KORA

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Spatio-temporal interactions between sympatric felids in the Swiss Jura Mountains

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LP Espaces Naturels option MINA

Internship report

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Foreword

1. *Internship structure:*

KORA, Coordinated research projects for the conservation and management of carnivores in Switzerland, used to be a group of scientists from the universities of Berne, Lausanne and Neuchâtel and was created in 1996. Today, the group is affiliated to the University of Berne and is formally registered as a non-profit association according to the Swiss legislation. KORA scientists perform applied research in the field of monitoring, ecology and conservation of carnivores in the cultivated landscape and their coexistence with humans. They more particularly focus on large predators that were exterminated, such as the lynx (*Lynx lynx*) the brown bear (*Ursus arctos*) and the wolf (*Canis lupus*).Other species as the fox (*Vulpes vulpes*) that can be increasingly encountered in cities are also researches topics. KORA projects aim to provide scientific basis to find practical solutions to current problems related to predators' conservation or management.

The main mandatory is the Swiss FOEN, Federal Office of the Environment, because large carnivores are protected and managed according to the national legislation. However some cantons' wildlife departments and privates' foundations devoted to nature conservation and science are also involved in various projects. The KORA association main tasks are: monitoring and trend study of carnivores' populations by means of different methods like camera trapping, research, status surveys of large carnivores in Europe and their impact on other species populations and human activities to provide information and scientific background for government agencies, interest groups and the general public. Findings are published in scientific reviews popular papers, presentations, courses and large media.

KORA scientists collaborate internationally and are involved in conservation programs in Switzerland, Europe and Asia. The projects within this association are: the Lynx monitoring, LUNO (Luchsumsiedlung Nordostschweiz) monitoring individuals that were released, the Wolf in Switzerland, SCALP Status and Conservation of the Alpine Lynx Population, ELOIS European Lynx Online Information System, Balkan Lynx Recovery Program, CDP Newsletter of the Large Carnivore Initiative for Europe (LCIE) and Genetic Lynx project for the Swiss reintroduced populations

Another part of their activities concerns the IUCN/SSC Cat Specialist Group, bringing together more than 200 of the world's leading cat experts from 50 countries, who are dedicated to advancing the understanding and conservation of the wild felids. This group was created to allow dialogue and exchanges between scientific experts and practitioners throughout the world. The Specialist Groups perform species assessments for the IUCN Red List of Threatened Species, and produce species action plans and policy guidelines.

SPECIES SURVIVAL COMMISSION
CAT SPECIALIST GROUP

2. *Activities nature*

My internship in KORA started the 24 of January 2011 and finished the 15 of September 2011. It was interrupted from 15 of April to 31 of July 2011. This work took place in the frame of the Lynx monitoring program. Every year the abundance of lynx is estimated in different reference areas in the Swiss the Alps & the Jura Mts. In that last mountain range, three reference areas were defined and each being sampled every three years. The area Jura center was the subject of the present field work.

The first period was dedicated to the field part and consisted in preparing material and organizing the field session although a part of it had been set up before my arrival. Then the field session began and was dedicated to the installation and the use of camera-traps explanation with gamekeepers and volunteers. During two months, the follow-up was carried out with a checking every week. There were 60 sites with two camera-traps each. On part of the site was checked by member of the KORA staff (23 sites) and the rest by game wardens and volunteers. At KORA three people were responsible to check the camera-traps in the central Jura Mts: two KORA volunteers and me. We alternate between office work and field work each week: on person was doing some office work (such as scanning pictures or entering the trap nights in the excel sheet, gathering the wild and domestic cat photographs,...) while the two others were in the field checking camera-traps and collecting the films and SD-cards of the game wardens and volunteers.; . The end of the first period was dedicated to the removal and cleaning of the material and the data processing.

A second period was used to analyze the data and write the present report. The three species studied are the lynx, the wildcat (*Felis silvestris*) and the domestic cat (*Felis catus*). Until today, there is no study on the interactions of this three species. It took a lot of time to elaborate the protocol of identification of the European wildcat. Specialists have been contacted for opinion and advices like Estelle Germain (Wildcat French expert, CROS association) or Beatrice Nussberger (PhD student on the wildcat hybridization, University of Zurich).

Abstract

The carnivore abundance depends of three factors: preys abundance, inter-specific competition and intra-guild killing. When carnivores use the same area, modifications of behavior allow the coexistence. Data of three camera-trapping monitoring sessions conducted by KORA in the Jura Mountains from 2008 to 2011 are used to know the relationships and daily patterns of three felids that live there: the lynx *Lynx lynx*, the European wildcat *Felis silvestris* and the Domestic cat *Felis catus.* To be able to possible resemblance between these two last species rather for tabby cats required identification by phenotypic criterions and by general aspect. The determination of the forest cat remains rather difficult with these methods although currently there is no solution which gives results sure. 82 cats' pictures on 106 were classified as wildcat. The three felid species have an activity pattern mainly nocturnal and the spatial distribution does not show segregation. These felids have been reported on the same sites and the only element which influences these species is the probability of detection. The inter-specific competition and intra-guild killing do not seem to affect these species.

Keywords: Eurasian lynx, European wildcat, domestic cat, camera-trapping, inter-specific interactions.

Résumé

L'abondance des carnivores est fonction de trois facteurs ; l'abondance des proies, la compétition et la prédation interspécifique. Lorsqu'ils utilisent un même espace, des modifications comportementales leur permettent de coexister. Les données du piégeage-photo de 3 sessions de lynx monitoring du KORA entre 2008 et 2011 dans le massif du Jura Suisse, sont utilisées pour connaître les relations spatiales et les rythmes d'activité journaliers des trois félins qui y vivent : le lynx (*Lynx lynx*), le chat forestier (*Felis silvestris*) et le chat domestique (*Felis catus*). Pour pouvoir différencier ces deux dernières espèces assez similaires surtout pour les chats tigrés, une identification par critères phénotypiques et par l'aspect générale a été faite sur les différentes photos. La détermination du chat forestier reste cependant assez difficile par ces méthodes même si actuellement il n'y a pas de solution qui donnent des résultats sûres. 82 images de chats sur 106 ont été identifiées comme chat forestier. Ces trois espèces ont un rythme d'activité journalier principalement nocturne et leur distribution spatiale ne montre pas de ségrégation. Ces félins ont été rencontrés sur des mêmes sites et le seul élément qui influence ces espèces est la probabilité de détection. La compétition et la prédation interspécifiques semblent peu affecter ces espèces.

Mots-clés : Lynx eurasien, chat forestier d'Europe, chat domestique, piégeage-photos, interactions interspécifiques.

Introduction

Three felid species are sympatric in the Jura Mountains: the Eurasian lynx (*Lynx lynx*) which is the largest, the European wildcat (*Felis silvestris*) and the domestic cat (*Felis catus*). Domestic cat includes feral cat (ie domestic cats that became wild) and their intermediaries (Dickman, 1996; Germain, 2007). All three felids are solitary predators. The lynx is far larger than the two other felid species and its main preys are small ungulates mainly on roe deer (Jobin et al. 2000) while the wildcat and domestic-cat are of similar sizes and prey mainly on small mammals and little birds (Germain et al., 2007).The wildcat is present only in the Jura Mountains, whereas the two others are also present in the Alps and, for the domestic cat, in the Swiss Plateau. The lynx and wildcat populations are threatened due to small population sizes, habitat fragmentation and illegal killing (Stahl and Artois, 1995; Von Arx et al., 2001). And for the wildcat, a threat due to hybridization with the domestic cat (Germain, 2007, Krüger et al, 2009, Eckert et al., 2009, Kitchener et al., 2005, Liberek, 1999). Since 1962, the wildcat is a protected species listed as vulnerable in the Red List of Switzerland[1] (Stahl and Artois, 1995). The lynx is fully protected in Switzerland, quoted in the Bern Convention[2] in Appendix III, in the CITES[3] in the appendix II (Von Arx et al., 2001), and to do the object of concept: the lynx concept, **appendix 1**. It is interesting to study these species as their communities seem to have similar habitats and activity patterns.

The number of species in a community is limited by the availability of resources, a key factor for competing species. Indeed the coexistence between two or more species having a strictly identical ecological niche is impossible; one eventually eliminating the other one. This is known under the Gauss principle or mutual exclusion (Fischesser and Dupuis-Tate, 1996). According to the Gauss principle, the inter-specific competition increases with the similarities of two species. (Di Bitetti et al., 2010; Donadio and Buskirk, 2006). Indeed, the wildcat and the domestic-cat could only coexist; if they co-evolve and the overlap of their ecological niche decreases. Specialization is a key element to allow several species to use the same habitat and resources and can concern food, space, hiding places, etc. The species behavior and the activity pattern as well as habitat use can be modified to avoid a strong competition for food allowing the coexistence of species morphologically similar. For example, despite a great similarity in the morphology, the jaguarundi (*Puma yagouaroundi*) and the margay (*Leopardus wiedii*) were able to coexist by reducing the overlap in their activities pattern; the first is diurnal and the second is nocturnal, and they use their habitat differently (Di Bitetti et al., 2010).

[1] UICN Red List, it is not a protection, but an inventory of the state of preservation species.

[2] Convention of European Wildlife and Natural Habitats, appendix III concerns the game species and allows for traditional management of these species.

[2] Convention of European Wildlife and Natural Habitats, appendix III concerns the game species and allows for traditional management of these species.

[3] Convention on International Trade in Endangered Species of Wild Fauna and Flora, appendix concerns the species which are not necessarily threatened with extinction but may become so if trade is not controlled.

Another interaction is known in mammalians carnivores, the intra-guild competition or killing, which is an important selective factor (Di Bitetti, 2010). Interactions may be symmetrical or asymmetrical, and in some interactions adults of one species kill only young of the other. In Africa up to 68% of cheetah cubs (*Acinonyx jubatus*) are killed by leopards (*Panthera pardus*), lions (*Panthera leo*) or spotted hyenas (*Crocuta crocuta*). In North America bobcats (*Lynx rufus*) are killed by pumas (*Puma concolor*) (Macdonald and Loveridge, 2010). A modification of the victim species comportment can be observed such as the change of activity pattern: lions hunt mainly at night, spotted hyenas in early morning, and cheetahs around the middle of the day. Another strategy consists in avoiding each other is observed for example by the black bears (*Ursus americanus*) and the brown bears (*Ursus arctos*) (Macdonald and Loveridge, 2010; Palomares and Caro, 1999;). The inter-specific killing can be very important depending on the species. It can have an impact on the predator population called "victim" and also an indirect impact on the prey populations of both species after decreasing of predators. The importance of the interaction increases with the difference of size of species (Di Bitetti et al., 2010). That is why interactions between species are a very important research topic.

This study is based on the analysis of interactions between the three felids species, lean on data coming from three camera-trapping monitoring sessions conducted in the Jura Mountains form 2008 to 2011. It was based on space and time aspects. The data stemming from the camera-trapping are particularly relevant to study this type of interactions. Since 1998, the KORA[4] is using the photographic capture-recapture method to estimate lynx population size and density in different reference areas in Switzerland (e.g. Laass, 1999; Zimmermann et al. 2007). Wild and tabby domestic cat cannot easily be distinguished (Kitchener et al., 2005 ; Leger et al., 2008) and the accuracy of phenotype characters for the identification is disputed (Kitchener et al., 2005 ; Krueger et al., 2009, Eiholzer, 2010). In a first step, two different approaches were used to distinguish the domestic cats of the wildcats on the basis of images stemming from the camera-trapping. The first consisted to use ten phenotypic characters (Suminski, 1962 ; Stahl & Leger, 1992 ; Ragni & Possenti, 1996 ; Kitchener et al., 2005 ; Leger et al., 2008), and the second is only based on a global criterion. The classification of the cat pictures between wildcats and domestic-cats on the basis of one of both approaches described above was used then to study the spatial and temporal interactions between these three species. Like Di Bitetti et al. (2010), we predicted: (1) a higher segregation for morphologically similar species with a higher potential of competition interaction; (2) the two smaller cat species adjust their behavior to reduce the interaction with the lynx.

[4] KORA: Coordinated research projects for the conservation and management of carnivores in Switzerland

Materials and methods

1. *Study area*

The Jura Mountains are a secondary limestone mountain chain with an oceanic climate regime (yarely precipitation: 1000 – 2000 mm) (Blant, 2001) and an altitude varying from 700 to 1'700 m a.s.l and culminating at 1'718 m a.s.l, the "Crêt de la Neige". They are made of calcareous rocks (permeable), and poorly retain the water, resulting in a karstic system. The landscape is constituted of a forest and pastures mosaic. Forest are fragmented and, cover 40-50% of the area with mixed deciduous forest along the slopes (dominated by *Fagus sylvatica*) and coniferous forest on the ridges with *Abies alba* and locally *Picea abies*. The settlements cover 3% of the Jura Mts. The human density in the Jura Mts. is 130-140 inhabitants/km^2

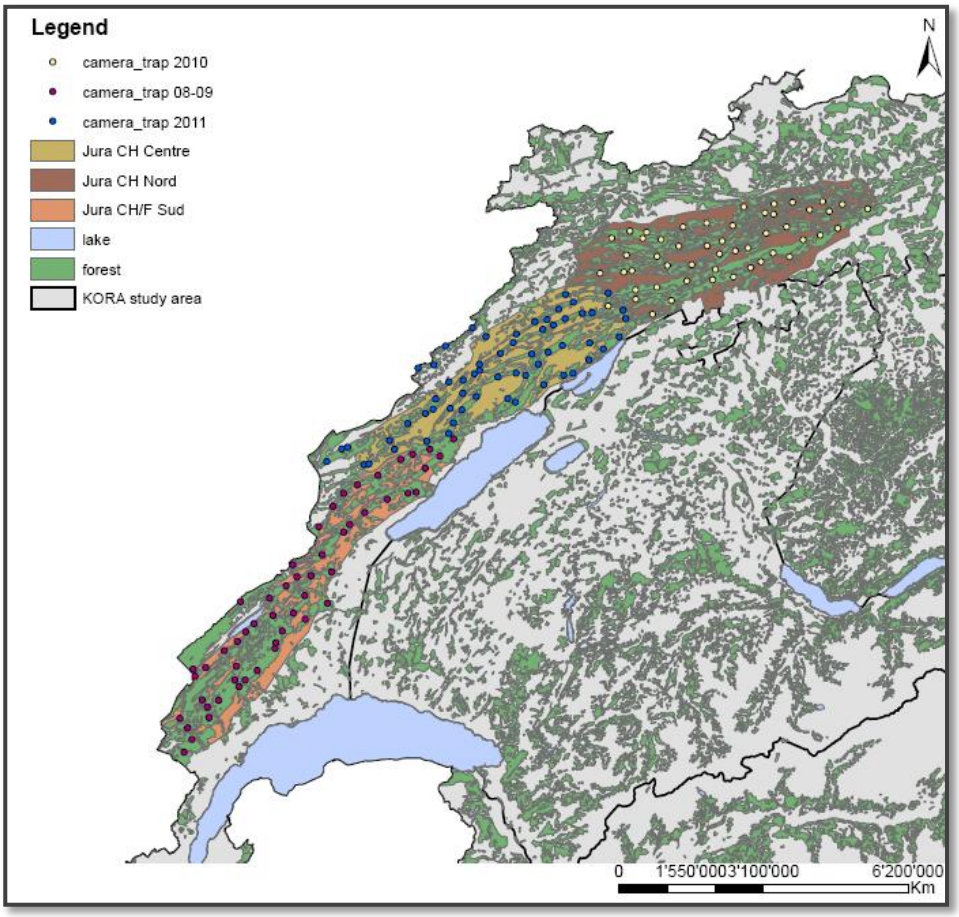

Fig. 1: Localization of the 3 lynx monitoring areas and the camera-traps, KORA study area: **appendix 2**

This study was carried out from November 2008 to April 2011 in the Swiss Jura Mountains for the greatest part, corresponding to three Lynx camera-trapping monitoring session. We focus on this area because all signs of wildcat presence in Switzerland for the last decades and during historic come from this region (Nussberger et al., 2007). The area encompassing 2295 km^2 stretches from the canton of Soleure to the canton of Vaud and follows the French border.

2. *Camera-trapping*

The Capture-mark-recapture methodology (CMR) by camera-trapping is the best tool to study cryptic species with natural marks (Karanth, 1995; Karanth & Nichols, 2002; (Maffei et al., 2005; Jackson et al., 2006). Moreover that method is highly standardized. The lynx identification is also made with that method because the animal has an individual coat marking. (Thüler, 2002; Laas, 1999).

During these three lynx monitoring sessions, 170 sites were equipped with two opposing camera-trap each. For the majority, CuddeBack Capture, Camtrakker CANON or FUJIFILM and exceptionally (for the South session) a "mother-camera" and a "slave camera"[5]were used. Every site was equipped with a CuddeBack Capture which is active 24hs. Each trap consisted of an electronic tripping device activated by animal movement and the two cameras take simultaneously both flanks of the animal (Karanth et al., 2004). The camera-traps were positioned along forest paths, hiking paths and, to a lesser extent, along game paths because lynx usually uses same ways as humans during its long travels (Zimmermann et al., 2007). A session lasts 60 days (**Tab. 1**) and the sites were checked every 5 to 7 days (**appendix 3**). The distribution of camera-trap was set up to optimize the chances of lynx capture. For more details see Zimmermann et al., 2007.

Survey	Duration	Total number of stations actives	Theoretical sampling effort	Sampling effort *	Area sampled (km^2) *
South 08-09	Nov 08-Jan 09	53 + 4 extensions	3420	2986	728
North 09-10	Feb-April 2010	53	3180	2861	882
Center 10-11	Feb-April 2011	53 + 7 extensions	3600	3499	685
Total		170	10200	9346	2295

Table 1: Sampling effort (total number of stations and camera-trap days) and area sampled in the Jura Mountains
* Sampling effort represents 92% of the real potential. Area sampled doesn't take into account extensions.

3. *Wildcat's criterions*

To be able to analyze the data, it has been necessary to differentiate wildcats and domestic cats. Unfortunately it is impossible to distinguish a domestic-cat from a feral cat because because they differ only in their behavior (Dickman, 1996; Germain, 2007). After sorting out the pictures, the ones that seemed to be wildcats and tabby cat were selected for validation. A questionnaire was established with ten criterions which were chosen on the basis of five documents **Tab. 2** (Suminski, 1962 ; Stahl & Leger, 1992 ; Ragni & Possenti, 1996 ; Kitchener et al., 2005 ; Leger et al., 2008). The criterions concern the tail, stripe dorsal, legs, coat color, flank stripes among others. For this part, all the pictures of the same individual taken simultaneously by both camera-traps were used for a better identification of the phenotype but counted for one in the analyses. See **appendix 4 & 5** for details.

[5] The camera-trap "Mother"' has an infrared detector and reacts to the movement of warm animal or thermal currents. The "Slave", of simpler conception, is activated by the flash of the first one (Zimmermann et al., 2007).

Article name	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	Total
Léger	1	1	1	1	1	1	1	1	1	1	**10**
Kitchener	1	1	1	1	1	1	0	0	0	1	**7**
Ragni	1	1	0	1	1	1	1	0	0	0	**6**
Stahl	1	1	1	1	1	1	1	1	1	1	**10**
Suminski	1	1	1	1	1	1	1	1	0	1	**9**
Total	**5**	**5**	**4**	**5**	**5**	**5**	**4**	**3**	**2**	**4**	

Table 2: Criterions' validation. The five names are the documents used to establish the criterions, C1, C2 are the code criterions. 7criterions of Kitchener were gathered on 3 and the Scottish wildcats are more marked at the level of the coat. Ragni doesn't mean legs.
C1: dorsal line, C2: color hare, C3: white chin, C4: shape on the tail, C5: stripes on nape, C6: stripes on flanks, C7: pink truffle, C8: the underside legs, C9: white whiskers, C10: stripes on legs

A second method concerning the cat's general aspect was added to allow a double validity. This one was just done by performing a rapid judgment of the overall aspect of the cat. The questionnaire was submitted in an independent way to three people: two KORA collaborators and me. It was necessary to place pictures of tabby cats in the sampling to verify the efficiency of the methods. These pictures were only known by me.

Interactions

- Occupancy:

Within program PRESENCE (http://www.mbrpwrc.usgs.gov/software/doc/presence/presence.html) MacKenzie et al. (2002) developed a methodology incorporating non-detection into the model - it is possible to investigate species co-occurrence pattern and to address questions about the importance of interspecific interactions such as competition, The two species interaction models on the program Presence were run. All the sessions were grouped for the analyses, and the data of the three species were used to measure the interaction between following species pairs: lynx-wildcat, lynx-domestic-cat and wildcat-domestic-cat. No co-variable were used for this survey similar to Di Bitetti et al., (2010).

The matrix was based on the capture calendar used for the lynx. A period of five consecutive nights was defined as one capture occasion (Zimmermann et al., 2007). There are 12 capture occasions for a session so 60 camera-traps days. For every capture occasion a species detected at least "1" or not captured "0", forming a vector consisting in as many "1" and "0" as there are capture occasion (Zimmermann et al., 2007 ; Otis et al., 1978). The data gathered "before and after" the first and last occasion of capture, were not included in the analyses.

- Activity patterns:

The hours on the pictures can be used to describe the daily activity pattern of the three species (Di Bitetti et al., 2010. To analyze the daily activity patterns, pictures of the same event were not taken into account to avoid redundancy, which can bias the results. For every species, the hours were grouped into 24 x 1h intervals without considering sites and sessions.

Results

1. Wildcat's identification

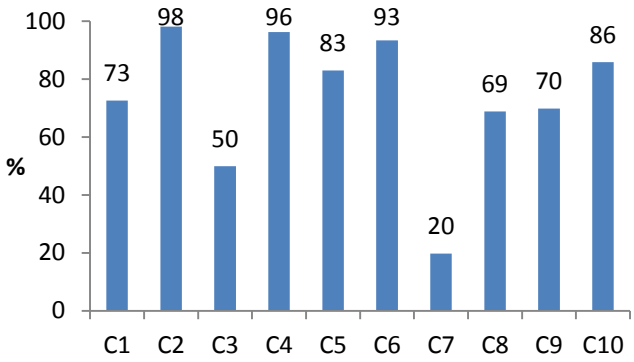

Figure 2: Percentage visibles criterions , C1, C2, ... are the code criterions

Pictures did not allow to distinguish all the criterions and when they were visible, it was rather difficult to validate or not the criterion depending on the pictures quality. The criterions C2 (color of the coat) was logically the most visible with the 98%. The truffle (C7) 20% and the white chin (C3) 50% were less visible and had then a lowest percentage. The shape of the tail (C4) 96%, drawings on flank (C6) 93%, the stripes on the nape (C5) 83% and the stripes on the legs (C10) 86% were the most visible criterions (**Fig. 3**) with the color of the coat. In total, 106 cats were submitted to these criterions with a prior validation on general aspect. 82 were classified as wildcats and 24 as domestic-cats. As it can be seen on the graph, (**appendix 6**) that the cut off value between both species is around 60%. Nevertheless, both approaches (phenotypic criterions and general aspect) gave very similar results. Only a cat was badly classified by using phenotypic criterions (**appendix 7**) and by fixing the threshold to 62% (above 62% it is a wildcat and below it is a domestic cat).

For all the sites, the lynx obtained 143 records, the wildcat 82 and the domestic-cat 646 (**Table 3**). The most frequently recorded is the domestic-cat. But the number of stations with detection and the proportion of stations with detections are very close of the lynx while the frequency of records is much lower for the lynx.

Species	Frequency of records	Number of stations with detections	Proportion of stations with detections
Lynx	143	55	0.32
Wildcat	82	33	0.19
Dom-cat	646	56	0.33

Table 3: Camera-trapping activity for these 3 sessions, 170 sites

2. Occupancy

The probability to detect the lynx when the two smaller cats are present increases. It's also the case for the domestic cat when lynx but decrease on presence of wildcat. On the other hand the probability to detect the wildcat is less high when the others species are present. Meanwhile, the presence of the domestic cat significantly reduced the probability to detect the wildcat. Indeed, the confidence interval does not overlap (**Tab. 4**). From the SIF it can be concluded that the three species do not avoid each other because the large confidence interval always included 1 which corresponds to tolerance.

Parameter	Probability or mean value	SE	95% confidence interval for the parameter
ψ lynx	0.3962	0.0480	0.3069 – 0.4931
ψ wildcat	0.2334	0.0384	0.1666 – 0.3169
p lynx	0.1291	0.0202	0.0644 – 0.1740
p wildcat	0.1898	0.0292	0.1391 – 0.2536
r lynx	0.1897	0.0369	0.1276 – 0.2727
r wildcat	0.1256	0.0330	0.0739 – 0.2056
SIF	1.2762	0.4241	0.6552 – 2.4856

Parameter	Probability or mean value	SE	95% confidence interval for the parameter
ψ lynx	0.4628	0.0489	0.3695 – 0.5589
ψ domestic-cat	0.5292	0.1420	0.2688 – 0.7746
p lynx	0.1202	0.0204	0.0856 – 0.1662
p domestic-cat	0.0419	0.0235	0.0137 – 0.1211
r lynx	0.1275	0.0174	0.0971 – 0.1655
r domestic-cat	0.3138	0.0242	0.2684 – 0.3631
SIF	0.9740	0.1860	0.6699 – 1.4161

Parameter	Probability or mean value	SE	95% confidence interval for the parameter
ψ wildcat	0.3863	0.0467	0.2997 – 0.4809
ψ domestic-cat	0.3963	0.0480	0.3071 – 0.4930
p wildcat	0.3065	0.0595	0.2033 – 0.4335
p domestic-cat	0.6273	0.0588	0.5069 – 0.7338
r wildcat	0.0694	0.0108	0.0509 – 0.0939
r domestic-cat	0.1395	0.0166	0.1101 – 0.1753
SIF	1.3982	0.4111	0.7858 – 2.4880

Table 4: Bio-statistical analysis with Presence program **ψ** : probability to detect species; **p**: detected when the other species is not present; **r**: detected when the other species is present; **SIF**: species interaction factor of the detection probabilities indicates whether the probability of detecting a species during survey increase (SIF > 1) or decrease (SIF < 1) the probability of detecting the other species during that survey.

The domestic-cat and wildcat were only detected at a limited number of sites in the southern Jura: wildcat was detected at 3 sites for the south session and for the domestic cat only 2 sites for 57 sites in total (**Fig. 3**). There are only very few sites where the wildcat was detected, only 33 to 170 sites (**Tab. 4 and Fig. 3**). The lynx is present on the whole zone while the domestic-cat was principally restricted to the two upper zones. Very few domestic-cats individuals were pictured at several sites. It is more difficult to identify the wildcats as their coat pattern has few predominant marks that would allow an easy identification of the individuals.

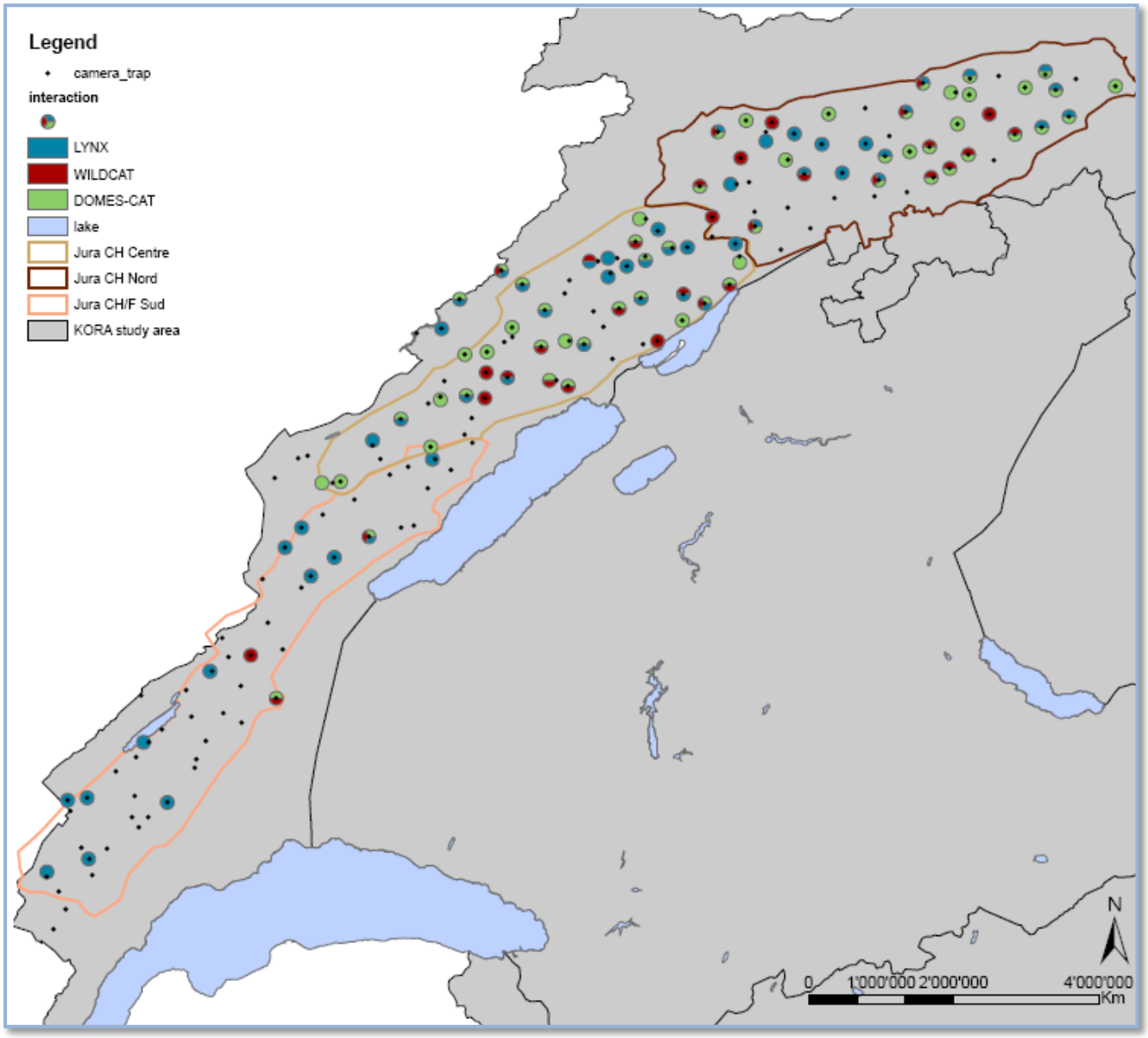

Figure 3: repartition of three species by sites.

3. Activity patterns

The three species have a rather nocturnal and crepuscular activity. Only the domestic-cat has a continual activity and can be classified as rather cathemeral species. The lynx and wildcat are mostly nocturnal with a small amount of diurnal activity. The lynx highest peak of activity was located between 20 - 22h, while for the wildcat and the domestic-cat it was located between 22 -1h. (**Figure 4**)

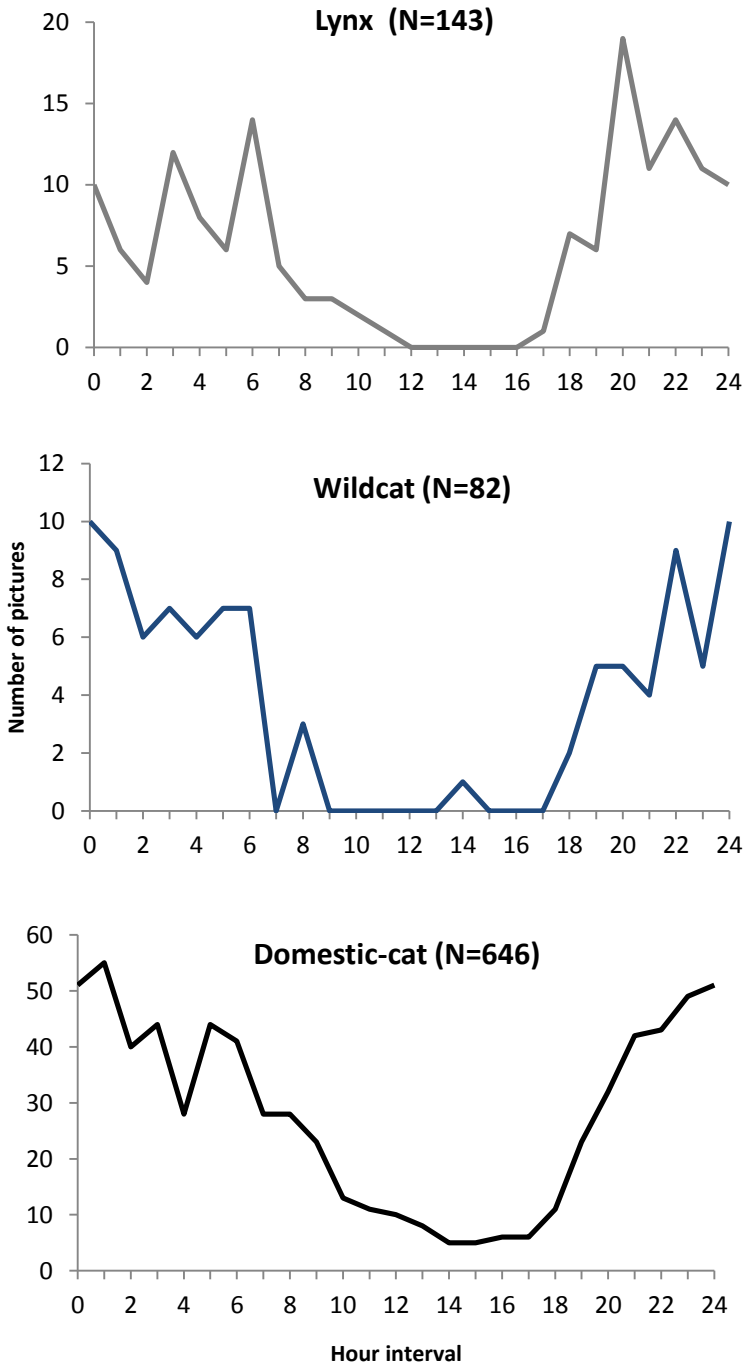

Figure 4: Daily pattern of activity for the three species

Discussion

For capture-recapture analyses every lynx should have a non zero probability of detection and thus at least one camera-trap within its home range. In the Swiss camera-trap studies each female lynx has at least 4 camera-trap sites within its home range. Beacause lynx have very large territoiries up to 283 km^2 the camera-trap density is very low compared to the territory size of a wild cat and domestic cats which varies between 1-5 km^2 and 0.01-4 km^2, respectively . (Germain, 2007; Stahl & Leger, 1992; Artois et al, 2002). Furthermore camera-traps were put in lynx favorable habitats ; forest (Breitenmoser et al., 2007) while the wildcat also uses opened environments as prairies or land fallow (Germain, 2007; Stahl & Leger; Liberek, 1999) and the domestic cat is usually closer to human settlements and uses also prairies and wheat-growing (Germain, 2007; Artois et al., 2002; Libert, 1981). Therefore these data should be taken with caution and are applicable only to forest habitats.

Wildcat's identification

The identification of wildcats is problematic. Before new genetics methods are developed (Nussberger.pers. comm), two alternative approaches exist currently. The first one is based on the phenotypic criterions. The disadvantage is that these criterions are often difficult to see on the pictures taken by camera-trapping compared to a direct specimen observation. Furthermore this method is not 100 % sure and it already happened that cats with wildcat phenotype were identified as domestic cats on the basis of genetic analyses. The morphological characteristics traditionally considered to be those of wildcat are the truffle, : the dorsal line and the shape of tail (Suminski, 1962 ; Stahl & Leger, 1992 ; Ragni & Possenti, 1996 ; Kitchener et al., 2005 ; Leger et al., 2008, Krueger et al., 2009; Kitchener et al., 2005). In our study the truffle was only visible in a few cases nevertheless the dorsal line and the shape of the tail which according to Kitchener et al. (2005) and Krueger et al., (2009)are the best phenotypic criterions for the wildcat identification were visible in 77% and yy% of the cases, respectively (**Fig. 2**). The criterions are valid for the wildcat of Jura. Indeed, the marking of the coat is different according to regions; for example, it is the case for the Scottish wildcat (Liberek, 1999; Stahl & Leger, 1992 ; Ragni & Possenti, 1996).

The second and most recent method is the genetic based on the mitochondrial DNA. Besides the fact that it is not discriminating between the various hybridization degrees , the main problem is that it gives only information on the maternal line seen that mitochondria are transmitted on by ovules (Eckert, 2009).

The fact that the general aspect and the ten criterions used to distinguish wild from domestic cats species used in this study gave similar results, reinforce the validity of our species identification. Nevertheless, the determination of hybrids is not possible by visual identification because they often

look like and are classified as wildcats in the main cases (Germain, 2007). This problem is currently not solved by the genetic method for the reasons explained above. So hybrids were classified either

Environmental influence

As the data were grouped together for the three sessions because of reduced sampling size and in order to have significant statistical results, the various elements like weather conditions that could have played a role on the species distribution were not considered. Still, they can be used for the spatial distribution (**Fig. 3**). Indeed, weather conditions have a great influence on wildcat populations.

For the south session, the winter was very rough with a period of important snow coverage. Meanwhile the center session had a soft winter and very clement conditions. The snow has a significant impact on the presence of the wildcat, indeed it goes down in low altitude until the climate becomes more convenient again (Liberek, 1999). Another factor influencing species distribution is the altitude. Indeed, the wildcat can't be found above an altitude of 1000m, linked of course to the duration of snow coverage (Liberek, 1999. Germain, 2007, Weber et al., 2010).Its morphology is not suited for movements in the fresh snow (Liberek, 1999). It is also one of the reasons why there is no wildcat in the Alps. Moreover, the domestic cats would probably go more far away from habitations if the temperatures were clement (Germain, 2007), which could explain the strong presence of both cats in north and center study areas where the climate was more clement in the given years when camera-trapping was performed.

2. Activity patterns

The activity patterns of these felids are rather similar and thus they seem to co-exist on the same zone as well as show the SIF (**Tab. 4**) showed and which does not demonstrate avoidance. It induces that temporal and spatial segregations are relatively few important. It also means that inter-specific killing and competition are not very high factors of selection or don't have an important effect. Indeed, the behavior of this three species doesn't seem to change in the presence of other felids contradicting what was found in other studies (Von Arx et al., 2004 ; Germain, 2007 ; Liberek, 1999 ; Biro et al., 2005). However even if these analysis do not show inter-specific killing because it cannot be show by means of camera-trapping directly, but cases of wildcats and domestic cats killed by lynx (Hainard, 2003) have been already reported meaning that interactions process are occurring.

Anyway, the wildcat activity pattern found in the present work doesn't seem to be complete. There is a bias in the data set because the survey it does not take into account the whole of ecology of the wildcat. Several studies showed that the wildcat cannot be considered as a strictly nocturnal species (Germain, 2007 ; Steinmeyer et al., 2009, Liberek, 1999 ; Artois, 1985).

It can be active from 2 pm to 8 am, knowing that a part of that time can be dedicated to shelter activity. For the domestic cat, the pattern found corresponds quite well to what is reported in other studies; it is also mainly active at night. The pattern of the lynx is also a good representation of its activities that are known to be at dawn and dusk tied to the activity pattern of its preys (Von Arx et al., 2004). When the lynx and the wildcat are present on the same site, it can be supposed that it is a good habitat with enough resources. And the lynx and the wildcat do not compete for food. Furthermore lynx have very large home ranges compared to wildcats so the chance that kills given a wildcat is quite low.

3. Occupancy

The domestic cat and wildcat don't seem to be in strong competition as it could be expected. The highest competition should occur between wildcat and feral cats because they tend to have a similar behavior, prey on the same species and use similar habitat. On the other hand true domestic cats stay close to human settlements or single houses (Germain, 2007) and thus there should be a spatial segregation between both species On the other hand the competition would be more axed on preys, because a great part of the diet of the domestic cat is micro-mammals and human and/or pet food (Liberek, 1999 ; Germain, 2007 ; Biro et al., 2005), but it is not possible to test that with this survey.

A survey in the wildcat was made on its whole range with the use of the hair trap. It was conduce in 2010 by Weber and Huvyler to determine the abundance of this species. They use also the "Single-Species-Single-Season-Site-Occupancy" model but only on the presence / absence of wildcat with co-variables as percentage of forest or settlements. For the influence of the domestic cat presence on the wildcat presence, they use the Waddle et al., (2010) model. They did not find influence of the presence of the domestic cat on the presence of the wildcat. But the presence of the domestic cat significantly influenced the probability of detection of the wildcat: by control and site, the probability was 6 % (CI95 % 5-21) in the presence of domestic cat and 27 % (CI95 % 9-51) in the absence of domestic cat. Our results are similar and tend to confirm this observation. However the presence of the wildcat also influences the probability of detection of the domestic cat according to the analysis of this survey.

Conclusion

According to previous studies, the most characteristic criterions: shape of the tail, draw on flanks, stripes on legs for the wildcat identification are the most discriminating and during this study they were used because they were often visible on the pictures. The association of both methods used led to similar results nevertheless the identification of this species is rather problematic and can be questioned. However, the study conducted by Weber et al., 2010 by hair traps confirmed some results found by analysis of the occupancy of this species.

The temporal and spatial interactions do not show direct effects on these three felids. Indeed the behavior of three species did not change if we refer to studies which address the biology of these three species, it does not show avoidance due to the presence of another species when one is present. The results found cannot confirm a strong competition between the two smaller species but in any case they do not change their behavior on the use of resources. SIF on the program PRESENCE confirm that intra-guild killing is not a factor as important as that on these three species, even if it is real. So, the presence of the lynx does not seem to have induced a behavior modification of the two other species.

As these data can only be applied in the forester habitat, a larger field survey could be interesting to set up in order to have more complete results. The abundance of preys can also have a great importance on the presence of lynx and wildcats on the areas currently occupied. Nevertheless there are not temporal and spatial segregation for this three species and the predictions are not confirmed.

Assessment

This internship allowed me to have my first work experience in another country and it was a very good one, both at the level of work and the discovery of Switzerland. I was very interested by the subject of my master, wild felids are a fascinating subject and the interactions between felid species are a topic I always wanted to work with.

The use of camera-trapping is often seen only in theory but with this internship I discovered that it needs a lot of planning and effort is needed. I got in touch with the advantages and inconveniences of such a big session of follow-up. I also discovered new tools like the Presence software and the calendars of capture. I severely underestimated the time needed the report redaction with the suggestion of KORA to write it as a scientific paper was under estimating. Bibliographic researches were very important and asked more time than expected to be read and used. Knowing that analysis and cartographies realization have been accomplished in the same time. Writing this report in English was a big challenge but very enriching and a good exercise.

This internship fits to theoretical courses and it is rather complementary with the formation. It gave me the desire to include scientific researches in a future job. Before that experience, I was only interested in field work. I hope I'll have the opportunity to work again on a similar subject that integrates these two aspects.

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