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Abstract: In the early 1970s, the Eurasian lynx (*Lynx lynx*) has been reintroduced into the Swiss Alps and the Swiss Jura Mountains. Today, two distinct lynx populations exist in these two areas. In this study, we retrospectively evaluated 51 post-mortem exams of free ranging lynx which were found in Switzerland between 1987 and 1997. These data were compared with data from biological field studies. Our results show an increase of case numbers in the northwestern part of the Swiss Alps corresponding to an increase of this population. However, in other regions of the Swiss Alps, the lynx population is stable or decreasing. Submissions from the Jura Mountains remained relatively stable for the last 11 years. 45% of the dead lynx were juvenile, 20% subadult, and 31% adult. 62% of the mortality among lynx was human caused, mainly due to car accidents or poaching. Infectious diseases were encountered in 20% of all cases. Therefore we conclude that the human caused mortality is a major threat for the long term survival of the Eurasian lynx in Switzerland.

CAUSES OF MORTALITY OF FREE-RANGING LYNX IN SWITZERLAND

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Abstract

In the early 1970s, the Eurasian lynx (*Lynx lynx*) has been reintroduced into the Swiss Alps and the Swiss Jura Mountains. Today, two distinct lynx populations exist in these two areas. In this study, we retrospectively evaluated 51 post-mortem exams of free ranging lynx which were found in Switzerland between 1987 and 1997. These data were compared with data from biological field studies.

Our results show an increase of case numbers in the northwestern part of the Swiss Alps corresponding to an increase of this population. However, in other regions of the Swiss Alps, the lynx population is stable or decreasing. Submissions from the Jura Mountains remained relatively stable for the last 11 years.

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Zusammenfassung

Anfang der siebziger Jahre wurde der Eurasische Luchs (*Lynx lynx*) in den Schweizer Alpen und im Schweizer Jura wieder angesiedelt. Heute gibt es zwei getrennte Luchspopulationen in diesen Gebieten. In unserer Studie wurden 51 postmortale Untersuchungen frei lebender Luchse, die zwischen 1987 und 1997 in der Schweiz tot aufgefunden wurden, retrospektiv aufgearbeitet. Die Daten wurden mit biologischen Felddaten verglichen.

Unsere Ergebnisse zeigen eine Zunahme der Fallzahl aus dem nordwestlichen Teil der Schweizer Alpen, die mit einer Größenzunahme der Teilpopulation einhergingen. In den übrigen Regionen der Schweizer Alpen ist die Population stabil oder abnehmend. Die Zahl der Einsendungen aus dem Jura blieb relativ stabil während der letzten 11 Jahre. Unter den eingesandten Luchsen befanden sich 45 % juvenile Tiere, 20% subadulte und 31% adulte Luchse. 62% der Mortalität war bedingt durch menschliche Aktivitäten, hauptsächlich Autounfall oder Wilderei. 20% der Tiere starben an einer Infektionskrankheit. Daraus läßt sich schließen, daß der große Anteil menschlich bedingter Mortalität die Hauptgefährdung für das langfristige Überleben der Luchspopulationen in der Schweiz darstellt.

Résumé

Le lynx eurasiens (*Lynx lynx*) fut réintroduit dans les Alpes et le Jura suisses au début des années 70. Aujourd'hui, il existe deux populations de lynx distinctes dans ces deux régions. Dans cette étude, nous avons analysé 51 cas d'autopsie de lynx vivants en liberté et trouvés morts en Suisse entre 1987 et 1997. Ces données ont été comparées avec celles d'études biologiques.

Nos résultats montrent une augmentation de cas dans la partie Nord-Ouest des Alpes suisses, parallèlement à l'augmentation de cette sous-population de lynx. Cependant, dans les autres régions des Alpes suisses, la population de lynx est stable ou décroissante. Le nombre de cas provenant du Jura est resté relativement stable durant ces 11 dernières années.

Parmi les lynx envoyés pour analyse, 45% étaient juvéniles, 20% subadultes, et 31% adultes.

Dans 62% des cas, la cause de mort était directement liée aux activités humaines, principalement à la circulation routière et au braconnage. 20% des animaux furent victimes d'une maladie infectieuse. En conclusion, la mortalité causée par l'activité de l'homme est la principale menace pour la survie à long terme du lynx eurasien en Suisse.

Key words

Lynx lynx, mortality, population, Switzerland, pathology

Introduction

As the largest member of the genus *Lynx*, the Eurasian lynx (*Lynx lynx*) preys mainly upon ungulates (3). In the last century the population of the wild ungulates was dramatically low in Switzerland. Because of the lack of its natural prey the lynx had to live more and more on domestic sheep and goats. Therefore, the large cat was overhunted by humans and finally became extinct in Switzerland and other European countries. At the beginning of this century the population of wild ungulates in Switzerland started to rise again because of improved wildlife management. This opened new possibilities for the reestablishment of lynx in Switzerland. From 1972 till 1980, six female and eight male lynx have been released in the eastern and central part of the Swiss Alps and two females and two males in the Swiss Jura Mountains (1, 2). Additionally, several lynx were released illegally in Switzerland (1, 2, 6). Today there are two distinct lynx populations. One is located in the western Alps extending into France and Italy and one in the Jura Mountains (Switzerland and France).

Since 1983 the lynx have been followed by means of radiotelemetry in different parts of Switzerland (3, 4, 6). In the northwestern part of the Swiss Alps the number of lynx has been increasing for the past few years, whereas in other parts of the Swiss Alps it is stable or even decreasing (Swiss Lynx Project, unpublished data).

Causes of mortality in free-ranging lynx from outside Switzerland are rarely documented. It is known that lynx can be affected by sarcoptic mange (13), Herpesvirus infection, Feline Immunodeficiency Virus (FIV) (Stahl P., pers. comm.) or rabies (5, 7, 8, 12). Since 1987 carcasses of free ranging lynx which were found in Switzerland have been sent to the Institute of Animal Pathology for post mortem examination. In this study we retrospectively evaluated data we obtained from these pathological investigations to correlate them with data from field studies. The purpose of the study was to gain information about the causes of mortality in the two reintroduced populations in Switzerland. Together with data from biological field studies this provides useful information about the dynamics of wild populations and about factors which might threaten the survival of the Eurasian lynx in Switzerland.

Materials and methods

For our study material from 51 lynx found between 1987 and 1997 was available. Out of these, seven animals had to be euthanised because of severe debilitation. For reasons of better understanding, the underlying disorders leading to this condition were listed as causes of death under results in **table 1**. On all animals a complete necropsy was performed.

If indicated, further investigations such as histological, bacteriological, and parasitological examinations were carried out according to established diagnostic techniques. 9 animals were tested for rabies with a direct immunofluorescent antibody test.

In several cases, autolysis and decomposition of the carcasses prevented further investigations. We classified the examined lynx according to the year of death, the location where they were found, their age and sex, and the cause of mortality. We distinguished between the two populations in the Swiss Alps and the Swiss Jura Mountains. The alpine population has been further subdivided into a central, northwestern and southwestern part. With regard to the distribution among the Swiss cantons six areas were represented, Berne and Vaud, Fribourg, Neuchâtel, Valais, and Nidwalden. Animals coming out of the canton Valais were counted to the southwestern part of the Swiss Alps population. Nidwalden belongs to the central part of the Swiss Alps. Three animals were found in France near the border to Switzerland. They belonged to the population of the Jura Mountains.

Three age groups were distinguished: juveniles (animals before dispersing from their mothers home range at approximately 10 months of age), subadults (animals before sexual maturity, females less than two years, males less than three years), adults (females over two years, males over three years). For estimation of the age the size, weight, and dentition of the animals were taken into account.

Results

Provenance of lynx examined is shown in Fig. 1. The numbers of submitted carcasses from these two populations in each year is shown in Figure 2.



Fig. 1:
Map of Switzerland with lynx examined between 1987 and 1997 which belonged to the two populations (Swiss Alps, Jura Mountains)

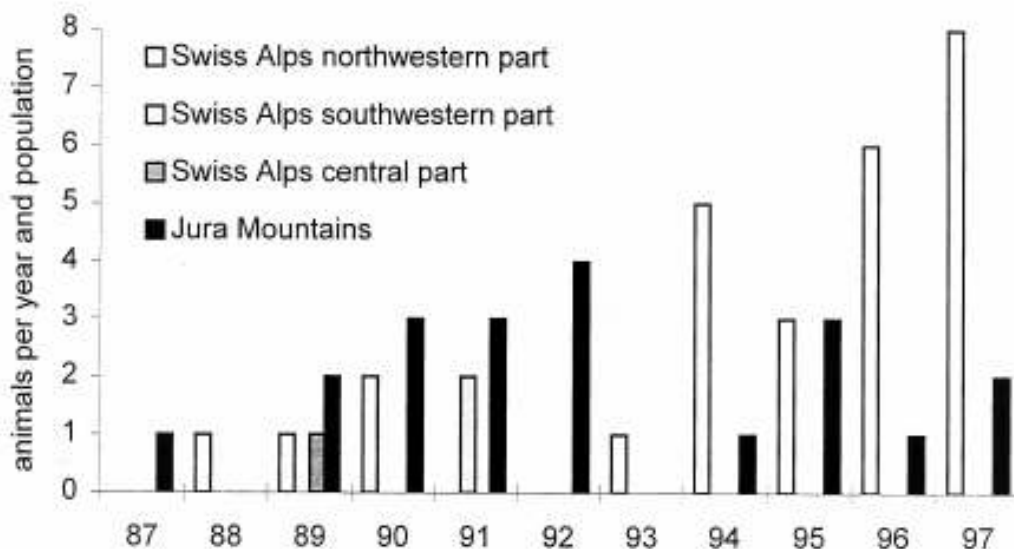


Fig. 2:
Origin of the lynx examined

In recent years the number of carcasses found in the northwestern part of the Swiss Alps increased. Since 1994, lynx from this region make up the largest part of all submitted cases while in the late 1980s only occasional carcasses were reported. From other parts of the

Swiss Alps only sporadically carcasses were send in, one case in 1989 from the central part of the Swiss Alps where the lynx were originally released and in 1991 two carcasses from the southwestern part. Submissions from the Jura Mountains remained relatively stable over the examined period (Fig. 2).

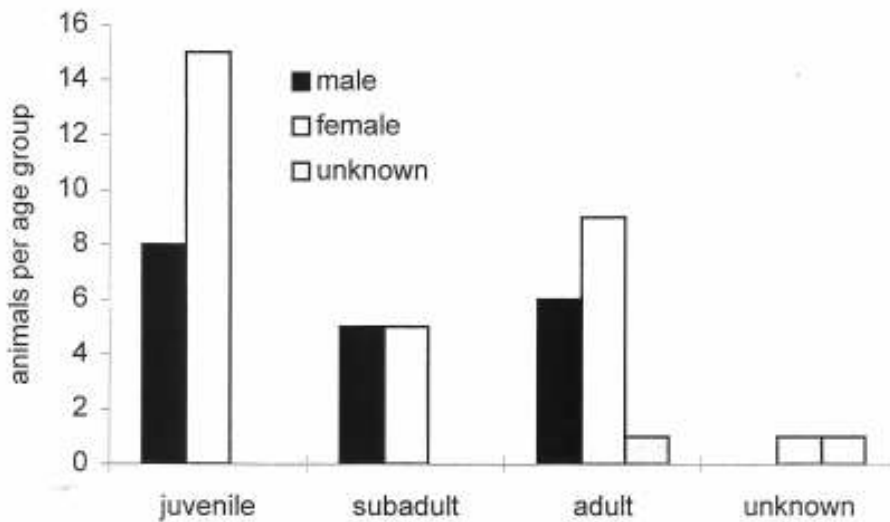
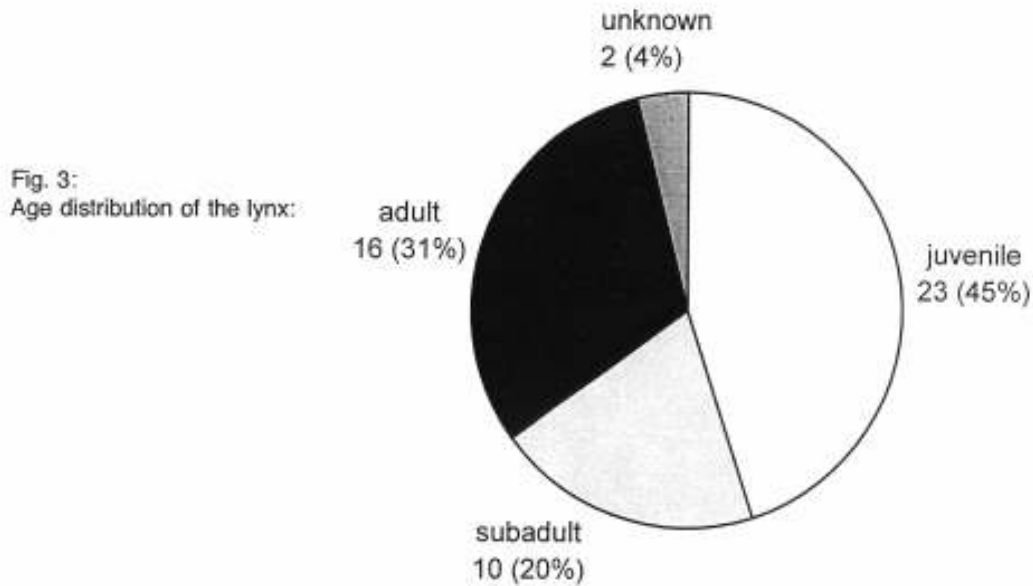


Fig. 4:
Sex distribution among the age classes of the examined lynx

Most of the lynx examined were juvenile (44%), 20% subadult, and 32% adult (Fig. 3). Among juveniles and adults more females than males were found (Fig. 4).

Most of the dead juveniles were found from October till January, whereas adult and subadult lynx were submitted over the whole year (Fig. 5).

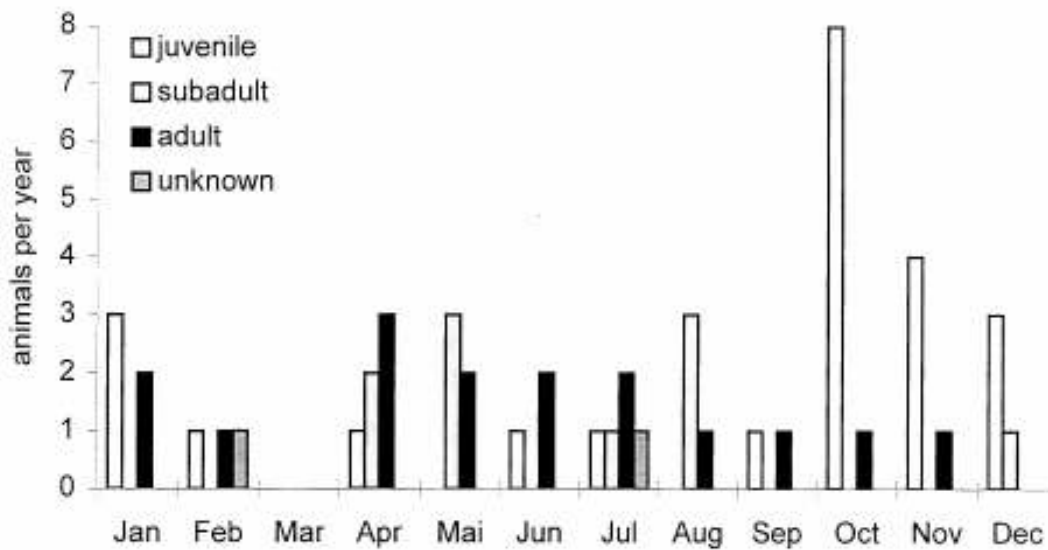


Fig. 5:
Seasonal pattern of mortality among lynx in Switzerland

The parasitological examinations of 22 lynx revealed *Toxocara cati* as the most frequent endoparasite, in most cases without clinical signs. Occasionally *Taenia taeniaformis*, *Trichinella sp.*, *Trichuris sp.*, *Capillaria sp.*, *Toxascaris leonina*, and *Coccidia* were diagnosed.

Table 1 lists the causes of mortality among animals of each age group.

Human caused trauma (car accidents and illegal killing) is the most frequent cause of mortality.

15 out of the 23 juvenile animals (65%) were cachectic. In three of them starvation was the actual cause of death while all others died due to further impacts, mostly trauma.

Infectious diseases were determined as the cause of death in 10 lynx (20%). Two juveniles died of a severe infection with *Toxocara cati*. In one juvenile and two adult animals a severe purulent bronchopneumonia of bacterial origin was diagnosed as the cause of death. In the juvenile lynx additionally a purulent necrotising laryngitis, a rhinitis and an ulcerative stomatitis were found.

Two juvenile lynx developed a bacterial septicemia after a wound infection. In one adult animal a broken caninus lead to a pulpitis, periodontal infection, osteomyelitis and subsequent septicemia.

In two cases with signs of an infectious disease, associated with pancreatitis, pneumonia, and gastroenteritis, the etiology could not be determined.

One additional juvenile which died of an undetermined trauma also showed signs of a purulent bronchopneumonia.

In 1997 one lynx was shot legally by state authorities. This adult female with two kittens preyed almost exclusively on domestic sheep and had to be removed.

In none of the lynx tested evidence of a rabies infection was found.

Tab.1

Causes of mortality among free-ranging lynx in Switzerland on which a necropsy was performed (1987-1997)

causes of mortality		age group total				total (percentage)
		juvenile	subadult	adult	unknown	
non infectious						
	car accident	2	6	2	1	11 (22%)
	illegal killing	3	2	2		7 (14%)
	unidentified trauma	6		4		10 (20%)
	dog attack	1				1 (2%)
	anesthesia			1		1 (2%)
	legal shooting			1		1 (2%)
	starvation	3				3 (5%)
total non infectious		15	8	10	1	34 (67%)
infectious						
	sepsis after wound infection	2		1		3 (5%)
	bacterial bronchopneumonia	1		2		3 (5%)
	endoparasitosis	2				2 (4%)
	unknown etiology		1	1		2 (4%)
total infectious		4	1	4		10 (20%)
unknown		3	1	2	1	7 (14%)
Total		22	10	17	2	51

Discussion

During our study period the number of submissions of dead lynx from the northwestern part of the Alps increased steadily while there were only occasional cases from the southwestern and the central parts of the Alps. The number of cases from the Jura Mountains remained stable. This development correlates with the actual size and distribution of the population. Since their reintroduction in central and eastern parts of the Swiss Alps, the alpine lynx population increased in size and extended its range westwards. At the moment, the population is relatively stable due to increasing numbers of lynx in the northwestern Alps, whereas in all other parts of the Swiss Alps the number of free-ranging lynx is stable or decreasing (Swiss Lynx Project, unpublished data).

The population in the Jura Mountains has remained stable for several years now. This is also reflected by relatively constant numbers of dead animals found in this region.

64% of the examined animals were juvenile or subadult. Breitenmoser et al. (4) showed that the predispersal mortality of the lynx population of the Jura Mountains lies at about 50%. After dispersing from their mother's home range, at approximately 10 months of age, only one out of six monitored subadults survived (4). This was also shown for other large felids such as pumas and leopards (9,10).

Juveniles which died in the first months of their life have a low probability to be found. Only three out of 22 juveniles have been discovered during the summer months. Most of the

juveniles examined died during autumn and winter. This corresponds with data obtained from previous field studies in the Jura Mountains (4).

Most of the juveniles found dead were cachectic (64%). Several of these animals lost their mother. Although the exact number of juveniles who lost their mother due to accidents is not known, we hypothesize that this factor has an important impact on the overall survival rate of juvenile lynx in Switzerland. This hypothesis is further supported by the high proportion of adult lynx (32%) among dead animals.

Our results show that infectious diseases are of minor importance for the development of the lynx population in Switzerland. The most frequent causes of mortality were human related such as traffic accidents and illegal shooting. These made up 36% of the mortality among all examined lynx. Compared to our data, illegal killing of lynx in the southwestern part of the Swiss Alps was even more important, being the major cause of death among lynx (7). However, animals dying because of human related causes have a higher chance to be discovered and therefore may be overrepresented in this study.

We conclude that the high rate of human caused mortality including illegal killing of adult animals is a major threat for the long-term survival of the two populations in Switzerland.

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