2.3/15	-/ 0
3-6	6.1/58	4.1/60	4.2/48	2.4/55	3.9/35	3.8/37	3.4/35	3.0/ 4
2-6	6.4/83	5.7/68	5.1/80	4.9/86	5.2/83	5.0/85	5.8/70	5.5/74
1-6	5.8/83	5.3/80	5.4/85	5.5/86	5.5/91	5.5/85	6.0/80	5.2/96

b.

Week	31–40	41–45	46–47	48–49	50–51	52–53	1–2	3–4	5–6	7–8	9–13
n	24	22	24	21	40	17	35	38	27	26	10
shade 6	3.7/38	3.0/18	2.0/13	-/ 0	3.0/15	-/ 0	-/ 0	1.5/ 5	1.0/ 4	-/ 0	-/ 0
5-6	4.3/63	3.5/50	2.6/21	2.5/19	3.7/28	1.0/12	1.8/11	2.0/ 8	1.8/15	2.3/12	1.5/20
4-6	4.9/71	4.2/59	3.1/54	2.6/38	3.7/48	2.6/29	2.1/26	1.9/21	2.7/37	1.8/23	3.0/30
3-6	5.3/75	4.2/77	4.1/79	3.5/71	4.8/58	3.1/47	2.5/51	2.9/50	3.4/63	2.2/50	3.1/70
2-6	5.3/88	5.2/82	4.6/96	5.8/75	5.5/73	5.2/65	4.0/83	4.1/84	4.7/85	4.4/77	5.6/70
1-6	5.7/88	5.7/86	5.0/96	6.8/91	6.1/75	5.3/76	5.0/89	5.0/87	5.5/89	5.3/77	6.3/70

c.

Week	31–40	41–49	50–53	1–2	3–4	5–6	7–13
n		16	28	22	21	10	24
shade 6		-/ 0	3.0/ 7	-/ 0	-/ 0	-/ 0	-/ 0
5-6		1.0/ 6	3.5/14	2.0/ 9	-/ 0	-/ 0	-/ 0
4-6		2.8/31	3.2/36	2.6/32	3.8/19	1.0/10	3.0/ 8
3-6		3.8/56	4.0/61	3.7/45	4.3/43	3.0/30	2.7/ 38
2-6		5.3/94	5.1/75	4.5/77	4.7/86	4.3/80	4.1/75
1-6		5.7/64	5.7/79	5.4/82	4.7/95	4.2/90	4.1/92

Table 2. **Mean litter sizes as calculated from the isopleths of 40, 50, 60, and 70 % whelping frequencies in Västerbotten, Bergslagen, and Småland**

Whelping frequency	Mean litter size Västerbotten	Bergslagen	Småland
40	3.8	3.1	3.4
50	3.8	3.1	3.7
60	4.6	3.5	4.0
70	5.3	4.5	4.4

counts is valid. The only assumption needed is that the uteri collected during each subperiod provide an unbiased sample from the population of females alive previous spring.

Acknowledgements

Special thanks go to YLVA LINDROOTH and CHRISTINA LINDSTRÖM for doing the necropsies and the accompanying analyses. Critique and support were offered by JON SWENSON. He also corrected my English language. CHRISTINA LINDSTRÖM, EGON NILSSON, JAN and BIRGIT ÅBERG organized the collection of carcasses. I am also in debt to all hunters who provided the raw material of the study. ANDREAS SEILER helped me with the Zusammenfassung. The study was an integrated part of the environmental monitoring program (PMK) of the Swedish Environmental Protection Agency.

Zusammenfassung

Zählungen von Implantationsnarben beim Rotfuchs (Vulpes vulpes L.), eine Revision

Die Wurfgröße und Wurfhäufigkeit von Säugern mit einer Placenta zonaria können über Implantationsnarben im Endometrium ermittelt werden. Beim Rotfuchs (*Vulpes vulpes* L.) verblassen die Narben jedoch nach erfolgter Geburt. Hier präsentiere ich eine revidierte Methode zur Feststellung, welche Färbungsgrade berücksichtigt werden sollten, um eine korrekte Schätzung der Reproduktion zu verschiedenen Zeitpunkten zu erhalten. Diese Methode basiert auf sukzessiven Berechnungen von Narbenanzahlen unterschiedlicher Intensität. Die Narben, welche die besten Übereinstimmungen mit den beobachteten Durchschnittswurfgrößen ergaben, wurden für jährliche Reproduktionsanalysen bei schwedischen Füchsen verwendet.

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Zeitschrift/Journal: Mammalian Biology (früher Zeitschrift für Säugetierkunde)

Jahr/Year: 1994

Band/Volume: 59

Autor(en)/Author(s): Lindström Erik R.

Artikel/Article: Placental scar counts in the Red fox (Vulpes vulpes L.) revisited 169-173