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Ovulation rates in European lynx, *Lynx lynx* (L.), from Norway

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Abstract

Variation in ovulation rates in European Lynx, *Lynx lynx*, was studied with reference to condition and availability of prey species.

Over a period of 17 years, the mean ovulation rate of 83 females older than two years was 3.10 ± SD 1.87. No significant relationships were found between ovulation rate and important parameters like food availability, general condition of the female, age or year.

Introduction

Brand and Keith (1979) found significantly lower ovulation rates in Canadian lynx, *Lynx canadensis,* during a snowshoe hare *Lepus americanus* decline in Alberta, Canada, than during increases.

The snowshoe hare is the major food of the Canadian lynx, and lynx numbers fluctuating with hare abundance in approximately 10-year cycles (Keith 1963).

In Norway the European lynx, *Lynx lynx,* is not nearly as restricted to only one prey species as it's North American counterpart (Birkeland and Myrberget 1980), and fluctuations in abundance are small.

Materials and methods

From 1960 to 1981, the Norwegian state bounty on lynx required that the skinned carcasses were to be sent to the Directorate for Nature Management. The present study is based on samples accumulated from 1960 through 1976, and includes skulls and reproductive tracts with ovaries of 176 females.

Ovaries were macroscopically examined for form, colour, size and stage of development, sectioned by a freezing microtome and stained with Heidenhain's haematoxylin (Romeis 1948; Baker 1966). Sections were analysed with a microscope, and Graafian follicles and corpora lutea were counted.

Fresh luteal bodies can be found the year round. Normally they are easily distinguishable from luteal bodies of the previous cycle (Crowe 1975). There are differences in colour and consistency. Fresh luteal bodies are light yellow. One year later, when they turn into "lutein bodies of the previous cycle", they are red-brownish or gray with a significantly less grainy appearance. Luteal bodies from three cycles have been observed in eight cases.

Ovulation rates were calculated by counting the fresh luteal bodies and Graafian follicles in ovaries (Cheatum 1949; Duke 1949; Gashwiler et al. 1961). Age was determined by means of incremental lines in tooth cementum (Kvam 1984).

In order to avoid bias due to lower ovulation rates in young individuals, only females older than 2 years were used. A total of 83 females were investigated.

Since hunting of lynx is almost exclusively restricted to the period from January through April, the youngest individual investigated was almost 3 years old. Lynx kittens are born in May or early June, and the rutting season takes place from January through April.

According to Birkeland and Myrberget (1980) reindeer, *Rangifer tarandus*, roedeer, *Capreolus capreolus,* Mountain hare, *Lepus timidus* and small rodents Microtinae made up respectively 31 %, 17 %, 19 % and 8 % by number of the inspected stomach contents of 146 lynx from Norway.

Official hunting statistics for these major prey species except rodents were compared with annual

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records of the number of lynx killed, in order to study fluctuations in population size in relation to lynx condition and ovulation rates.

Small rodent abundance in Norway follows approximately a 4-year cycle. Peak years, based on data from Myrberget (1973) and Christiansen (1983) are plotted in Fig. 1.

Specimens were assigned an index value from 1 (low) to 5 (high) indicating general condition, based on results of initial laboratory examinations of intestine fat deposits, and kidney fat index (Langvatn 1977).

Results

The annual kill of lynxes in Norway around 1960 was relatively low. A positive trend which peaked in 1968 was followed by a decline in the 1970s, and numbers started increasing again in 1977 (Fig. 1).

There is no correlation between hunting statistics for European lynx and roedeer the same year in the period 1960–1981 (Fig. 1) ($r = -0.41$, $n = 22$, $P = 0.43$ Pearsons corr.).

There is no significant correlation between lynx ovulation rate and roedeer hunted the same year ($r = -0.04$, $n = 83$, $P = 0.35$ Pearsons corr.).

Individual lynx ovulation data were compared to roedeer hunted the year each animal was born, to see if the condition of the mother, which might be connected to roedeer availability, had influence on the reproductive performance of the young. The correlation was statistically significant, but not very high: $r = +0.31$, $n = 83$, $P = 0.002$ (Pearsons corr.).

Hunting statistics are available for mountain hare after 1971 (Fig. 1). Correlation with numbers of lynx killed is low and even negative: $r = -0.16$, $n = 11$, $P = 0.32$ (Pearsons corr.). Possible correlation between lynx ovulation rate and statistics on mountain hare hunting cannot be tested, since data on both parameters are available for only five common years. The lynx is most abundant in areas of Norway where reindeer husbandry is practised, and therefore comparisons with statistics on hunting of wild reindeer would be futile. No statistics on reindeer husbandry were available before 1980.

Fig. 1 shows that there is no obvious correlation between small rodent peak years and lynx population size as measured by annual numbers of lynx killed.

Correlations between mean numbers of corpora lutea and numbers of lynx killed annually are low and not significant ($r = 0.20$, $n = 17$, $P = 0.21$ Pearsons corr.).

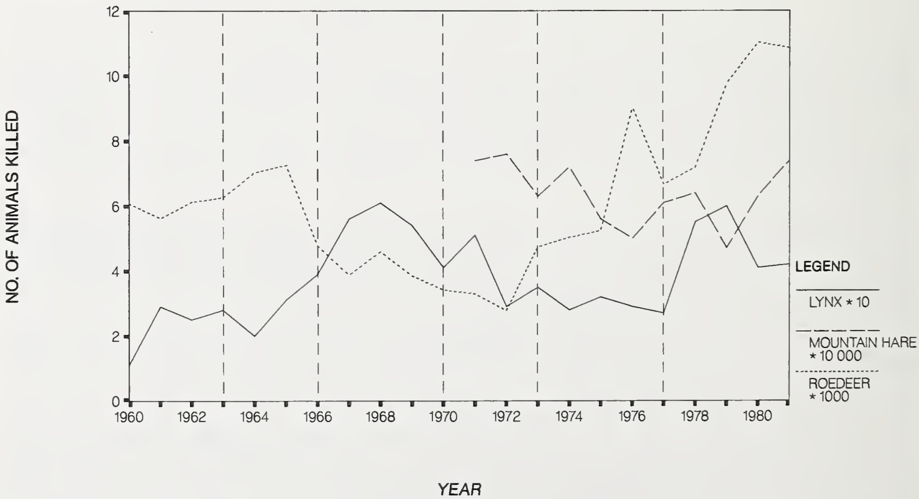
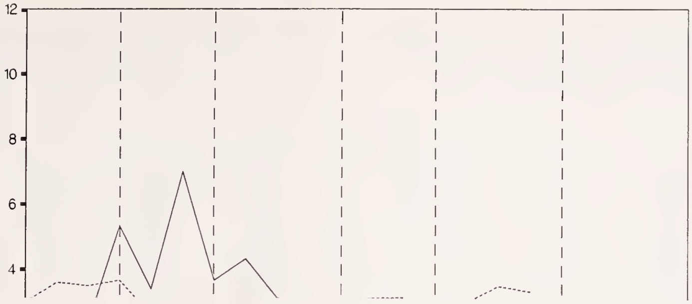


Fig. 1. Numbers of European lynx, *Lynx lynx* × 10, mountain hare *Lepus timidus* × 10 000 and roedeer *Capreolus capreolus* × 1000 killed per year in Norway since 1960 according to official hunting statistics. Small rodent peak years are indicated by vertical dotted lines



Erratum

Zeitschrift für Säugetierkunde, Band 55, Heft 4, S. 253–259 (1990)

VERLAG PAUL PAREY

Im Beitrag K. AL-ROBAAE und H. FELTEN, „Was ist *Erythronesokia* Khajuria, 1981 (Mammalia: Rodentia: Muridae)?" muß es im Kapitel „Lebensweise" (S. 258) in der ersten Zeile heißen:
Nesokia bunnii lebt im Irak . . .

4, 3 and 1 fresh corpora lutea. The resulting mean ovulation rate was 2.66, which was far below 3.10, the mean ovulation rate for the entire sample. Only one female was classified in the general condition index 1, indicating "lean". Although this female was 17 years old (No. 3/74), she carried 4 fresh corpora lutea and 1 luteal body of previous cycles. The result does not indicate the difference between ovulation rates in animals of extremely bad and extremely good condition to be significant when speaking in terms of population biology.

Discussion

The European lynx is a known predator on a variety of animals, from small rodents to ungulates (BIRKELAND and MYRBERGET 1980; BREITENMOSER and HALLER 1987; DULKEIT 1953; HAGLUND 1966; HELL 1973; JONSSON 1980; PULLIAINEN 1974, 1981; PULLIAINEN and HYYPIA 1975; SUMINSKI 1973). Prey preferences seem to differ between different parts

Table 1. Ovulation rate expressed by number of fresh corpora lutea and Graafian follicles ranged according to age classes

Age in years	x̄	SD	N	Range
2	3.09	1.57	22	0– 7
3	3.80	2.17	20	0– 8
4	2.91	2.62	11	1–10
5	2.40	1.65	10	1– 5
6	1.83	1.16	6	0– 3
7	3.20	1.10	5	2– 4
8–9	3.16	1.47	6	1– 5
10–17	3.67	1.53	3	2– 5
Total	3.10	1.87	83	0–10

Table 2. Ovulation rate expressed by number of fresh corpora lutea and Graafian follicles ranged according to year of killing

Year	x̄	SD	N
1960	1.00	0	1
1961	2.17	1.60	6
1962	2.33	2.08	3
1963	5.33	4.16	3
1964	3.40	2.70	5
1965	7.00	0	1
1966	3.67	2.07	6
1967	4.33	2.00	9
1968	3.13	0.64	8
1969	2.88	1.69	9
1970	2.00	0	1
1971	3.00	1.31	8
1972	3.00	1.70	8
1973	3.00	1.41	2
1974	2.00	0.82	4
1975	2.33	1.37	6
1976	2.00	1.73	3
Total	3.10	1.87	83

Table 3. Ovulation rate expressed by number of fresh corpora lutea ranged according to a general condition index

Gen. condition index	N	x̄	SD
1	1	4.00	0
2	8	2.63	2.45
3	54	3.06	1.71
4	13	3.62	2.36
5	3	3.00	1.73
(No index)	4	2.75	1.89
Total	83	3.10	1.87

Legend to general condition indexes: 1 = "lean"; 2 = not too good; 3 = normal; 4 = very good; 5 = fat

of the distribution area of the lynx, dependent on availability of relevant prey species (Breitenmoser and Haller 1987; Pulliainen et al. 1988).

It has previously been demonstrated that roedeer may represent a major part of the diet of the European lynx (Birkeland and Myrberget 1980; Egorov 1965; Johnson 1980). Roedeer were not originally members of the native Norwegian fauna before 1900, and regular hunting for roedeer was not registered before 1927 (Olstad 1944). The annual numbers of lynx killed before the turn of the century were much higher than in more recent years. Although the roedeer is an important food resource when available, it is consequently in no way a prerequisite to the survival of lynx in Norway.

Haglund (1966) and Birkeland and Myrberget (1980) report a shift in the diet of lynxes from predominantly small game during autumn, to cervids in winter. Small game and rodents are inaccessible under deep snow, and cervids experience difficulties moving in deep snow, while a lynx with its well adapted large paws travels with ease in snow covered terrain (Formozov 1946).

The European lynx is bigger than the other *Lynx* species (Kurten and Rausch 1959; Matjuschkin 1978; Werdelin 1981), and may therefore be more ready to accept larger prey species (Moors 1980; Stenseth et al. 1977; Werdelin 1981).

Small game in Northern Europe follow a 4-year-cycle similar to that of small rodents (Hagen 1953; Myrberget 1984; Østbye and Mysterud 1984). As the European lynx readily accepts a variety of prey species, it is only slightly influenced by such cycles as long as alternative prey is available. Pulliainen et al. (1988) report a significant difference in available prey, stomach-contents and condition between lynxes in Tavastland and in South-Eastern Finland in the 1980s. The lynx in Tavastland had the opportunity of switching to white-tailed deer *Odocoileus virginianus* when hare populations were low, while the lynx in SE-Finland did not have this opportunity. Switching for prey (Murdoch and Oaten 1975) in the European lynx is also indicated by Breitenmoser and Haller (1987), and in the Canada lynx by Bergerud (1967, 1971, 1983).

The Norwegian lynxes show no fluctuations in number or ovulation rate comparable to variations in abundance of its most important prey species over a 17 year period. The most likely explanation seems to be prey switching, which imply dampened tendency for individuals to deviate too much from normal condition. The Norwegian lynx has a variety of prey species available, and thereby the necessary prerequisite for stable condition and stable ovulation rate.

Zusammenfassung

Ovulationsraten beim Europäischen Luchs, Lynx lynx (L.), aus Norwegen

Die Ovulationsrate norwegischer Luchse *(Lynx lynx)* wurde in Beziehung zur Häufigkeit ihrer Beutetiere und zu ihrer Kondition untersucht. Für 83 Weibchen betrug die mittlere Ovulationsrate in 17 Jahren 3,10 ± 1,87 (SD). Signifikante Beziehungen ergaben sich weder hier noch zwischen Ovulationsrate und Alter oder Ovulationsrate und Erlegungsjahr.

References

Baker, J. R. (1966): Cytological technique. London: Methuen and Co.
Bergerud, A. T. (1967): The distribution and abundance of arctic hares in Newfoundland, Canada. Can. Field Nat. **81**, 242–248.
— (1971): The population dynamics of Newfoundland caribou. Wildl. Monogr. **25**, 4–55.
— (1983): Prey switching in a simple ecosystem. Scientific Amer. **249**, 116–124.
Birkeland, K. H.; Myrberget, S. (1980): The diet of the lynx *Lynx lynx* in Norway. Fauna norv. Ser. A **1**, 24–28.
Brand, C. J.; Keith, L. B. (1979): Lynx demography during a snowshoe hare decline in Alberta. J. Wildl. Manage. **43**, 827–849.
Breitenmoser, U.; Haller, H. (1987): Zur Nahrungsökologie des Luchses *Lynx lynx* in den schweizerischen Nordalpen. Z. Säugetierkunde **52**, 168–191.
Cheatum, E. L. (1949): The use af corpora lutea for determining ovulation incidence and variations in the fertility of white tailed deer. Cornell vet. **39**, 282–291.
Christiansen, E. (1983): Fluctuations in some small rodent populations in Norway 1971–1979. Holarct. Ecol. **6**, 24–31.
Crowe, D. M. (1975): Aspects of ageing, growth, and reproduction of bobcats from Wyoming. J. Mammalogy **56**, 177–198.
Duke, K. L. (1949): Some notes on the histology of the ovary of the bobcat. Anat. Rec. **103**, 111–131.
Dulkeit, G. D. (1953): Znachenic rysi i rosomakhi kak khischnikov v pridrodnom kpmlekse Altaiskoi taiga. In: Sbornik Preobrazovanie fauny poxvonochnykh nashei strany. Ed. by A. A. Nasimovich Moskva Moip.: Cit. according to Stroganov 1969.
Egorov, O. V. (1965): Wild ungulates of Yakutia. (Transl. from Russian.) Israel Program of sci. Transl., Jerusalem 1967.
Formozow, A. N. (1946): Snow Cover as an Integral Factor of the Environment and its Importance in the Ecology of Mammals and Birds. Edmonton: Boreal Institute, Univ. of Alberta.
Gashwiler, J. S.; Robinette, W. L.; Morris, O. W. (1961): Breeding habits of bobcats in Utah. J. Mammalogy **42**, 76–84.
Hagen, Y. (1953): De periodiske svingninger i individtallet hos enkelte pattedyr og fuglearter på den nordlige halvkule. Fauna **6**, 97–121.
Haglund, B. (1966): Winter Habits of the Lynx *(Lynx lynx)* and Wolverine (*Gulo gulo* L.) as Revealed by Tracking in the Snows. Viltrevy **4**, 81–299.
Hell, P. (1973): Ergebnisse der Luchsforschung in der CSSR Teil I: Nahrungsökologie und jagdwirtschaftliche Bedeutung. Beiträge zur Jagd- und Wildforschung **8**, 335–344.
Jonsson, S. (1980): Det är rådjuren som reglerar lostammen och inte tvärtom. Jaktmarker och Fiskevatten **68**, 338–341.

Keith, L. B. (1963): Wildlifes ten-year-cycle. Madison: Univ. Wisconsin Press.
Kurten, B.; Rausch, R. (1959): Biometric comparison between North American and European mammals. Acta Arctica **11**, 1–44.
Kvam, T. (1984): Age determination in European lynx by incremental lines in tooth cementum. Acta Zool. Fenn. 171, 221–223.
Langvatn, R. (Ed.) (1977): Criteria of physical condition, growth and development in Cervidae, suitable for routine studies. Stockholm: Nordic Council for Wildlife Research.
Matjuschkin, E. N. (1978): Der Luchs *Lynx lynx*. Die Neue Brehm Bücherei 517. Wittenberg-Lutherstadt: Ziemsen.
Moors, P. J. (1980): Sexual dimorphism in the body size of mustelids (Carnivora): the roles of breeding habits and breeding systems. Oikos **34**, 147–158.
Murdoch, W. W.; Oaten, A. (1975): Predation and population stability. In: Advances in Ecological research. Ed. by A. Macfadyen. London: Academic Press.
Myrberget, S. (1973): Geographical synchronisms of cycles of small rodents in Norway. Oikos **24**, 220–224.
— (1984): Forskning og viltstell med tanke på lirypa. Viltrapport **29**, 79–84.
Olstad, O. (1944): Rådyrets *Capreolus capreolus* (L.) utbredelse i Norge. Statens viltundersøkelser Medd. **14**.
Pulliainen, E. (1974): Suomen suurpedot. Helsinki: Tammi.
— (1981): Winter diet of *Felis lynx* L. in SE Finland as compared with the nutrition of other northern lynxes. Z. Säugetierkunde **46**, 249–259.
Pulliainen, E.; Hyypia, V. (1975): Winter food and feeding habits of lynxes *L. lynx* in southeastern Finland. Suom. Riista **26**, 60–63.
Pulliainen, E.; Lindgren, E.; Tunkkari, P. S. (1988). Lodjurets vinternäring: Hare eller vitsvanshjort? Jägaren **3**, 42–44.
Romeis, B. (1948): Mikroskopische Technik. München: R. Oldenbourg.
Stenseth, N. C.; Hansson, L.; Myllymaki, A. (1977): Food selection of the field vole *Microtus agrestis*. Oikos **29**, 511–524.
Suminski, P. (1973): Rys. Warzawa (Panstwowe i Lesne).
Werdelin, L. (1981): The evolution of lynxes. Ann. Zool. Fenn. **18**, 37–71.
Østbye, E.; Mysterud, I. (1984): Smågnagere og spurvefugler i høyfjellet – Søkelys på to av Yngvar Hagens hypoteser. Viltrapport **29**, 72–78.

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