Feeding Ecology of the Spanish Lynx in the Coto Doñana

Miguel DELIBES


To study the food habits of the Spanish lynx were analysed 1537 droppings collected throughout two periods of one year in Doñana, S. W. Spain. A food test which was carried out on a captive lynx allowed us to relate the number of occurrences of each kind of prey in the samples with the actual number of individual prey and the biomass devoured. The main prey is the rabbit which amounts to 79% of prey captured and 86% of the biomass consumed. The next in importance are the ducks (9% and 7% respectively) and the ungulates (9% and 5%). Seasonal variations in the diet are not very pronounced. The importance of rabbits is at its maximum between July and October, that of the ducks between March and June and that of the cervids between November and February. The prey is selected for the facility in which they may be caught rather than for their abundance. It is estimated that an individual lynx consumes about 74 gr of food per kilo of body weight daily. The impact of the predation on the prey populations is difficult to evaluate, but it seems to be very important on the fallow deer population, relatively important on these of rabbits and red deer and very slight on that of ducks. Predation on ungulates in the study area may be a kind of starvation-related mortality.

[Est. Biol. Doñana, C.S.I.C., Paraguay 1, Sevilla 12, Spain]

1. INTRODUCTION

The Spanish lynx, Lynx pardinus (Temminck, 1824), whose specific identity has recently been upheld by Kürten (1963) and van den Brink (1970) by demonstrating that in the past it has coexisted sympatrically with the European lynx, Lynx lynx (Linnaeus, 1758), is one of the most characteristic predators of the Iberian Mediterranean ecosystems. Despite this, its ecology and biology are not well known, mainly due to its small area of distribution and its rarity, since it is a seriously endangered species (I.U.C.N., 1978). The only works published until present on the food habits of this species, include some field observations compiled by Valverde (1957, 1963, 1967), the analysis of a few gut contents and faeces by Delibes et al. (1975), Delibes (1976) and Palma (1977) and the paper by Rogers (1978), in which are presented, incorrectly in some aspects, some of my unpublished data.

Continued on page 332
The table of the results are shown in Table 1 where we also show the indices.

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In the second part, the factors were shown to be significant in some cases.

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**Table 1**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Effect</th>
<th>Table Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor A</td>
<td>Significant</td>
<td>0.05</td>
</tr>
<tr>
<td>Factor B</td>
<td>Significant</td>
<td>0.01</td>
</tr>
</tbody>
</table>

**Results**

The results of the food test are quite consistent with a high level of confidence.

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**Methodology**

The methodology used in this study included the following steps:

1. Collection of data
2. Analysis of data
3. Reporting results

In conclusion, the study was successful in demonstrating the effectiveness of the proposed methodology.

**References**


which relate for each type of prey the number of occurrences with the actual number of individual prey and the biomass consumed. The index of the mallard (Anas platyrhynchos Linnaeus, 1758) will be used for all the Anatidae, the index of the red deer fawn (Cervus elaphus Linnaeus, 1758) for all the ungulates, and the magpie (Pica pica Linnaeus, 1758) index for all the birds (including unidentified ones), with the exception of ducks and red-legged partridges (Alectoris rufa Linnaeus, 1758).

The described method is certainly open to criticism as its reliability depends on numerous assumptions. In spite of this, I think it is possible to interpret the results much more precisely than by simply showing the data of frequency of occurrence.

4. RESULTS AND DISCUSSION

4.1. Prey Species

The food of the lynx is not very varied and is based on the rabbit, whose remains appear in more than 89% of the samples (Table 2). Although a minimum of 21 species of vertebrates have been found in the diet, only two, the rabbit and the mallard, occur in more than 5% of the faeces and only six [the previously mentioned plus the red deer and fallow deer (Dama dama Linnaeus, 1758), the red-legged partridge and the Apodemus-Mus] in more than 1%

Among the unidentified Anatidae there is probably some greylag goose (Anser anser Linnaeus, 1758), as wild lynxes have been observed eating this prey on three occasions. Also, among the unidentified ungulates, some young wild boar (Sus scrofa Linnaeus, 1758) can be represented, as lynxes have sometimes been seen in Doñana carrying young wild boar in the mouth (Valverde, 1967).

In short, the Spanish lynx is primarily a predator of mammals (89.9% of the total occurrences) and secondarily of birds (19%), with a monotonous diet despite the fact that it occasionally captures different prey including reptiles [as well as the ladder snake (Elaphe scalaris Schinz, 1822) reported on here, we can add an eyed lizard (Lacerta lepida Lauinn, 1804, found in one stomach by Delibes et al., 1975)]. The capturing of cattle (sheep, goats, calves) seems to be exceptional (Valverde, 1957; Delibes et al., 1975). In relation to the diet of the lynx in other European and American localities, the small role played by hares (Lepus spp.) is noteworthy; in Spain these are preyed upon very seldom by Lynx pardina, due mainly to the fact that the two species occupy different habitats.

Some remains have not been considered as food (Table 2). Mongooses (Herpestes ichneumon Linnaeus, 1758), as other carnivores, are usually killed but not eaten by the lynx in Doñana, while the insects found in droppings were probably previously consumed by the prey themselves.

### Table 2

<table>
<thead>
<tr>
<th>Prey species</th>
<th>Number of occurrences</th>
<th>Frequency of occurrence</th>
<th>Percent of occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAMMALIA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lepus capensis</td>
<td>4</td>
<td>0.26</td>
<td>0.22</td>
</tr>
<tr>
<td>Oryctolagus cuniculus</td>
<td>1356</td>
<td>80.33</td>
<td>73.21</td>
</tr>
<tr>
<td>Lagomorpha (unidentified)</td>
<td>5</td>
<td>0.33</td>
<td>0.27</td>
</tr>
<tr>
<td>Ectomys sp., sp.</td>
<td>12</td>
<td>0.78</td>
<td>0.65</td>
</tr>
<tr>
<td>Batrachus sp.</td>
<td>6</td>
<td>0.30</td>
<td>0.33</td>
</tr>
<tr>
<td>Arvicola spadis</td>
<td>1</td>
<td>0.07</td>
<td>0.03</td>
</tr>
<tr>
<td>Apodemus-Mus spp.</td>
<td>10</td>
<td>1.24</td>
<td>1.02</td>
</tr>
<tr>
<td>Small mammals (unident.)</td>
<td>14</td>
<td>0.91</td>
<td>0.75</td>
</tr>
<tr>
<td>Cervus elaphus</td>
<td>38</td>
<td>3.12</td>
<td>2.50</td>
</tr>
<tr>
<td>Dama dama</td>
<td>49</td>
<td>3.61</td>
<td>2.90</td>
</tr>
<tr>
<td>Ungulates (unidentified)</td>
<td>16</td>
<td>1.04</td>
<td>0.86</td>
</tr>
<tr>
<td>AVES</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anas platyrhynchos</td>
<td>204</td>
<td>13.27</td>
<td>11.00</td>
</tr>
<tr>
<td>Anas crecca</td>
<td>7</td>
<td>0.46</td>
<td>0.36</td>
</tr>
<tr>
<td>Anas strepera</td>
<td>4</td>
<td>0.26</td>
<td>0.22</td>
</tr>
<tr>
<td>Anas penelope</td>
<td>1</td>
<td>0.07</td>
<td>0.05</td>
</tr>
<tr>
<td>Anatidae (unidentified)</td>
<td>59</td>
<td>3.64</td>
<td>3.02</td>
</tr>
<tr>
<td>Alectoris rufa</td>
<td>31</td>
<td>2.02</td>
<td>1.67</td>
</tr>
<tr>
<td>Coturnix coturnix</td>
<td>1</td>
<td>0.07</td>
<td>0.05</td>
</tr>
<tr>
<td>Gallinula chloropus</td>
<td>2</td>
<td>0.13</td>
<td>0.11</td>
</tr>
<tr>
<td>Fulica atra</td>
<td>2</td>
<td>0.13</td>
<td>0.11</td>
</tr>
<tr>
<td>Ratitae (unidentified)</td>
<td>3</td>
<td>0.20</td>
<td>0.16</td>
</tr>
<tr>
<td>Columba sp.</td>
<td>1</td>
<td>0.07</td>
<td>0.05</td>
</tr>
<tr>
<td>Strigidae (Athene noctua?)</td>
<td>1</td>
<td>0.07</td>
<td>0.05</td>
</tr>
<tr>
<td>Turdus merula</td>
<td>1</td>
<td>0.07</td>
<td>0.05</td>
</tr>
<tr>
<td>Pica pica</td>
<td>1</td>
<td>0.13</td>
<td>0.10</td>
</tr>
<tr>
<td>Passeriformes (unidentified)</td>
<td>39</td>
<td>2.45</td>
<td>1.90</td>
</tr>
<tr>
<td>Birds (unidentified)</td>
<td>10</td>
<td>0.60</td>
<td>0.47</td>
</tr>
<tr>
<td>REPTILIA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elaphe scalaris</td>
<td>1</td>
<td>0.07</td>
<td>0.05</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1855</td>
<td>100.00</td>
<td>99.93</td>
</tr>
<tr>
<td>OTHER REMAINS (not food)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lynx hairs</td>
<td>197</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mongoose hairs</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insects</td>
<td>39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Faecal pellets of deer</td>
<td>51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetal matter</td>
<td>185</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As to the deer faecal pellets and the vegetal remains, they must have been ingested accidentally by the predator together with some food. All these remains are incorrectly included as prey species by Rogers (1978).

4.2. Seasonal Fluctuations in Diet

Although the rabbit plays an important part in the diet throughout the whole year, there are appreciable seasonal fluctuations, both considering the number of individual prey captured and the biomass consumed (Fig. 1). These fluctuations are clearer if the year is divided into
The carrying capacity of the 300-kilometer (186-mile) long [missing text]

The carrying capacity of the 300-kilometer (186-mile) long [missing text]
from May, and also to a probable increase in the vulnerability of the
fawns after the mating season of the adults (in September-October),
when the materno-filial bond is weakened and the protection provided
by the mother to the young diministes (Leont, 1974). Alvarez et al.
(1975) have described the defensive behaviour of adult female fallow
deer accompanied by infants when faced with the Spanish lynx. Apart
from this, there is no doubt that the severe drought of the autumns of
1973, 1974 and 1975 made the cervids much more vulnerable, as some of
them even died of starvation.

Table 4

<table>
<thead>
<tr>
<th></th>
<th>Rabbits</th>
<th>Ungulates</th>
<th>Ducks</th>
<th>Other Mammals</th>
<th>Other Birds</th>
</tr>
</thead>
<tbody>
<tr>
<td>(March—June)</td>
<td>++</td>
<td>+</td>
<td>+++++</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(July—Oct.)</td>
<td>+++</td>
<td>+++++</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Nov.—Febr.)</td>
<td>+</td>
<td>++++</td>
<td>+++++</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Although systematic studies have not been carried out, it seems that
since 1976 the predation of the lynx on the ungulates has diminished
notably in the area.

4.2.3. Ducks

From March to May the principal food source alternative were the
ducks, especially Anas platyrhynchos. In this period many mallards
leave the marshes in order to mate and to nest in the small pools of
the maquis. During the mating period many of them walk on dry
ground and are very noisy both during the night and day, being
therefore a very vulnerable prey. Again, the vulnerability is more
important than the abundance in determining the intensity of predation,
as the greatest density of waterfowl in the area is reached during the
winter, from October to February.

4.3. Food Requirements

In order to discuss the impact of the lynx on the populations of preys
it is necessary to know not only the relative frequencies of each type
of prey in the diet, but also the absolute quantities which each individual
ekills and uses. This is difficult as the data available often comes from
animals in captivity, and individual differences also play an important
part.

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Our captive lynx which was fed in the conditions mentioned in
section 3.3., remained in good physical condition consuming 40,199 g in
68 days. This means 591 g/day which represents about 7.4% of body
weight (74 g/kg/day). It is considered that this intake, halfway between
the maximum values estimated for other species of the genus Lynx
of similar body weight (Sawders, 1963; Golley et al., 1965; Brand
et al., 1976), could be a valid approximation to the average intake of
a free-living individual Spanish lynx.

4.4. Annual Consumption per Individual

Knowing the average biomass taken daily by an individual lynx, it is
data find the total biomass consumed in one year, which will
then be distributed among the different kinds of prey according to the
percentages summarised in the last column of Table 3. Admitting that
the average biomass consumed of each individual prey agree with the
values obtained in the food-test (column 3 in Table 1), we can calculate
the approximate number of individual preys killed and consumed by
a lynx in one year (Table 5).

As indicated in 3.3., the number of ungulates in Table 5 should be
considered with caution. Due to the fact that the captive lynx only
used 1250 g of the fawn carcass offered in the test, a total annual
consumption of less than 12 kg of ungulates corresponds to the capture
of 9 individual deer. This estimation would be considerably lower if
any one of the following circumstances would occur: (a) the lynx eat
from the deer carcass again after having eaten from it once, as
frequently shown by other species of the genus, (b) various individual
lynxes eat from the same carcass, (c) a single lynx takes more than
1250 g in one feeding session, (d) the Spanish lynx eat carrion.

Of all these possibilities, (a) and (d) have not been confirmed for,
Feeding ecology of the Spanish Igneva

A's impact on nutrients

Feeding ecology of the Spanish Igneva.


(1997 (1981) indicates for the predation by fine muds and nutrients, a modified model which contains both fine muds and nutrients, a modified model which contains both fine muds and nutrients, a modified model which contains both fine muds and nutrients, a modified model which contains both fine muds and nutrients, a modified model which contains both fine muds and nutrients, a modified model which contains both fine muds and nutrients, a modified model which contains both fine muds and nutrients.
(competition predation, Errington, 1967). Supporting this hypothesis is the fact that 4 of 6 fawns (red and fallow deer) killed by the lynx were completely lacking in their bone marrow, which points to a physical condition near to starvation (Cheatum in Metch, 1970).

4.5.4. Impact on Ducks

The marshes of the Guadalquivir are the annual wintering quarters for 100,000 to 150,000 Anas cœtus (Sanchez, 1975) and the breeding ground for 5,000 pairs of mallards and lesser numbers of other species (Agüiar-Amat, pers. com.). Only a small fraction of these actually occupy the study area, but in any case the impact of the lynx need not be given much importance.

4.5.5. Impact on Other Preys

The impact of the lynx on the populations of small mammals is negligible as very few individuals are captured. The predation on partridges affects less than 1% of the annual production.

5. CONCLUSIONS

The results of this study on the diet of the Spanish lynx confirm previous data of Valverde (1957, 1963, 1967), Delibes (1975), Delibes et al. (1975) and other authors. As with other species of the genus, Lynx parda appears as a medium-sized predator specialized in the capture of homeothermic vertebrates, especially mammals. The basic prey is the rabbit. The Spanish lynx differs from the European lynx whose basic food are hares (i.e., in Finland, Pulliainen & Hyypiä, 1975; in Poland, Suminski, 1972; etc.) or ungulates (i.e., in Sweden, Hávelund, 1966; in Altai, U.S.S.R., Novikov, 1962; in Czechoslovakia, Heil, 1962; in Romania, Vasiliu & Decel, 1964, etc.).

Apparently the lynx population responded to the increase in rabbit availability by concentrating their food gathering efforts on this prey. When it is relatively difficult to catch rabbits, lynxes have to turn to a more varied diet, including mainly ducks or ungulates. Availability of the different preys depends less on their relative abundance than on the facility to capture them, which appears to be a common kind of response among many large and medium size carnivores (Schoener, 1971).

Although the actual figures presented in this study relating to the magnitude of the impact on prey populations are only approximate, lynxes appeared to be an important source of mortality in rabbit, red deer and specially fallow deer populations, but it is not known what impact this mortality had on the densities of these prey species. In the case of the ungulates, predation may be a form of starvation-related mortality. In the case of the rabbits, the lynx appears to behave at the end of summer and in autumn as a no prudens predator (Slobodkin, 1968), exercising a great pressure of predation on specimens with a high reproductive value, which could limit the rate of reconstruction of the numbers of prey populations.

Predation on deer is age-selective, disproportionately more fawns being killed. Old animals are not selected, most probably because of being too large. There is also evidence that even among fawns predation is not at random, the sick and the weak being selected. This is opposed to the point of view of Bergerud (1971) who states that with lynx, this kind of culling is largely absent and confirms the results of Hornocker (1970), who supplies evidence for non-random selection by another stalker, the puma Felis concolor (Linnaeus, 1771) (for a discussion on the stalker-courser dichotomy of prey selection, see Schaller, 1972, and Curio, 1976). As Curio (1976) points out with reference to the puma, this supposes that the perceptual powers of assessing the vulnerability of prey by lynx are extraordinarily good. The lynx can probably prey selectively on the deer in Doñana because after the extinction of the wolf there does not exist any other coursing carnivore which does so (Schaller, 1972).

Finally, in the future it will be necessary to improve methods of censusing of rabbits and lynxes, to study the dynamics of ungulates populations and to determine carefully the patterns by which deer carcasses are used. Only in this way can the impact of predation be correctly established.

Acknowledgments: I wish to express my sincere gratitude to J. Calderón, Dr. J. Castroviejo, E. Collado, Dr. F. Hiraldo and Dr. J. A. Valverde for their constructive criticism and permanent encouragement. My thanks are also due to Dr. C. M. Herrera and Dr. S. Erline for critical comments on the manuscript, to L. García, K. Kowalski, A. Chico and P. M. Rogers for their help in collecting the material and to Dr. R. C. Soriguier and J. Aguilier-Amat for giving me access to some unpublished data. I have a special debt of gratitude to my wife, Isabel, who give me her assistance with field work and laboratory analysis. The investigations were supported by a grant from the Juan March Foundation.

REFERENCES

The Diet and Growth of Fox Cubs in Two Regions of Scotland

H. H. KOLB & R. HEWSON


Analysis of stomach contents showed that in North-east Scotland fox cubs are mainly fed on rabbits and hares, whereas in the West of Scotland they are fed on lambs and voles. The rate of growth of litters is the same in the two regions, but cubs in the West are born on average between a week and a fortnight later than those in the North-east. It is suggested that this is due to different periods of availability of the main foods in the two habitats.

[Department of Agriculture and Fisheries for Scotland, Agricultural Scientific Services, East Craigs, Edinburgh, EH7 5ND, Scotland]

I. INTRODUCTION

Foxes Vulpes vulpes (Linnaeus, 1758) live in a great variety of habitats and eat a wide range of foods. The way in which populations adapt to these local circumstances is poorly understood. Previous work on foxes in Scotland has described the food, changes in density and reproductive condition of adults (Kolb & Hewson, 1979, 1980). This paper presents some information on the diet, date of birth and growth of fox cubs in two parts of Scotland and discusses the possible role of food availability in determining variations in the breeding and development of foxes.

II. MATERIAL AND METHODS

Litters of cubs killed during normal fox control operations were collected from gamekeepers, forestry rangers and shepherds between 1971 and 1976. One sample came from North-east Scotland (Grampian), an area of moorland, forestry and lowland farming. The other came from the West of Scotland (Strathclyde and parts of Central and Highland), an area of forestry, upland sheep farming and deer forest. No significant differences were found in diet or growth within these areas so that they represent two homogeneous samples from either side of Scotland (see Fig. 1, Kolb & Hewson, 1976).

All data came from litters killed on a known date. Each cub was weighed and measured from the top of the snout to the root of the tail (head and body length). The animal was then autopsied and its stomach contents identified as described in Kolb & Hewson (1979). In the analysis of diets the litter was taken as the sampling unit. Results are presented as the percentage frequency