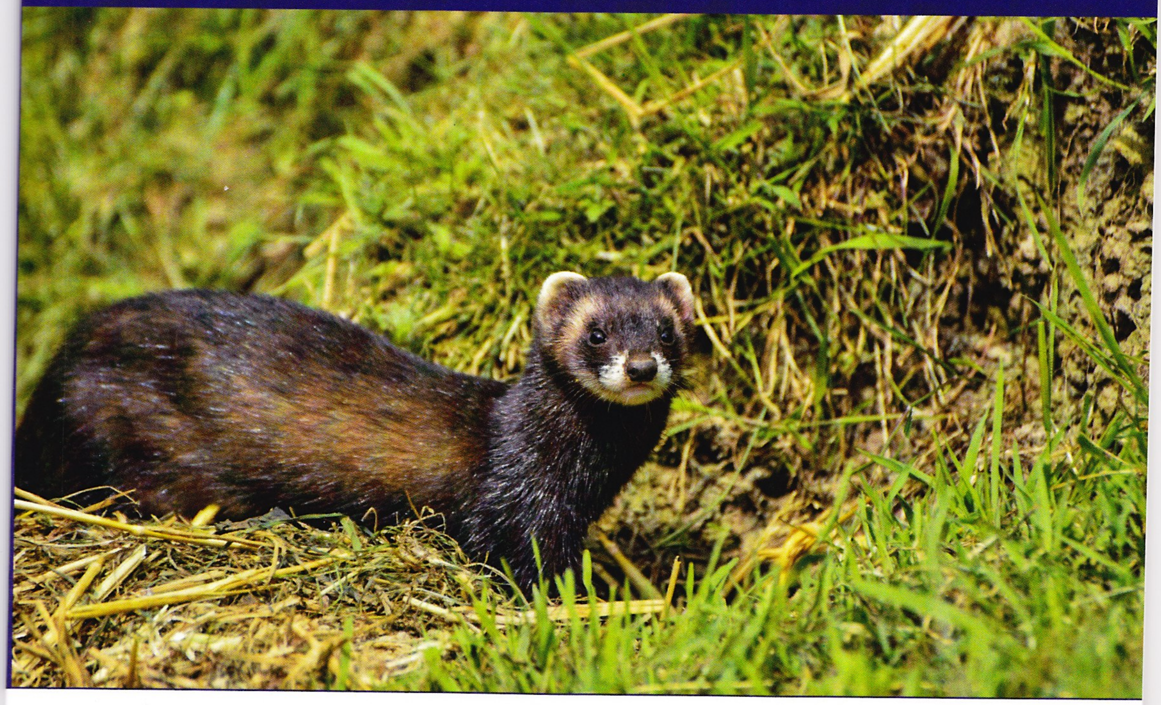

Roland Libois

Trophic niche comparison of three mustelids in southwestern France

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Trophic niche comparison of three mustelids in southwestern France :

European mink (*Mustela lutreola*), Polecat (*Mustela putorius*), Eurasian otter (*Lutra lutra*).

Roland LIBOIS

Août 2019

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Contents

Key-words : European mink, polecat, otter, France, predation, food, individual variations

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Abstract

The European mink, *Mustela lutreola*, is the most threatened carnivore in the world particularly in France. He lives only in the southwestern departments: Pyrénées-Atlantiques, Landes, Gironde, Lot-et-Garonne, Dordogne, Charente and Charente-Maritime. The causes of the decline in mink populations were addressed in a multidisciplinary manner, with food being a key factor. Data on mink prey were scarce, particularly due to confusion between the faeces of the polecat (*Mustela putorius*) and those of the mink. A few individuals of both species have been equipped with a transmitter collar in three sites: two rivers, one in the Garonne basin (the Ciron, near Langon), another leading into the Arcachon basin (the Eyre) and a large pond, north of Bayonne (Orx). The faeces were therefore collected per individual. The objective was to have results on the feeding of mink and, above all, the possible competition of the three mustelids. Overall, mink consumes anurans (31%), birds (25%), mammals (24%) and fish (19%), while polecat it more specialized for anurans (61%) and mammals (30%). However, between anurans, the polecat catches mainly toads (90.8%) while the mink catches frogs (73.4%). For mammals, we see a separation of prey between polecat and mink respectively: lagomorphs (44% *vs* 0.4%), small rodents (27% *vs* 15%), rats (12% *vs* 39%), water voles (7% *vs* 32%). The overlap index of the trophic niche is one third (0.34) considering that prey are quite abundant in the three sites, the competition is relatively low. For the otter (*Lutra lutra*), spraints were collected only along the Eyre River. Therefore, trophic niche comparisons were calculated on two mink (M1E, one female, and M3E, one male) and five polecats, including only one female with only four faeces. The recovery index is minimal for otters, which mainly consume fish and aquatic insects, few amphibians.

However, the data must be criticized: minks and polecats have a different diet per individual. It cannot be excluded that these are individual preferences. In addition, the samples are not random or independent.

Résumé

Le vison européen, *Mustela lutreola*, est un carnivore le plus menacé dans le monde et particulièrement en France. Il vit seulement dans les départements du sud-ouest : Pyrénées-Atlantiques, Landes, Gironde, Lot-et-Garonne, Dordogne, Charente et Charente-Maritime. Les causes de la régression des populations du vison ont été appréhendé d'une manière multidisplinaire dont l'alimentation étant un facteur capital. Les données sur les proies de vison étaient rares notamment par une confusion entre les fèces du putois (*Mustela putorius*) et des celles du vison. Quelques individus des deux espèces ont été équipés d'un collier émetteur dans trois sites: deux rivières, l'une dans le bassin de la Garonne (le Ciron, près de Langon), d'autre débouche dans le bassin d'Arcachon (l'Eyre) et un grand étang, au nord de Bayonne (Orx). Les fèces ont été donc collectés par individu. L'objectif était d'avoir des résultats sur l'alimentation de vison et, surtout, l'éventuelle compétition des trois mustélidés. D'une façon globale, le vison consomme des anoures (31 %), des oiseaux (25 %), des mammiféres (24 %) et des poissons (19 %) alors que le putois est plus spécialiste pour les anoures (61 %) et les mammifères (30 %). Toutefois, entre les anoures, le putois prend surtout des crapauds (90,8%) alors que le vison capture des grenouilles (73,4 %). Pour les mammifères, on voit une séparation des proies entre putois et vison respectivement: lagomorphes (44% *vs* 0,4%), petits rongeurs (27 % *vs* 15 %), rat (12 % *vs* 39 %), campagnol aquatique (7% *vs* 32 %). L'indice de recouvrement de la niche trophique est d'un tiers (0,34) en considérant que les proies sont assez abondantes dans les trois sites, la compétition est revativement faible. En ce qui concerne la loutre (*Lutra lutra*), des épreintes ont été recoltées seulement le long de la rivière Eyre. Dès lors, les comparations de niche trophique ont été calculées sur deux visons (M1E, une femelle, et M3E, un mâle) et cinq putois dont seule femelle avec seulement quatre fèces. L'indice de recouvrement est minime pour la loutre qui consomme essentiellement des poissons et des insectes aquatiques, peu d'amphibiens.

Toutefois, les données doivent être critiquées : visons et putois ont un régime alimentaire différent par individus. On ne peut pas exclure qu'il s'agit des préférences individuelles. De plus, les échantillons ne sont pas aléatoires ni indépendants.

1. Introduction

Undoubtedly, the European mink, *Mustela lutreola*, is one of the most threatened species of carnivores (Baillie *et al.,* 1996; Maran *et al*., 2011). Its distribution area is presently fragmented and its populations seem to be strongly declining (Maran, 1992; Tumanov, 1992; Sidorovich, 2000a; Maran *et al*., 2011). American mink (*Neovison vison*) was introduced around 1920-1930 in most European countries, including Russia (Dunstone, 1993). The regression of the European mink is probably related to the American mink: it is heavier, body weight and have larger litters than do European mink (meaning 5.8 *vs* 2.4) and may suggest a competition for food or direct interspecific aggression (Macdonald & Harrington, 2003).

The species is recorded in the eastern part of Belarus, Estonia, Latvia and in different parts of Russia (Sidorovich, 2000; Larivière & Jennings, 2009; Maran *et al*., 2011) and in Romania, namely in the Danube delta (Gotea & Kranz, 1999) whereas in the west, its occurrence is reported only in seven departments of the south-westernmost part of France (Charente, Charente-Maritime, Dordogne, Gironde, Landes, Lot-et-Garonne and Pyrénées-Atlantiques) as well as in the valley of the Ebra River (Ruiz-Olmo & Palazón, 1991).

In the western part of its range, its regression is amazingly fast but the reasons of the phenomenon remain not yet understood (de Bellefroid & Rosoux, 1998).

In 1990, in its synthesis, Camby also highlighted the fact that it was a species whose ecology was particularly poorly known, particularly in the western part of its range. However, as part of a strategy to protect the species, it is essential to gather information on the environments frequented, inter- and intra-specific interactions and on the way resources are used. In a programme supported by the Ministry of the Environment, the Conseil général des Landes, the Conseil régional d'Aquitaine, the Agence de l'eau Adour-Garonne and WWF-France, the European mink has been studied in a multidisciplinary way: conservation (Maizeret *et al*., 2002), pathogens (Fournier-Chambrillon *et al*., 2004); parasitology (Torres *et al*., 2003, 2008); genetics (Michaux *et al*., 2004, 2005); etho-ecology : space, time (Fournier *et al*., 2007) ; diet (Libois, 2001).

Unfortunately, with regard to the latter aspect, it is almost certainly impossible to distinguish the droppings of the European mink from those of the polecat (*Mustela putorius*) or those of the American mink (*Neomustela vison*), where the species live together. It is probably this methodological difficulty that explains why, apart from the analysis of 15 stomach contents. Camby (1990) found in stomachs, muskrats (*Ondatra zibethicus*), brown rats (*Rattus norvegicus*), red voles (*Myodes glareolus*), other voles (*Microtus sp*.), a mole (*Talpa europaea*), amphibians (two cases), birds (two cases) and fish (two cases including a roach (*Rutilus rutilus*).The presence of the muskrat and of the coypu (*Myocastor coypus*) confirms the previous data of Chanudet (Saint Girons, 1991). As these animals are quite strong and large preys, it cannot be excluded that their consumption by the mink could occur as carrion.

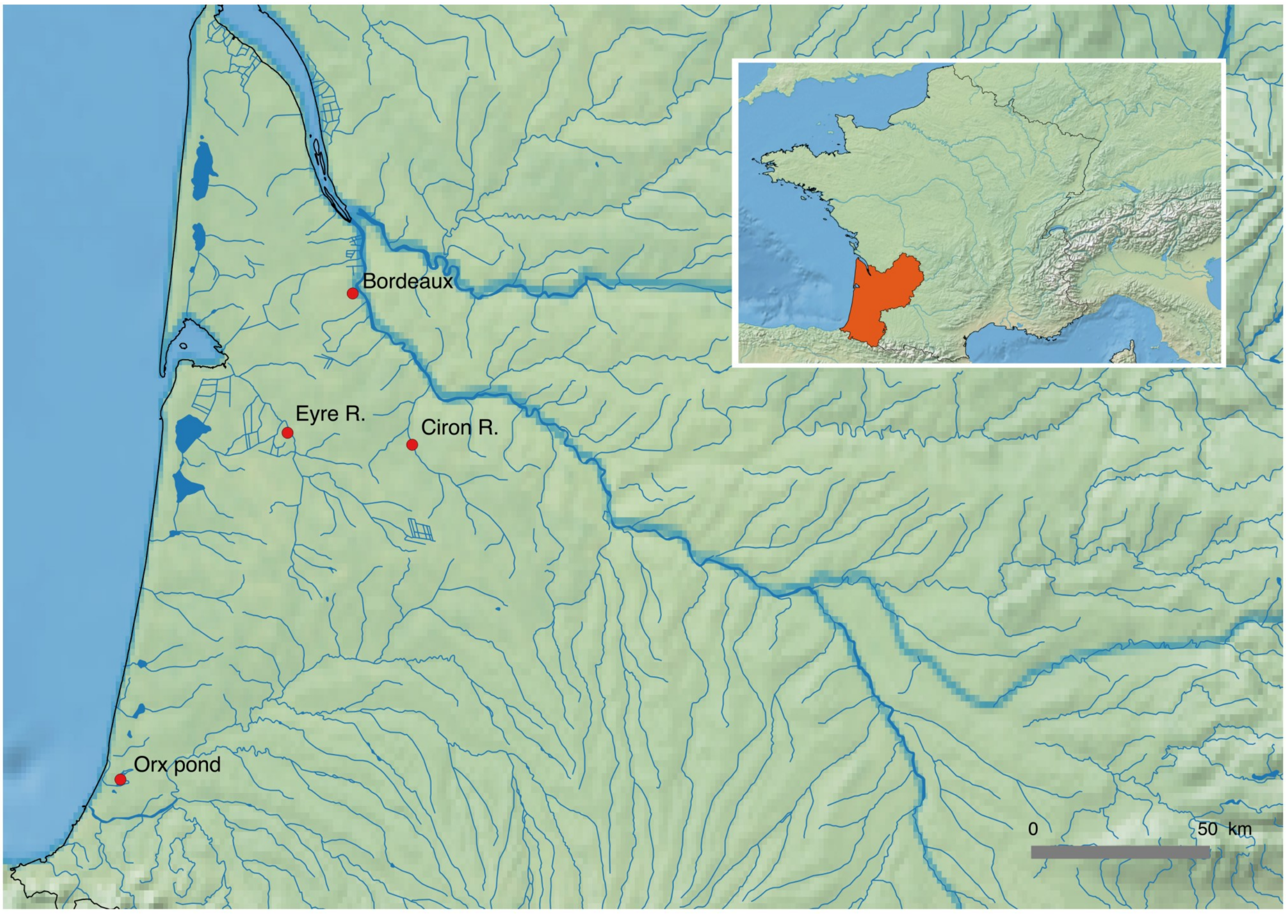
So there is hardly any information on the feeding of the species in Western Europe except for a study in northern Spain. Mink consumes small mammals, particularly wood mouse (*Apodemus sylvaticus*), fish (many barbels) and birds, and few anurans (Palazon *et al*., 2004).

Since April 1996 and until July 1999, a few minks and polecats have been equipped for a transmitter, which makes it possible to track them and recover faeces, especially in the couches. Pascal Fournier (GREGE) had the task of tracking these animals and taking all the scats.

The working hypothesis is twofold: first, to have a diet of the mink population in the western part of its range; second, to have information to understand whether there is a trophic competition between the polecat, which is more terrestrial, and the mink, which lives in transitional habitats (aquatic and terrestrial) and the otter, which is very aquatic.

2. Study area

In southwestern France, The Landes de Gascogne region covers an area of fossile sand-dunes of over than one million hectares and is mainly occupied by pine (*Pinus pinaster*) plantations and are characterized by a variety of forested and non-forested habitats. However, the valleys and marshy areas are not suitable for intensive forestry and are occupied by a variety of deciduous forests or herbaceous formations. The Eyre River (44.48°N, 0.81°W) flows between a succession of open marshes (generally in oxbows), shrubby moorlands (with *Frangula alnus* and *Salix acuminata*), willow-alder (*Alnus glutinosa*) riparian forests, either with big tussocks of sedges (*Carex paniculata*) or on swampy bare ground. Oak (*Quercus robur*) woodlands are found in less frequently flooded areas. The understorey is a scarce herbaceous layer or a dense cover of *Molinia caerulea* and shrubs (*Rubus sp., Crataegus monogyna…*). The banks of the Ciron (44.45°N, 0.37°W) are more varied: always oaks and alders but also ash trees (*Fraxinus angustifolia*), chestnut trees (*Castanea sativa*), gorse (*Ulex europaeus*), butcher's broom (*Ruscus aculeatus*) but less "wild", flowing mostly in more open areas, namely cultivated fields and cattle meadows. Both rivers cross roads and villages. Orx is a big pond with an important helophytes and hydrophytes belt (43.60°N, 1.40°W).



Map I : The city of Bordeaux is better located for the study sites: the Eyre River, the Ciron River and the Etang de l'Orx. Insert, the whole of France

Eyre River : Pissos 44.311°N, 0.759°W ; 01/06/2019

Eyre River : Mios 44.602°N, 0.939°W ; 01/06/2019

Ciron River : Pirec 44.485°N, 0.384°W ; 01/06/2019

Ciron River : Léogeats 44.510°N, 0.377°W ; 01/06/2019

Pond: Orx 43.583°N, 1.408°W ; 31/05/2019

3. Material and Methods

Different methods are available to study the diet of mammals. Their choice will depend in particular on the objectives to be achieved and above all on their ease of use for the species in question. A method well adapted to one species may be completely useless for another. In any case, two points should be given particular attention: on the one hand, the way in which sampling is carried out and, on the other hand, the way in which results are.

Independence, representativeness and exhaustiveness are the three essential qualities of a good sample. Meeting these latter conditions means defining the minimum number of food items to be identified or the minimum number of sampling units to be analysed in order to obtain a correct idea of the respective proportions of each category in the diet and to have at least one chance to meet each potential food category. In practice, this is not precisely the case for work realized.

In the field, the faeces of the mink are indistinguishable from those of the polecat on external characters. In this study, the material was recovered from radiotracked animals, mainly in their resting places, just a few days after they were left (Fournier *et al.,* 2007). Therefore, it was reliably identified as belonging to a known individual. The faeces were collected from April 1996 to August 1999 as indicated in Table 1.

After a 24h stay in clear water, the scats were individually washed on a 0.6 x 0.6 mm mesh sieve and then dried. Bones, hairs, feathers, scales and other remains were then sorted for further analysis.

Mammalian teeth or skull remains were identified according to Libois (1975). In each sample, several hairs were directly examined under a microscope to check their medullar structure. Cuticular prints were also made and compared to reference collections and to the pictures present in Day (1966), Herrenschmidt (1980) and Debrot *et al.* (1982).

Feathers were either compared to reference collections (Museum of La Rochelle) or microscopically identified according to Day (1966).

The reptiles were recognised after the characteristic pattern of some of their scales.

Amphibians were identified to the genus comparing their bone remains with reference collections. In most of the cases, these bones were so crushed that a specific identification was impossible.

Backbones, pharyngeal bones as well as preoperculars, maxillaries or dentaries were used in the identification of fish, according to Libois *et al*. (1987) and Libois & Hallet-Libois (1988) (fig. 2 & 3). Lampreys were determined by their small horny teeth, especially for the infra-oral blade (Keith *et al*., 2011).

Table 1: Origin of and periods covered by the scat samples.

Sex	Species* /N°	River	Collected from	to	Nb scats
M	M1	Ciron	II-97	V-97	32
F	M2	Ciron	X-97 XI-98	IV-98 III-99	191
F	M3	Ciron	XII-97	IV-98	83
F	M4	Ciron	XII-97	III-98	238
M	M5	Ciron	III-98 III-99	IX-98 V-99	158
M	M6	Ciron	IV-98	V-98	16
M	M10	Ciron	II-99	VIII-99	107
F	M1	Eyre	IV-96	VI-96	41
M	M3	Eyre	XII-96	I-97	143
M	M3	Orx	IV-96	VI-96	15
M	M5	Orx	III-97	IV-97	15
F	M11	Orx	III-98	III-98	5
M	P1	Ciron	IV-97	VI-97	41
F	P2	Ciron	III-98		3
F	P3	Ciron	II-98	IV-98	48
M	P4	Ciron	I-98	VIII-98	151
F	P5	Ciron	XII-98	II-99	55
M	P6	Ciron	I-99		1
F	P10	Ciron	II-99	III-99	2
M	P11	Ciron	III-99		31
M	P12	Ciron	III-99	VII-99	81
M	P4	Eyre	X-96	I-97	39
M	P6	Eyre	III-97	XI-97	39
M	P10	Eyre	V-97		10
M	P11	Eyre	X-97	II-98	82
F	P14	Eyre	XII-97		4
M	P1	Orx	XI-97	II-98	58
	Otter spraints	Eyre	V-97		

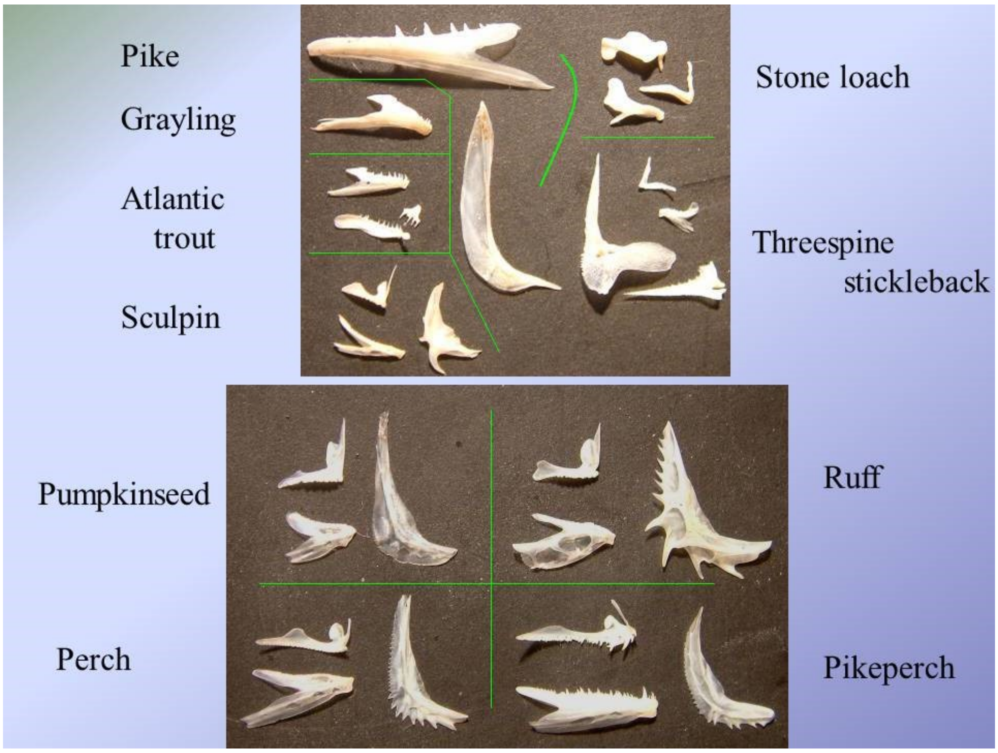


Fig. 2: A few bone pieces. Upper: Pike (*Esox lucius*): dentary and pre-opercular; Grayling (*Thymallus thymallus*): dentary; Atlantic trout (*Salmo trutta*): dentary, premaxillary and maxillary; Sculpin (*Cottus perifretum*): premaxillary, dentary and pre-opercular; Stone loach (*Barbatula barbatula*): maxillary, premaxillary and dentary; Threespine stickleback (*Gasterosteus gymnurus*): premaxillary, dentary, ventral spine and dorsal spine. Bottom: Pumpkinseed (*Lepomis gibbosus*), Perch (*Perca fluviatilis*), Ruff (*Gymnocephalus cernuus*) and Pikeperch (*Sander lucioperca*): premaxillary (top left), dentary (bottom left) and pre-opercular (right).

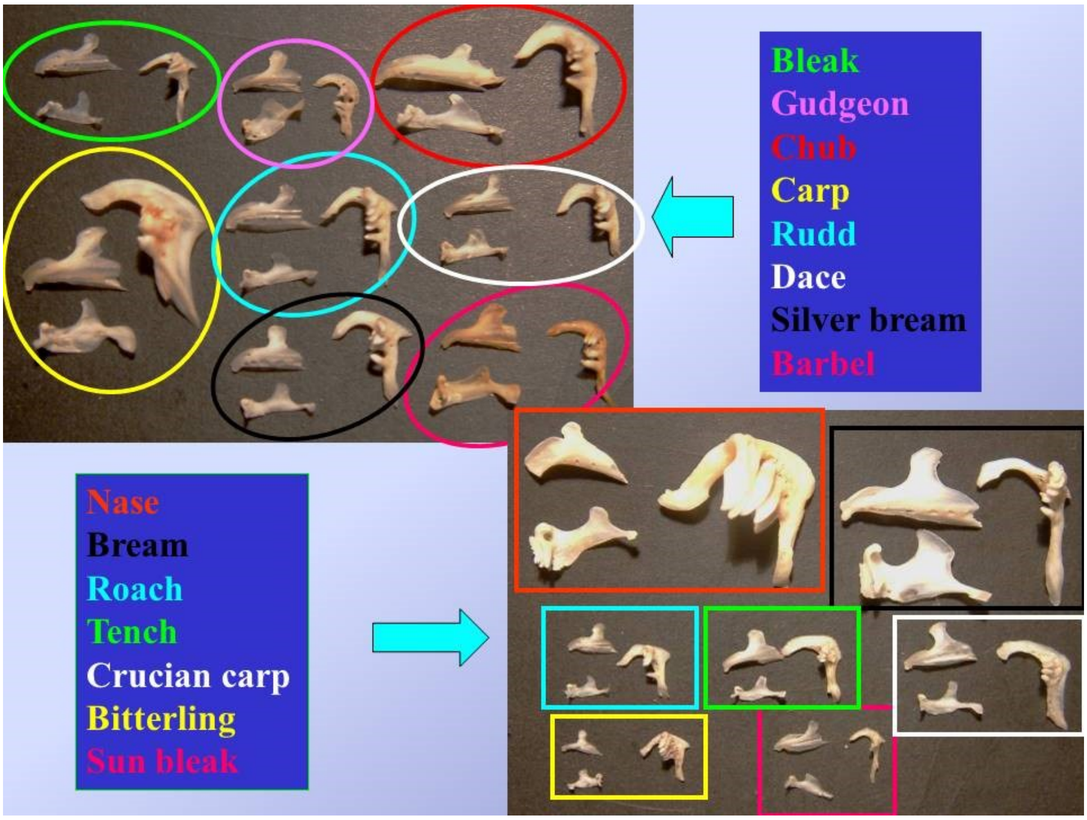


Fig. 3: Cephalic pieces of cyprinids: for each species there are, on the right, the pharygeal bone; on the left, the dental (top) and the maxilla (bottom).

Invertebrates were taken into consideration only when larger than 2 cm. The other were regarded as prey of the fish or amphibians present in the sample (Adrian & Delibes, 1987, Weber, 1987, Lodé, 1993). As numerous mustelids are known to eat earthworms either occasionally or regularly (Fairley, 1972; Bradbury, 1977; Holisova & Orbtel, 1982; Wroot, 1985; Weber, 1987; Cheylan & Bayle, 1988; Lodé, 1990 & 1991; Libois *et al*., 1991, Lodé, 1994), an attempt was made to evidence their presence in 20 scats of mink and 30 of polecat. A 2 ml volume of the soaking water was added to an equal volume of staining solution (Alcian Blue 1% in acetic acid 3 %). Several drops of this mixture were examined under a microscope to search for the setae of lumbricids (Grassé, 1959).

In some of the scats, plant material was recovered: dead leaves, mosses, stems of grasses… It was not taken into account because those elements are incidentally ingested by the predator or adhere to the scat when collected.

The results are expressed as occurrences or relative occurrences. Comparisons were performed using G-tests (Sokal & Rohlf, 1981). In the text, the subscript next to the letter “Gtest” indicates the number of degrees of freedom of the test. The G-statistics are always computed with a correction factor (see Sokal & Rohlf, 1981). The Pianka (1973) trophic niche comparison index (A_{ij}) was calculated: p_{ik} represents the proportion of resource *k* that is used by species *i* and p_{jk} represents the proportion the same resource *k* in the diet of *j*. Sidorovich (1992) used another formula: T = S_i min (p_{ik}, p_{ij}) where p_{ik} and p_{ij} represent the proportion of taxon i in the diet of species *k* and species *j*. A_{ij} and T vary between 0 and 1; the number 1 indicates complete similarity.

With regard to sprainting, occurrence, abundance and the size of fish - prey were estimated as in the previous articles (Libois, 1997) (fig 4).

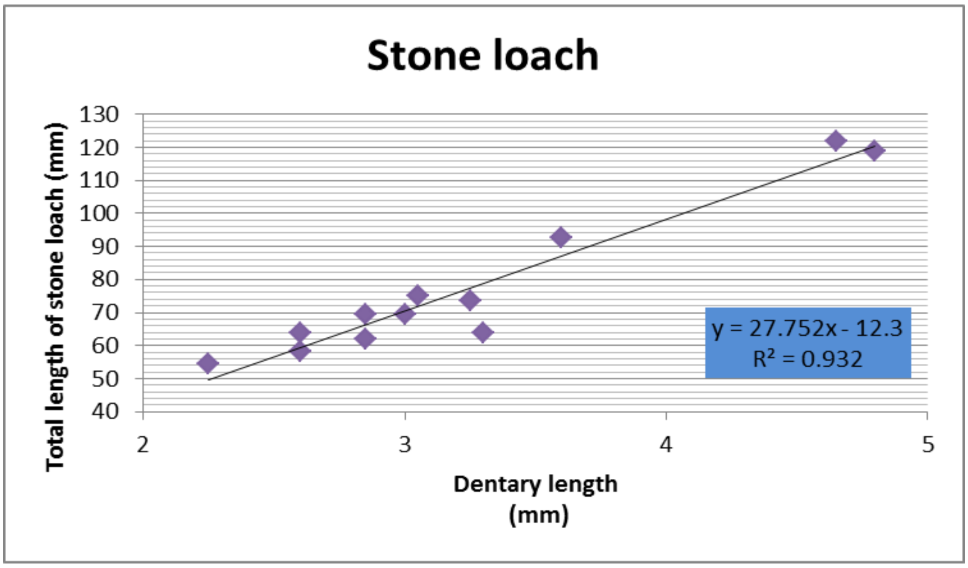


Fig. 4: Regression between the length of the dentary and the total length of the stone loach.

4. Results

4.1. The European mink

The results of the analyses are summarised in the table 2, whatever may be the sex of the individuals, the sampling season or the geographic origin (hydrographical system) of the scats. As a whole, the mink's diet is composed nearly part for part by fish, amphibians, birds and terrestrial or semi-aquatic mammals. In this group, rodents are the most

TABLE 2 : Composition of the food of the European mink in France (Occurrence and relative occurrence of each taxon is indicated by O and R.O., respectively).

FISH	O	R.O.		O	R.O.
Not identified	25	*2.14*	**AMPHIBIANS** (Anurans)		
Salmonidae	2	*0.17*	Not identified	63	*5.40*
Cyprinid fish (Not identified)	107	*9.17*	Frogs - *Rana sp.*	213	*18.25*
Minnow – *Phoxinus phoxinus*	1	*0.09*	Toads - *Bufo sp.*	77	*6.60*
Dace – *Leuciscus burdigalensis*	2	*0.17*	**REPTILES (Ophidians)**	9	*0.82*
Roach – *Rutilus rutilus*	17	*1.46*	**MAMMALS**		
Tench – *Tinca tinca*	3	*0.26*	Millet's shrew – *Sorex coronatus*	*8*	*0.69*
Gudgeon – *Gobio occitaniae*	3	*0.26*	Pygmy shrew – *Sorex minutus*	1	*0.09*
Stone loach - *Barbatula barbatula*	3	*0.26*	Water shrew – *Neomys fodiens*	1	*0.09*
Stickleback – *Gasterosteus gymnurus*	1	*0.09*	Greater white-toothed shrew – *Crocidura russula*	2	*0.17*
Bullhead – *Cottus perifretum*	3	*0.26*	Lagomorphs	1	*0.17*
Pike – *Esox lucius*	13	*1.11*	Muskrat – Ondatra zibethicus	11	*0.94*
Percidae/Centrarchidae	7	*0.60*	Bank vole – *Myodes glareolus*	15	*1.29*
Pumpkinseed– *Lepomis gibbosus*	9	*0.82*	Water vole – *Arvicola sapidus*	81	*6.94*
Eel – *Anguilla anguilla*	33	*2.83*	Short-tailed vole - *Microtus agrestis*	7	*0.60*
BIRDS			Voles – *Microtus sp.*	12	*1.03*
Not identified	75	*6.43*	Fieldmouse – *Apodemus sp.*	13	*1.11*
Eggs	55	*4.71*	House mouse – *Mus domesticus*	2	*0.17*
Grebes – *Podicipedidae*	1	*0.09*	Harvest mouse - *Micromys minutus*	2	*0.17*
Herons – *Ardeidae*	1	*0.09*	Rats – *Rattus sp.*	97	*8.31*
Ducks – *Anatidae*	105	*9.00*	Coypu – *Myocastor coypu*	12	*1.03*
Moorhens … - *Rallidae*	50	*4.28*			
Woodcocks… - *Scolopacidae*	8	*0.69*	**ARTHROPODS**		
Passeriformes	7	*0.60*	*Hydrophilidae*	1	*0.09*
Robin – *Erithacus rubecula*	1	*0.09*	*Cercyon ustulatus*	1	*0.09*
Bearded tit - *Panurus biarmicus*	1	*0.09*	Crayfish – *Procambarus clarki*	1	*0.09*
Blue tit - *Parus caeruleus*	1	*0.09*			
Starling - *Sturnus vulgaris*	1	*0.09*	**FRUITS**	2	*0.17*

frequent, accounting for more than 95% of the occurrences of mammals, rats (*Rattus sp.)* and water voles (*Arvicola sapidus)* being the main preys.

The specific identification of the rats was possible in only six cases (3 black rats, *R. rattus* and 3 Norway rats, *R. norvegicus),* when teeth were recovered in the scats. Otherwise, the presence of the genus *Rattus* was confirmed by the examination of hairs. Rats account for nearly 2/5 of the identified rodents. Very often, large size backbones were associated with the fur, evidencing the capture of adult rats. One third of the other rodents are water voles. Small murids and insectivores are quite uncommon.

Bird remains are frequently recovered too. The majority of the species are bound to ponds, rivers and marshes. Two thirds of the identified specimens are ducks or geese (*Anatidae*), most of them being adult. The next most frequent birds are the *Rallidae,* particularly the moorhen *(Gallinula chloropus)* : 24 out of the 50 occurrences of the family. Some passerine were also found (a starling, a robin, a blue and a bearded tit), as well as a woodcock (*Scolopax rusticola*) and an undetermined snipe, a heron and a grebe. It is worth to mention that all the remains of woodcock were recovered in scats collected at a single burrow during three successive days. It is therefore likely that the mink fed on a unique carcass.

Nine out of the 17 identified eggs belong to the Anatidae (mallard, *Anas platyrhynchos*, in 4 cases), 4 to the moorhen, 1 to a domestic hen, 2 to the dunnock (*Prunella modularis)* and 1 to another passerine.

As far as amphibians are concerned, frogs are considerably more frequent than toads.

Table 3 : Occurrences of the main prey categories in the diet of each individual European mink

	Sex	Fish	Anura	Reptiles Invertebra	Birds	Mammals	Partial Gtest	
M1C	M	2	22		4	16	21.69	p < 0.001
M2C	F	35	85		47	45	12.84	p < 0.025
M3C	F	10	51		4	7	54.93	p << 0.001
M4C	F	121	112	4	14	1	259.94	p <<< 0.001
M5C	M	19	5	2	75	51	95.60	p <<< 0.001
M6C	M	5	3		1	6	6.79	NS
M10C	M	14	21	5	50	17	31.09	p << 0.001
M1E	F		3		40	1	86.61	p <<< 0.001
M3E	M		30		38	93	131.21	p <<< 0.001
MO3	M	2		1	10	5	18.03	p < 0.025
MO5	F		2		1	14	28.45	p < 0.001

Amphibian eggs were recovered in a few scats of a mink from the Ciron River.

Unfortunately, most of the fish remains were backbones, preventing their specific identification. Nevertheless, among those that were identified, 70 % are slow moving or benthic fishes: eel, roach, tench, pike and stone loach.

Invertebrates are uncommon and no earthworm remain was recovered.

However, this general overview may be somewhat misleading because every individual

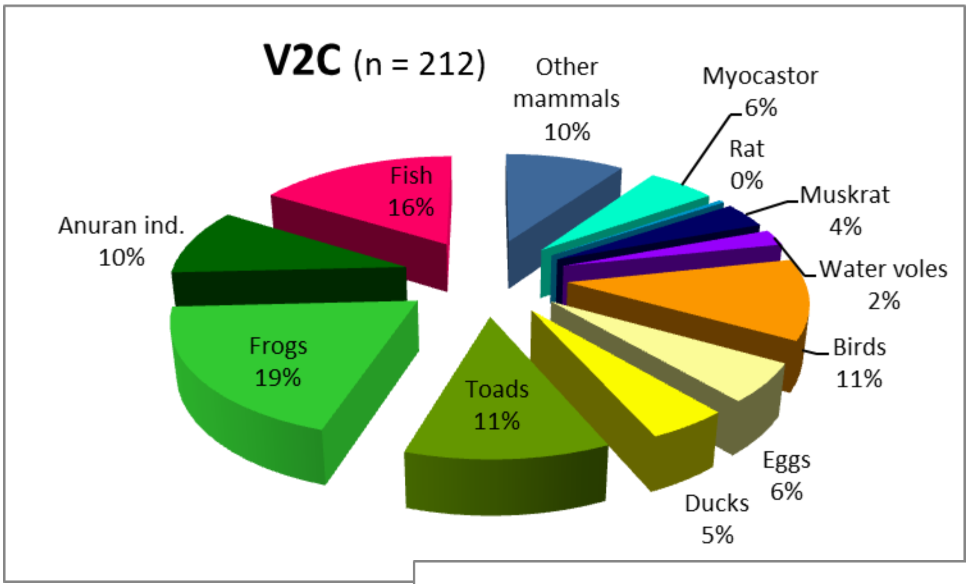
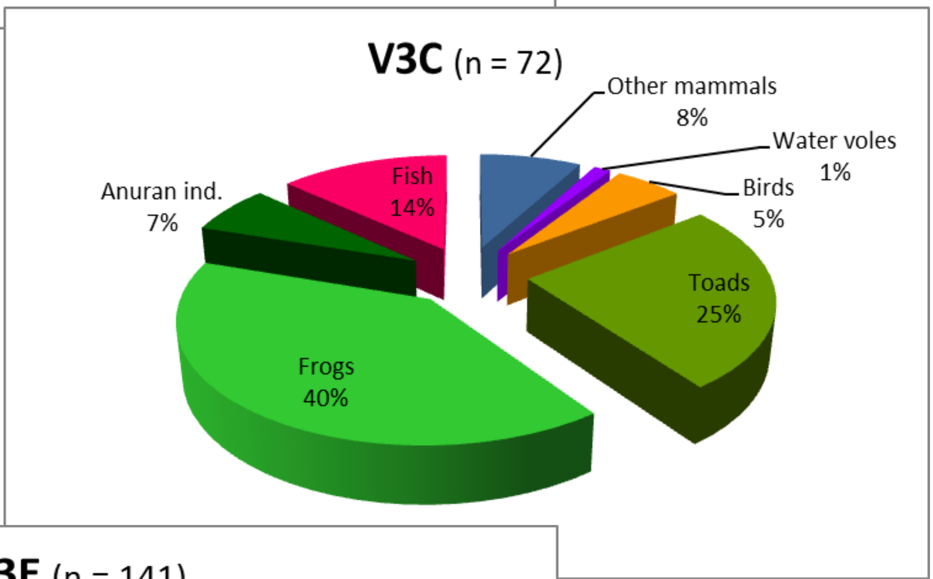
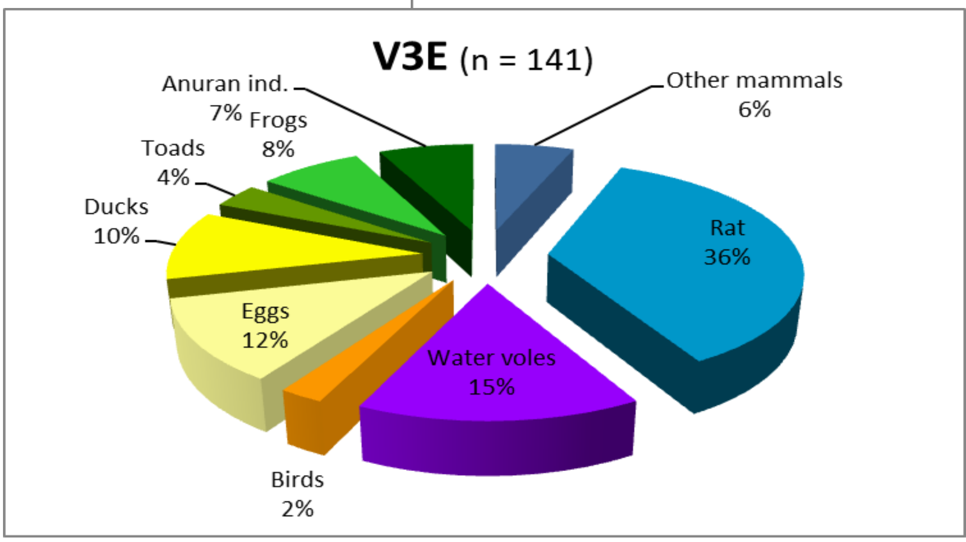


Fig. 5 : Relative frequency of prey occurrence for three minks: V2C and V3C environments are similar: large sedge alder, light substorey mesophilic woods and production forests; mink V3E has also evolved from alder, mesophilic woods and prairies.

The seasons were relatively extended for V2C (10-97 to 04-98 and 11-98 to 03-99) less for V3C (12-97 to 04-98) and for V3E only in winter (12-96 to 01-97).





seems to have a particular feeding pattern (see annex, table I)! For example, the relative occurrence of fish varies between nil in the minks of the Eyre River and 48 % in M4C. For the amphibians, the variations are still stronger: from nil in M3 (Orx) to 70 % in M3C (Table 3).

The G statistic computed on the table 3 (Gtest $_{ddl\ 40}$ = 739.08 ; $p <<< 0.001$) indicates an important heterogeneity between the mink's diets. Even in pairwise comparisons, none of the diets is similar to another one: all the computed G values are significant, most of them at the 0.001 level.

M1E mink consumed mainly birds, particularly ducks. Other minks, M5C, M10C and MO3, have more varied prey but remain on birds: ducks, rallids (moorhen) and eggs. On the other hand, the M1C and M3C minks despised the birds. Some minks (M3C, M5C and M10C) seem to be attracted to water voles and rats, others (M4C and ME1) are neglected.

Three examples to see the diversity of mink diets in the same places and seasons (fall and winter) (fig. 5).

The question is to known whether these differences are the consequence of individual specialisation, of seasonal, sexual or geographical food preferences. Data were analysed removing the reptiles and the invertebrates from the results as well as the few scats from Orx (less than 30 occurrences by sex) (Table 4). A multidimensional G-test was computed using the data of table 5. Its value is highly significant (Gtest $_{ddl\ 3}$= 108.2; $p << 0.001$), what shows obviously a strong dependence between the three factors analysed: river (geographic origin), sex and individual.

Table 4: Occurrences of the main prey categories in the mink diet according to sex and river system.

		Ciron	Eyre	Orx
Mammals	Males	90	93	5
	Femelles	53	1	16
Birds	Males	130	38	10
	Femelles	65	40	1
Reptiles	Males	5		
	Femelles	4		
Amphibians	Males	51	30	
	Femelles	248	3	4
Fish	Males	40		2
	Femelles	166		2
Invertebra	Males	2		1
	Femelles			

The seasonal variations in the diet are also remarkable (Gtest $_{ddl\ 12}$ = 75.5 ; p << 0.001 ; the invertebrates were not taken into consideration in this computation) except in what concerns the mammals and the reptiles. Birds are more often taken during summer and autumn whereas the amphibians are mainly winter and spring preys. Fish are principally eaten during the winter.

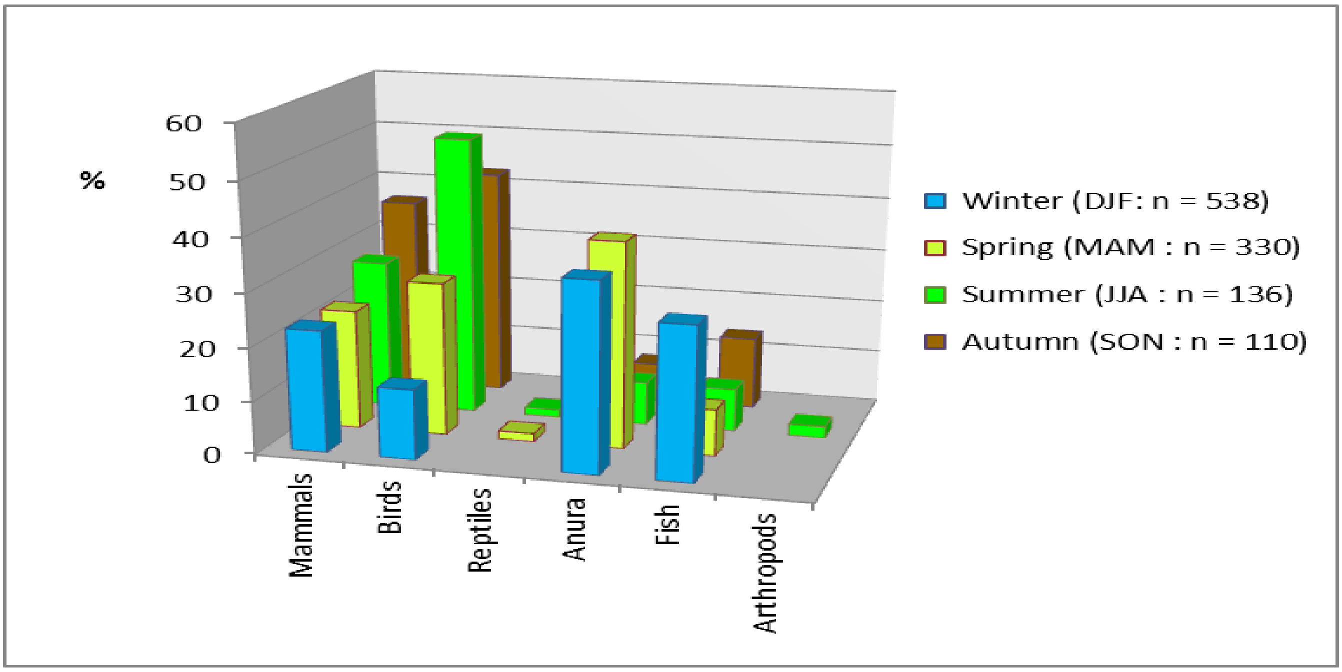


Fig. 6 : Seasonal variations in the diet of the European mink

The European mink seems therefore a generalist-opportunist predator whose diet is dominated by fish and by terrestrial vertebrates which are closely associated to aquatic ecosystems: water voles, ducks, frogs and also rats.

The size of fish in European mink faeces.

In mink faeces, scales, vertebrae and some rare cephalic parts are found. The vertebrae of eels, pike, salmonids and cyprinids can be easily distinguished without distinguishing between species. Unfortunately, therefore, analysis of the size classes of the fish consumed shows that minks catch undetermined cyprinids of medium size (12.5 to 17.5 cm) and small species (stone loach, bullhead, pumpkinseed, stickleback) and young of large species (roach, tench) (< 12.5 cm). In northern Spain, Palazon *et al.* (2004) also found that the size of fish prey was, on average, 13.5 cm.
For eels, most are less than 42 cm tall (Bootlace size): a finding already noted by the otter.

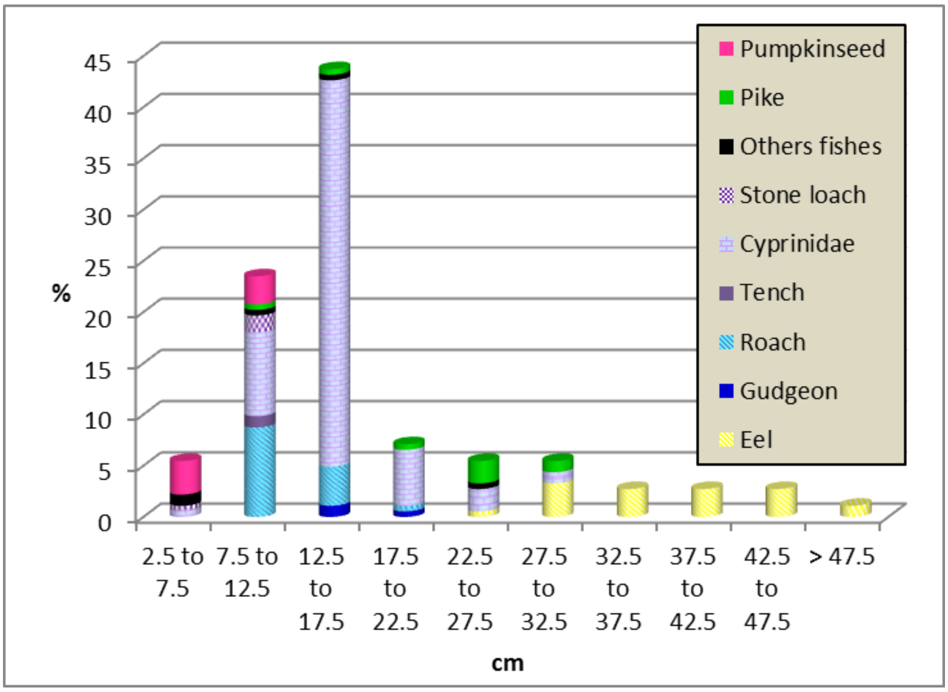


Fig. 7: Frequency distribution of the prey-fish size by European mink (n = 183)

4.2 The polecat

Table 5 summarises the results of the analyses, whatever may be the sex of the individuals, the sampling season or the geographic origin (hydrographical system) of the scats. As a whole, the polecat's diet is made up mainly by amphibians (61 %), particularly by the common toad (*Bufo bufo*). Mammals are the next important prey category, accounting for more than 25 % of the occurrences. In this group, rabbits and hares account for nearly 50% of the occurrences, small rodents (*Microtus, Myodes* and *Apodemus)* being the next main prey whereas rats and semi-aquatic rodents (water vole, muskrat and coypu) being far less frequent. Insectivores are uncommon prey.

Other prey, such as birds, reptiles, fish and invertebrates are much less frequent, accounting altogether for less than 12 % of the occurrences. No earthworm remain was found.

Table 5: Composition of the food of the polecat in south-western France (Occurrence and relative occurrence of each taxon is indicated by O and R.O., respectively).

FISH	**O**	**R.O.**	**MAMMALS** (next)	**O**	**R.O.**
Salmonidae	6	*0,82*	Bank vole – *Myodes glareolus*	18	*2,45*
			Water vole – *Arvicola sapidus*	14	*1,91*
AMPHIBIANS (Anurans)			Voles – *Microtus sp.*	21	*2,86*
Not identified	82	*11,17*	Fieldmouse – *Apodemus sp.*	16	*2,18*
Frogs - *Rana sp.*	32	*4,36*	House mouse – *Mus domesticus*	1	*0,14*
Toads - *Bufo sp.*	317	*43,19*	Harvest mouse - *Micromys minutus*	1	*0,14*
			Rats – *Rattus sp.*	25	*3,41*
REPTILES			Coypu – *Myocastor coypu*	11	*1,50*
Lizards – *Lacertidae*	5	*0,68*			
Snakes – *Natrix sp.*	13	*1,77*	**ARTHROPODS**		
			Orthoptera	2	*0,27*
BIRDS			Hemiptera	1	*0,14*
Not identified	30	*4,09*	Lepidoptera (caterpillar)	1	*0,14*
Eggs	5	*0,68*	Hymenoptera	1	*0,14*
Ducks – *Anatidae*	5	*0,68*	Unidentified Coleoptera	2	*0,27*
Starling - *Sturnus vulgaris*	1	*0,14*	Caraboidea	7	*0,95*
			Melolonthinae	3	*0,41*
MAMMALS			Silphidae	1	*0,14*
Mole – *Talpa europaea*	1	*0,14*	Chrysomelidae	1	*0,14*
Millet's shrew – *Sorex coronatus*	2	*0,27*	Curculionidae	1	*0,14*
Greater white-toothed shrew – *Crocidura russula*	3	*0,41*	Elateridae	1	*0,14*
Lagomorphs	93	*12,67*	Cerambycidae	2	*0,27*
Unidentified rodent	1	*0,14*			
Muskrat – *Ondatra zibethicus*	6	*0,82*	**GASTEROPODS**	2	*0,27*

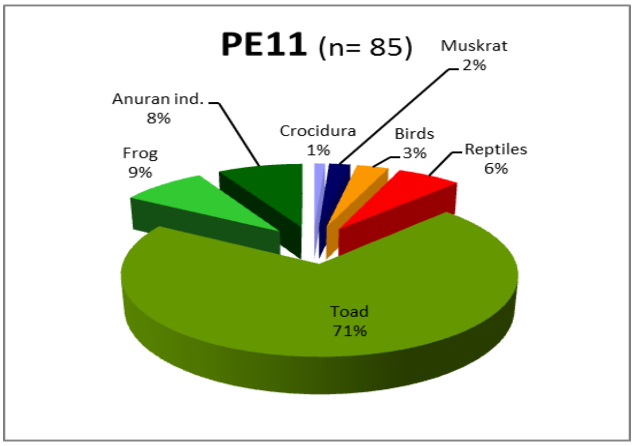
As already illustrated above in the mink, the individual differences are quite strong in the diet of the polecat (table 6).

Table 6 : Occurrences of the main prey categories in the diet of each individual polecat

	Sex	Fish & Invertebra	Anurans & Reptiles	Birds	Mammals	Partial Gtest	
M1C	M		21		16	9.63	p < 0.025
M3C	F		44		2	29;40	p << 0.001
M4C	M		148	2	2	111.34	p <<< 0.001
M5C	F		58		13	19.27	p < 0.001
M11C	M	1	30		1	19.18	p < 0.001
M12C	M	16	7	4	66	140.33	p <<< 0.001
M4E	M	2	25	7	19	7.65	p = 0.06
M6E	M	6	7	1	24	37.79	p << 0.001
M11E	M		79	3	2	51.17	p << 0.001
MO1	M		2	19	42	126.56	p <<< 0.001

The G statistic computed on the table 6 (Gtest $_{ddl\ 27}$ = 544.85 ; p << 0.001) indicates an important heterogeneity between the individual diets. In pairwise comparisons, most of the computed G values are significant at the 0.01 level except the pairs P1C(iron) and P4E(yre). The homogeneity of this group of amphibian-eaters (P3C, P4C, P11C and P11E) cannot be rejected (Gtest $_{ddl\ 3}$ = 1.91, N.S.). On the other hand, the polecats P12C and P1O have very few of them: they are "specialists" in lagomorphs, like the polecat P6E. This polecat consumed rats (*Rattus* sp.) and salmonids: only one polecat, P6E, ate fish. The polecat P1O is quite worn by rats and also by birds, especially ducks. Finally, the polecat P12C caught insects: ind. beetles, Carabids, Cerambycids, "beetles", Orthopterans, only one Hymenoptera. In fact, the diets for polecat are all different (Fig. 8). Here are two examples, both in winter and in the same environment: production pine trees and alder trees with large sedges (see annex table II).

The prey is first and foremost amphibians, especially toads, but the "secondary" prey is very different.



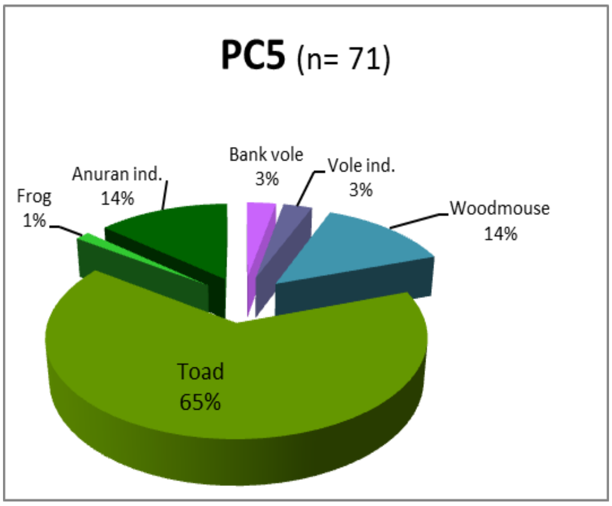


Fig. 8: Relative frequency of prey occurrence for two polecats : PC5 and PE11: winter 1998/1999 and 1997/1998 respectively.

As with the mink, it should be interesting to know whether these differences are the consequence of individual specialisation, of seasonal, sexual or geographical food preferences.

Data were analysed removing the invertebrates from the results as well as the scats from Orx (no data for females) (Table 7). A multidimensional G-test cannot be done due to lack of data on the diet of Eyre females. For Ciron, males have more mammals and arthropods in their diet than females (Gtest $_{ddl\ 4}$ = 33.66, p < 0.001). Between sites, for males only (no data on females), the differences are enormous, especially at Orx (Gtest $_{ddl\ 6}$ = 134.2, p << 0.001): here, this polecat consumes very few amphibians (G partial, $_{ddl\ 2}$ = 64.55, p < 0.001) but significantly more mammals and birds (G partial, $_{ddl\ 2}$ = respectively 19.56 and 41.18, p < 0.001).

Table 7: Occurrences of the main prey categories in the polecat's diet according to sex and river system.

		Ciron	Eyre	Orx
Mammals	Males	101	68	48
	Femelles	15	1	
Birds	Males	6	15	19
	Femelles			
Reptiles	Males	12	1	
	Femelles	6		
Amphibians	Males	206	119	2
	Femelles	102	3	
Fish	Males		6	
	Femelles			
Invertebra	Males	17		
	Femelles			

The seasonal variations in the diet are also remarkable (Gtest $_{ddl\ 12}$ = 73.4 ; $p << 0.001$; the fish were not taken into consideration in this computation) except in what concerns the reptiles. Birds are more often taken during winter and autumn whereas the amphibians are mainly winter and summer preys. Arthropods are eaten during in spring and summer.

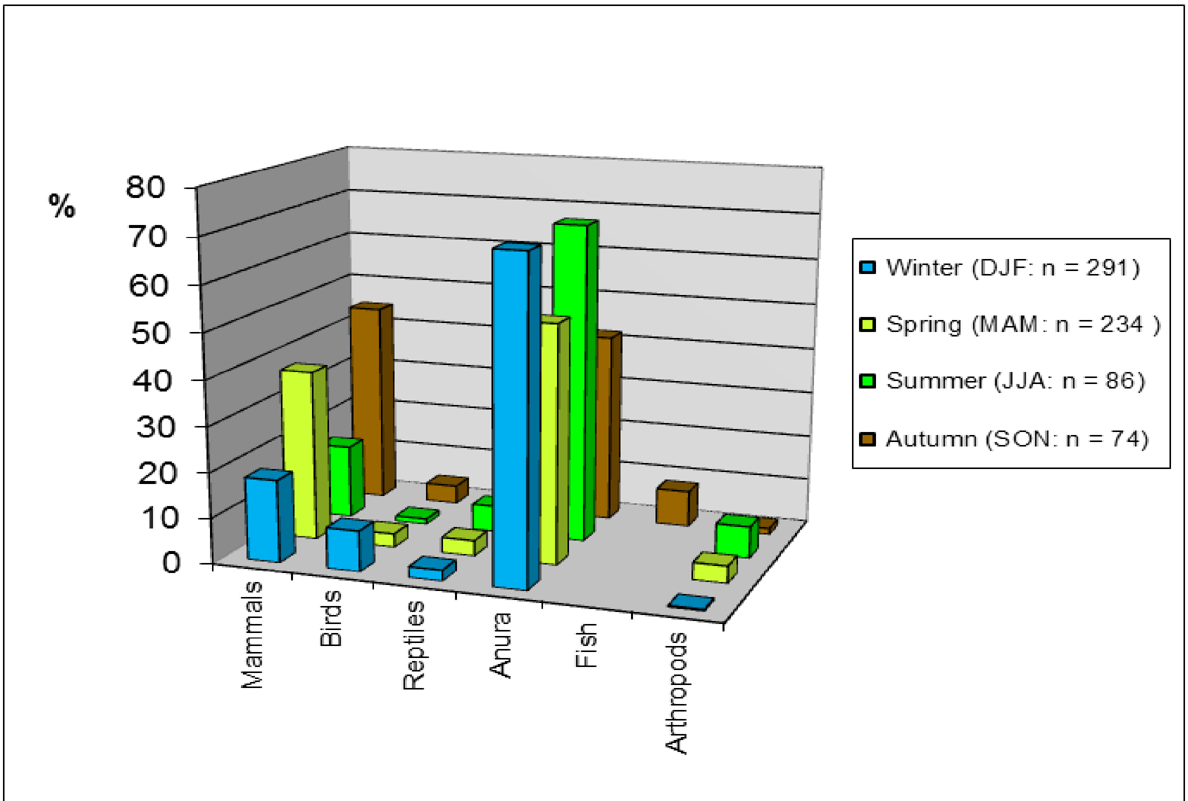


Fig. 9 : Seasonal variations in the diet of the polecat

4.3. Comparison European mink – polecat

A general comparison on the main food categories shows that the frequency distributions of the preys in the diet of both predators are completely different from each other (fig. 10 & fig. 11; tab. 2 & tab. 5). The Gtest is highly significant (Gtest $_{ddl\ 5}$ = 60.9, $p < 0.001$) and the partial G-tests show also highly significant differences for each prey category, except mammals. However, when considering the different mammalian taxa (insectivores are pooled as well as small muridae and *Microtus* voles), strong differences appear (Gtest $_{ddl\ 8}$ = 58.7; $p < 0.001$) but the heterogeneity of the data is exclusively due to the lagomorphs, the rats and the water vole. Polecats eat much more lagomorphs than minks, which prey more upon rats and water voles. Comparing the relative frequency of toads and frogs in the diet, it appears also that frogs are mainly eaten by the minks and toads by the polecats (Gtest $_{ddl\ 2}$ = 167.56; $p \ll 0.001$).

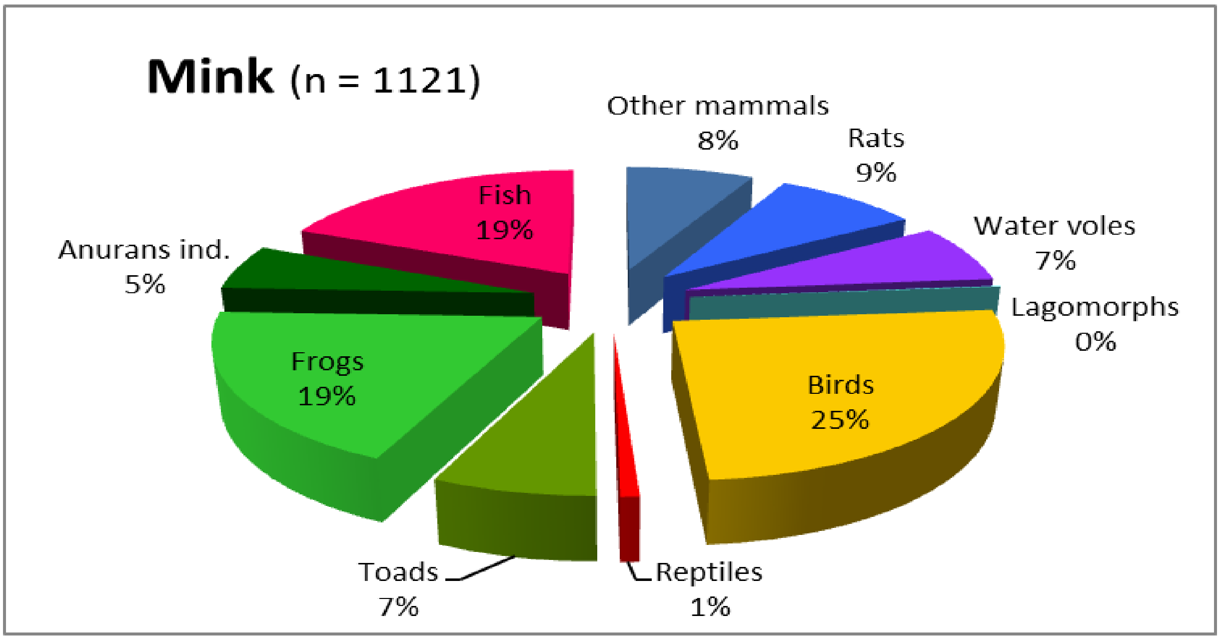
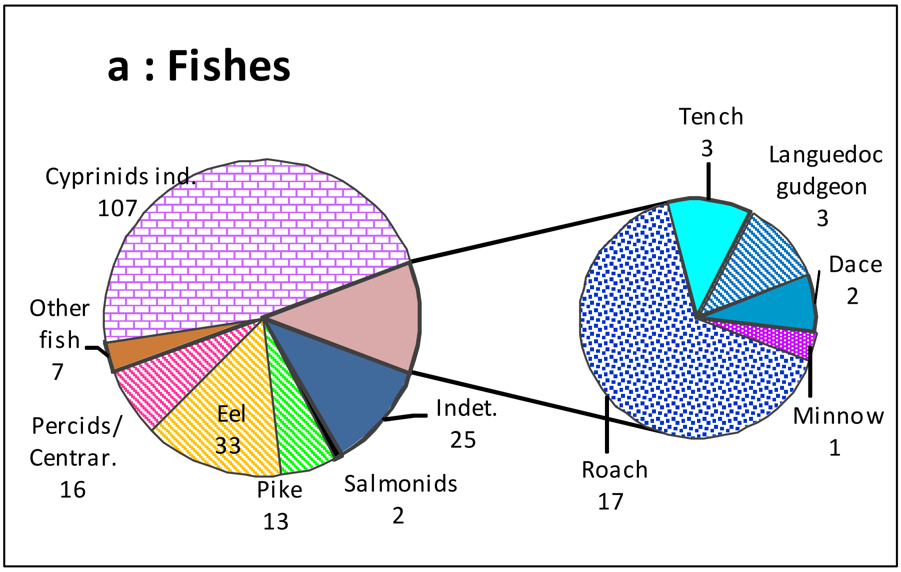
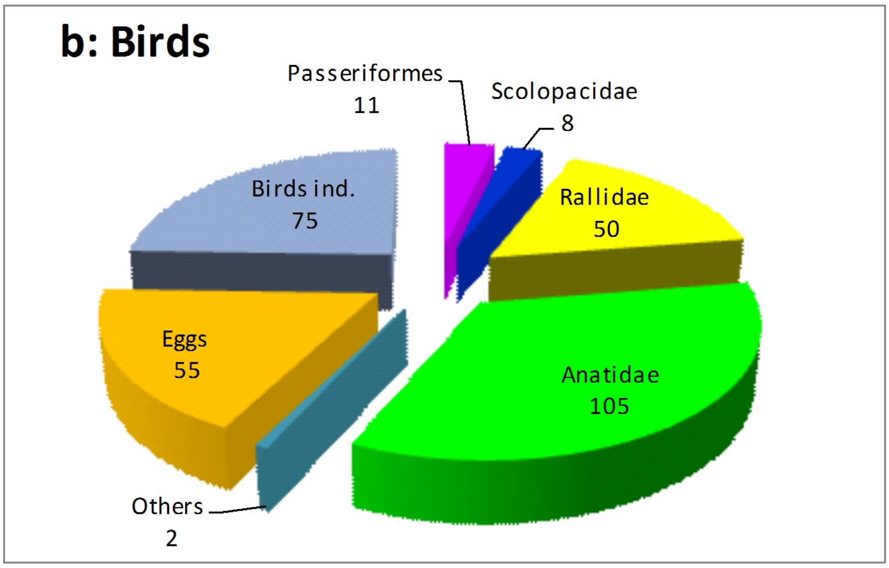
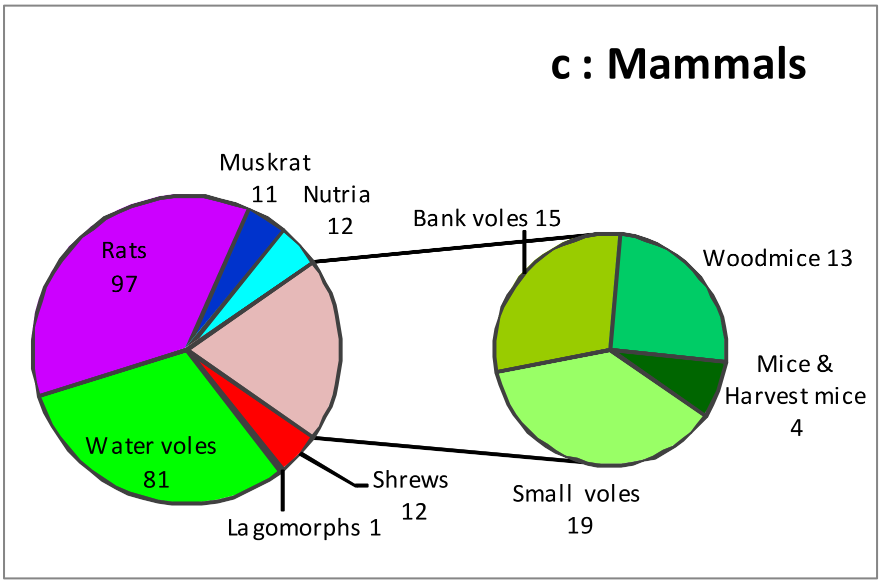


Fig. 10 : Relative occurrence of European mink prey in the three sites.

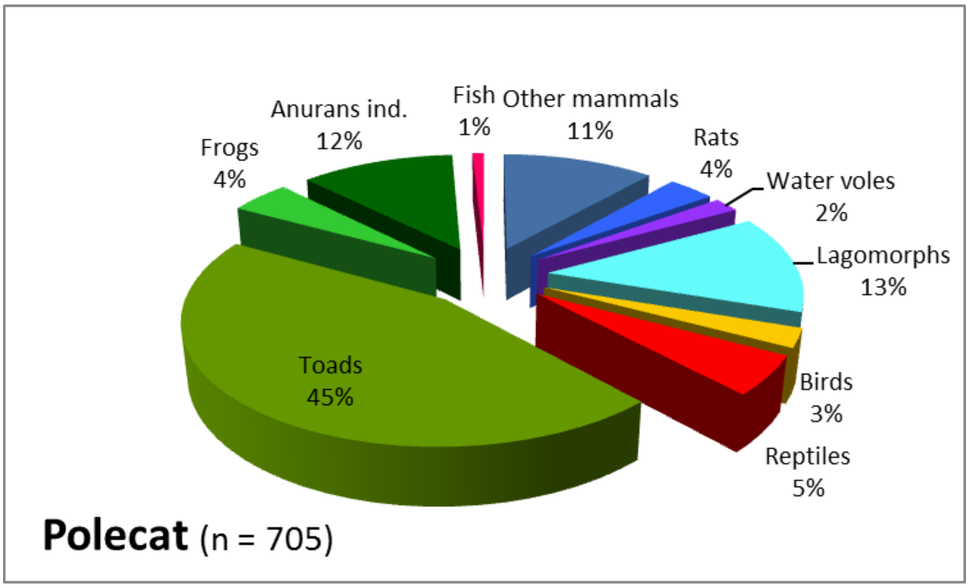
The three subgraphs (next page) give details for fish (a), birds (b) and mammals (c).


a : Fishes
Cyprinids ind.
107
Other
fish
7
Percids/
Centrar.
16
Eel
33
Pike
13
Salmonids
2
Indet.
25
Tench
3
Languedoc
gudgeon
3
Dace
2
Minnow
1
Roach
17


b: Birds
Passeriformes
11
Scolopacidae
8
Birds ind.
75
Rallidae
50
Eggs
55
Anatidae
105
Others
2


c : Mammals
Muskrat
11
Nutria
12
Rats
97
Water voles
81
Lagomorphs 1
Shrews
12
Bank voles 15
Woodmice 13
Mice &
Harvest mice
4
Small voles
19

Each season, the diet of the mink and the polecat are different (fig. 6, fig. 9). The Gtests are always very significant: 199.83 for winter, 127.86 in spring, 141.98 for summer and finally 58.9 in autumn. Mink prefer fish at all seasons except in autumn (small material) and birds except in winter. On the other hand, polecat consume a lot of amphibians in all seasons. Lizards were predated in winter and mammals in spring only for polecats. Arthropods are marginal prey.



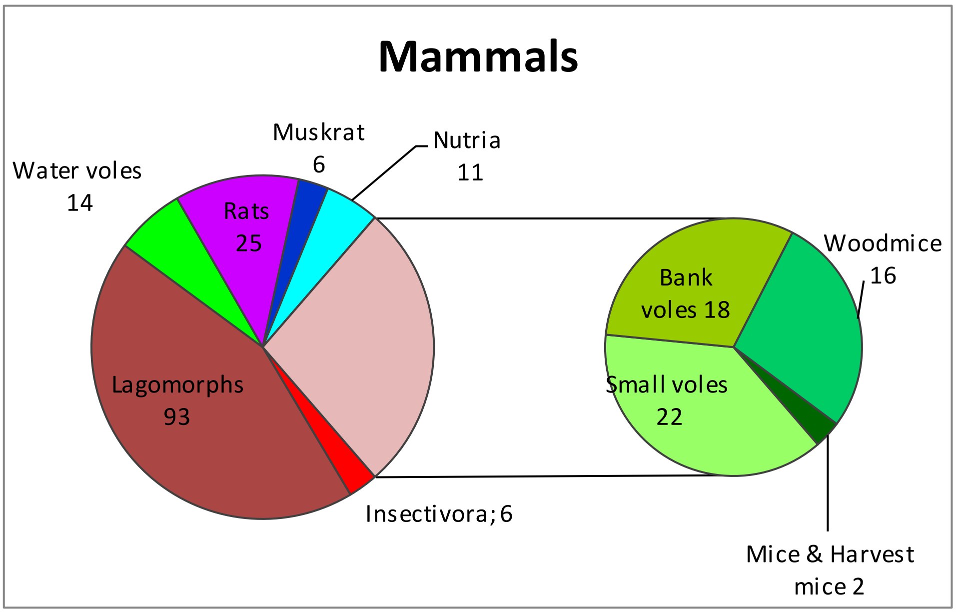


Fig. 11: Relative occurrence of polecat prey in the three sites.

The subgraph give details for mammals.

The food niche overlap seems quite important ($T = 0.617$ or $A_{ij} = 0.791$) when the food items are grouped inside comprehensive categories as shown in annex table I and II. However, when considering the finest taxonomic levels, these indexes drop to 0.353 or 0.334 for T and A_{ij}, respectively.

4.4. Comparison European mink – polecat - otter

Otter spraints were collected only on the Eyre River; therefore, mink (M1E and M3E) and polecat (P4E, P6E, P10E, P11E and P14E) feeding data will be processed here.
A comparison on the main food categories shows that the frequency distributions of the preys in the diet of predators are completely different from each other (tab. 2, 5 and 8). The G test is highly significant ($Gtest_{ddl:\ 39} = 976.9$, $p \lll 0.0001$) and the partial G-tests show also highly significant differences for each prey category, except insectivores.

Table 8 : Composition of the food of the otter in the Eyre River :
occurrence and relative occurrence of each taxon is indicated by O and R.O., respectively.
The same pattern for abundance (A) and relative abundance (R.A.)

	O	R.O.	A	R.A.		O	R.O.	A	R.A.
Cyclostomata					**Lizard**	1	*0,45*	1	*0,30*
Lamprey - *Petromyzontidae*	11	*5,00*	18	*5,41*					
					Birds	2	*0,91*	2	*0,60*
Fish					*Ducks - Anatidae*	3	*1,36*	3	*0,90*
Salmonidae	1	*0,45*	1	*0,30*					
Cyprinids ind.	14	*6,36*	12	*3,60*	**Mammals**				
Bleak - *Alburnus alburnus*	1	*0,45*	1	*0,30*	*Muskrat – Ondatra zibethicus*	9	*4,09*	8	*2,40*
Minnow - *Phoxinus phoxinus*	4	*1,82*	4	*1,20*	*Pygmy shrew - Sorex minutus*	1	*0,45*	1	*0,30*
Beaked dace - *Leuciscus burdigalensis*	2	*0,91*	2	*0,60*					
Roach - *Rutilus rutilus*	4	*1,82*	6	*1,80*	**Insects**	2	*0,91*	2	*0,60*
Languedoc gudgeon - *Gobio occitaniae*	7	*3,18*	7	*2,10*	Odonates larvae	5	*2,27*	5	*1,50*
Stone loach - *Barbatula barbatula*	38	*17,27*	55	*16,52*	*Dytiscidae larvae*	8	*3,64*	56	*16,82*
Pike - *Esox lucius*	3	*1,36*	3	*0,90*	*Dytiscidae adults*	8	*3,64*	10	*3,00*
Perch - *Perca fluviatilis*	4	*1,82*	8	*2,40*	*Hydrophilidae*	2	*0,91*	2	*0,60*
Pumpkinseed - *Lepomis gibbosus*	1	*0,45*	2	*0,60*					
Eel - *Anguilla anguilla*	46	*20,91*	74	*22,22*	**Bivalvia**				
					Unio sp.	1	*0,45*	1	*0,30*
Amphibia	35	*15,91*	42	*12,61*	*Sphaeriidae*	1	*0,45*	1	*0,30*
Frogs - Rana sp.	5	*2,27*	5	*1,50*					
Toads - Bufo sp.	1	*0,45*	1	*0,30*					

The diet of the otter on the Eyre shows an eclectic character, although the diversity, in abundance, is average (H' = 3.13 bits) the four categories of prey have the same importance in abundance: insects (22.5%), eel (22.2%), stone loach (16.5%) and amphibians (14.4%). It is the first that, in France at least, we found lampreys in the sprasprints, about 20 individuals. Insects are mainly odonate larvae and aquatic beetles, dytiscids. The total number of cyprinids is only minus 10%. Unfortunately, large cyprinids could not be identified as a species because they did not have the relevant cephalic parts. Many other taxa (reptiles, mammals and bivalves) are also present but with a very small number of individuals.

However, the specific richness (S) in fish is low (12), as in oligotrophic waters such as Brittany (Ellez: 9; Leguer: 6 (Libois, 1995), Margeride: 11 and gaves in the Pyrénées-Atlantiques: 5 (Rosoux *et al*., 2019)). In mesophilic or even eutrophic waters, the specific richness is more important such as the Poitevin marsh (21) (Libois, 1995), the Chavanon basin (tributary of the Dordogne) (19) (Libois, 1997), the Arnon basin (tributary of the Cher) (26) (Libois *et al.,* 2016), Ambène (sub-tributary of the Allier) (21), Brenne (ponds) (18), Loire moyenne (21) (Rosoux *et al*., 2019).

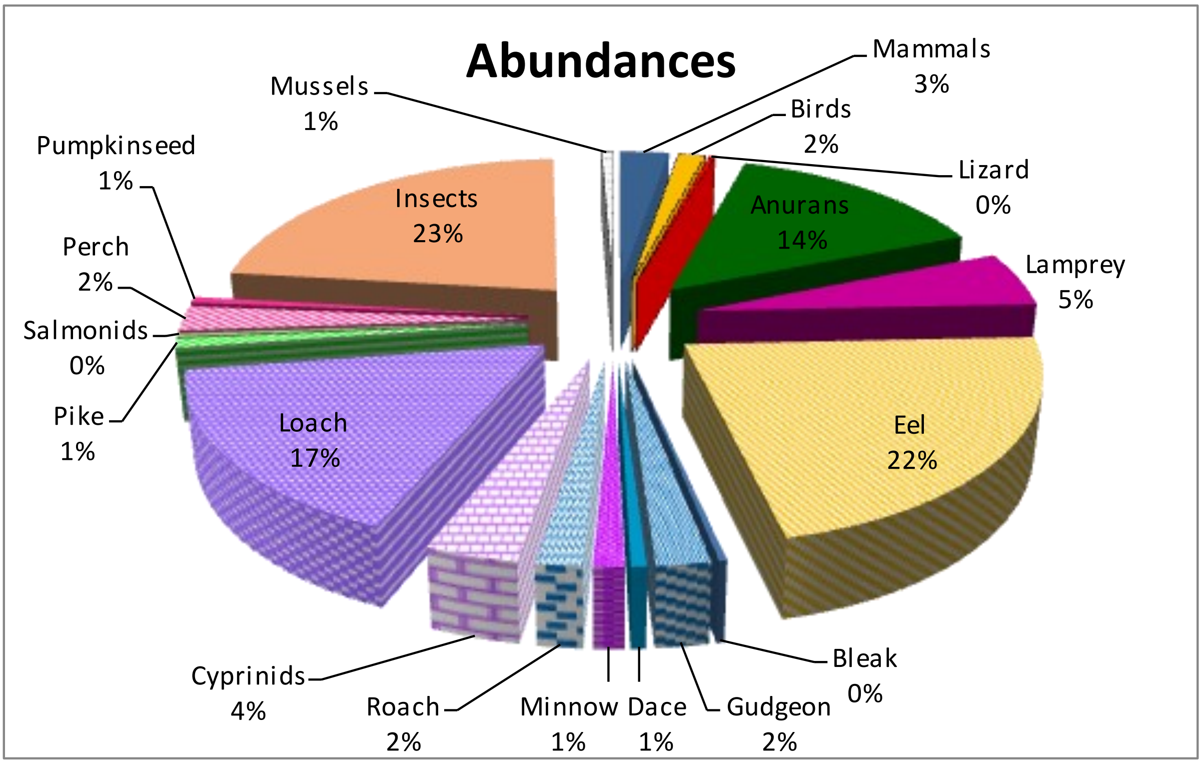


Fig. 12: Relative abundances of otter prey in the Eyre River (n = 333).

4.5. The size of the fish

Analysis of the size classes of the fish consumed shows that Eyre otters catch small species (loach, gudgeon, minnow) and young of large species (pike, salmonids, perch). For eels, some are almost elvers (less than 12.5 in length) and for others they are eels less than 40 cm in size: a finding already noted by different authors in similar conditions to see environments close to estuaries (Fairley, 1972; Webb, 1975; Jenkins *et al.,* 1979; Adrian & Delibes, 1987; Libois & Rosoux, 1989).

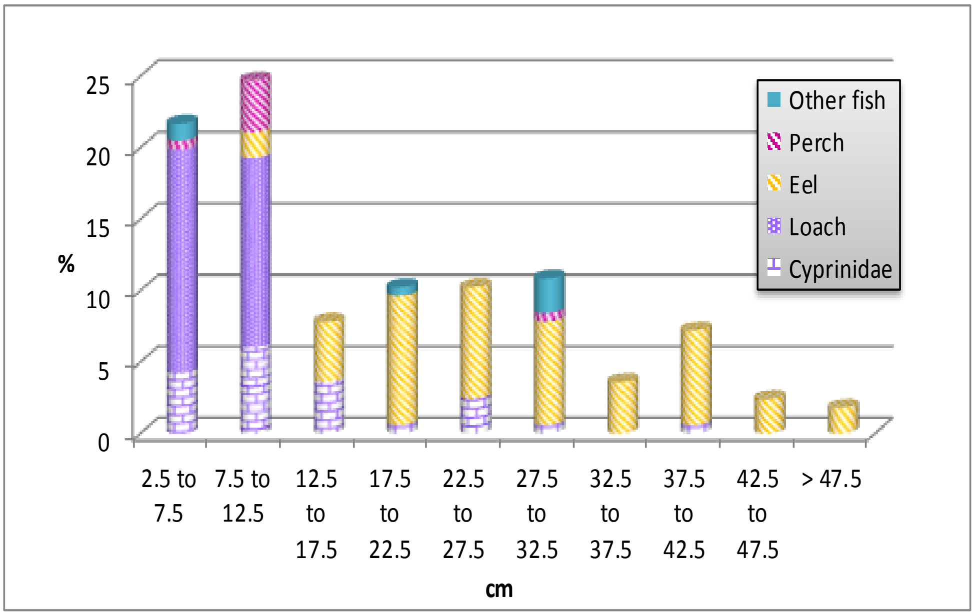


Fig. 13: Frequency distribution of the prey-fish size by otter (Eyre River, n = 166)

4.6. Comparison of trophic niche index : otter, mink and polecat

As usual, the otter eats mainly fish and anuran amphibians.

The two indices of the trophic niche comparison are comparable: low for the otter (tab. 9) and between the polecat and the female mink. Between polecat and male mink, and between male and female mink, diets are closer but far from being completely similar.

Table 9: Comparison of trophic niche index

	Aij	T
E. mink: F (M1E) - M (M3E)	0.265	0.216
E. mink F (M1E) - otter	0.033	0.066
E. mink F (M1E) - polecat	0.044	0.151
E. mink M (M3E) - otter	0.053	0.122
E. mink M (M3E) - polecat	0.246	0.292
Otter - polecat	0.069	0.159

5. Discussion

5.1. Overview of diets

The composition of the diet of polecat and otter is well defined and known in Europe and France. The polecat eats mainly rodents and lagomorphs, anurans, also birds and few fish, occasionally insects and carrion; juveniles eat more fruit and insects than adults (Kratochvil, 1952; Danilov & Rusakov, 1969; Heptner & Naumov, 1974; Brugge,_1977; Herrenschmidt *et al.,* 1983; Libois, 1984; Blandford, 1986; Weber, 1987; Cheylan & Bayle, 1988; Roger *et al.,* 1988; Lodé, 1990, 1991 and 1994; Baghli *et al*., 2002; Hammershoj *et al*., 2004; Lanszki & Heltai, 2007). Otters are mainly fish (summarized in Rosoux *et al*., 2019) with, at times, surprises when rivers dry up, as in the case of Donana National Park: otters survive thanks to crayfish (*Procambarus clarkii*) (Adrian & Delibès, 1987).

These results are quite similar to those found in the literature for the eastern populations of the mink. Fish relative occurrence (19 %) correspond to the results of some Russian studies, where they are present in at least 10 % of the samples, sometimes reaching a proportion of more than two thirds of the examined scats or stomachs (Ognev, 1931; Grigor'ev & Teplov, 1939 ; Heptner & Naumov, 1974 ; Tumanov et Smelov, 1980 ; Sidorovich, 1992). However, the important proportion of birds (26 %) is remarkable when compared to these studies. The birds are indeed not mentioned by Heptner & Naumov (1974) and their occurrence is less than 5 % in the samples of Ognev (1931), Grigor'ev & Teplov (1939) and Sidorovich (1992) and less than 10 % in those of Tumanov & Smelov (1980). The relative occurrences of the amphibians (30 %) and of the mammals (23 %) fall in the range of the available data: from 11 to 57 % and from 15 to 61 %, respectively, depending of the authors.

5.2. Fish size : otter and mink

Generally speaking, 64 to 84% of the fish consumed by otters are quite small, around 12.5 cm (total length), as in Brittany (Libois *et al*., 1987), Poitevin marsh (excluding eel) (Libois *et al*., 1991), Tarn River (Libois, 1995), Chavanon basin (Creuse and Corrèze) (Libois, 1997), Arnon basin (Cher) (Libois *et al*., 2016), Ambène (Puy-de-Dôme), Brenne (Rosoux *et al*., 2019) and also in Morocco (Libois *et al*., 2015a) and eastern Algeria (Libois *et al*., 2015b). In oligotrophic environments where the ichthyological fauna is quite poor, otters feed on larger trout (*Salmo trutta*) such as in the Atlantic Pyrenees or Margeride (Rosoux *et al.,* 2019). Spraints and stomach analyses of otters killed by collision

give identical results in terms of size (Rosoux *et al*., 2019). This confirms that this soft technique is effective in analyzing spraints. For mink, prey fish are larger: between 12.5 and 17.5, which has been noted in northern Spain (Palazon *et al*., 2004).
With regard to the size of eels, a difference was noted between otter (Eyre River) and mink (mainly Ciron River). However, Legault (1987) showed that there is a close relationship between eel mass and distance to the sea. The Eyre River in Belin-Béliet is quite close to the estuary (about 35 km), so the eels are smaller, sometimes glass eels. The eels of Ciron (from the surroundings of Villandraut) are larger where the distance is greater (90 km from the bec d'Ambès, 160 km in Royan).

5.3. Methods

However, the biological significance of these results should be carefully examined. Could they be extrapolated or generalised ? In fact, the method suffer from some important drawbacks.
Biologically sound samples ought to be independent from each other. In this case, the independence of the collects is probably verified but within a sample, the content of each scat is undoubtedly dependent of the content of the other scats constituting a collect. Indeed, they are fresh scats collected at a roost, which was used during a short period of time. Therefore, the probability to find the remains of a prey in a scat is influenced by the fact that this prey is also present in another scat collected the same day at the same roost. It could indeed happen that more than one scat corresponds to a same meal. Moreover, it could also happen that a big prey (duck, coypu, rabbit…) is exploited during more than one day.
Other factors could also affect the quality of the interpretations :
- some samples are too small,
- as the samples were not collected during the same season or in similar habitats, their comparison could be somewhat rickety,
- individual preferences are not excluded: each batch of faeces belongs to only one individual and we have seen that the diets were very different per individual (tables 3 and 5). Sidorovich *et al.* (2001) found that in the same river basin (Lovat River - Belarus), the nine European minks studied, three were "specialists" in frogs, one in crayfish and the others in generalists. The ten American minks, three were specialists in small mammals and the others were generalist predators.

Considering this point, it is very interesting to examine the diet of the individual M4C with more details, taking into account the moment of the collects.

Table 10 : Changes in the food composition of the mink 4C through time.

	20/12-8/1	12/1-7/2	8/2-24/2	25/2-11/3
Mammals	1	-	-	-
Birds	3	-	11	-
Reptiles	-	-	-	3
Amphibians	11	7	16	78
Fish	-	103	13	5

The heterogeneity of this diet is surprising: during a first period, the food consists mainly of frogs. Then, fish are nearly the only prey. In a third period, the diet is more varied, with equivalent proportions of fish, frogs and birds. Finally, frogs account again for the larger part (Gtest $_{ddl\ 6}$ = 148.9; p << 0.001 ; mammals and reptiles are not considered). These changes could be related to the phenology of the reproduction of the prey but this remains difficult to be proved.

5.4. Trophic competition

Between European and American mink, at the same site, Maran *et al*. (1998) found a difference in diet for the species: the European eats fish and crustaceans and the American eats mammals and frogs. After the disappearance of the European mink, the American switched his food to fish. The authors do not resolve the dilemma: the American mink aggressively ousted the European mink of the two species have a different niche, and the American mink could replace the European mink after the latter had disappeared for unrelated reasons. In Belarus, four mustelids were studied trophically in the same locations: otter, polecat, native mink and introduced mink (Sidorovich, 2000b). As in France, otters mainly consume fish, medium amphibians and few crayfish. The polecat prefers mammals and amphibians in spring and autumn (Oct-Nov). The trophic niches of the two mink species were wider than those of the otter and the polecat: were characterized by opportunistic feeding habits. It seems that the American mink may be a strong competitor for prey, especially the European mink but less than the polecat (Sidorovich, 2000b).
Yes, minks catch fish in otter sites (Sidorovich, 2000b; Palazon *et al*., 2008) but on the Eyre River, the two minks studied (M1E and M3E) did not catch fish... scorn or active competition?

6. Conclusions

Intraspecific variations in diet are quite common for most species except for hyperspecialists, e. g. certain parasites (the *Myoxopsylla laverani* flea on *Eliomys sp*. (Libois, 2016), tick eating birds (piqueboeufs, *Buphagus*) (Craig, 2009), large parrots (hyacinth, glaucous, blue-throated macaw) whose food (seeds) is reduced to a few palm species (Collar, 1997). Very often for the same species, differences in diet are justified by factors:

1. microallopatry *vs* micro-sympatry for two twin species: e. g. brown long-eared bat (*Plecotus auritus*) and grey long-eared bat (*Plecotus austriacus*) (Motte, 2011);

2. environmental, for example for otters (*L. lutra*) in fresh water or in brackish or marine environments (Kruuk & Moorhouse, 1990; Libois, 1995; Libois *et al*., 2015b). At the end of the dry season, most ungulates have to change their diet and, sometimes they are very thin (Kassa *et al*., 2008);

3. change in plant quality for ungulates (Rohmer & Ward, 1999): e. g. acacias emit ethylene when grazed by giraffes (*Giraffa camelopardalis*). The other acacias concerned react by increasing the toxin content of their leaves (tannins, prussic acid), the giraffes are "forced" to graze further! (Zinn *et al*., 2007; Wohlleben, 2017);

4. sex: several falconiforms have a different size between sexes: e. g. Harpy eagle, *Harpy harpyja* (male : 4 - 5 kg; female : 7.6 - 9 kg); Eurasian sparrowhawk, *Accipiter nisus* (male : 110 - 196 gr; female : 185-342 gr); Lanner falcon, *Falco biarmicus* (male : 500-600 gr; female : 700-900 gr). Females therefore have a much wider range of prey (Thiollay, 1994; White *et al*., 1994). There are also trophic differences between stag and hind (*Cervus elaphus*) (Clutton-Brock *et al*., 1982).

However, examples of individual dietary variation that cannot be explained by environmental or phenotypic:

1. social ties: these are very close family groups that can be seen, for example, in killer whales (*Orcinus orca*) and wolves (*Canis lupus*). Juveniles learn, through their parents, hunting techniques for this or that type of prey. For large prey, perfect group coordination is essential (Baird *et al*. 2000; Radinger, 2018);

2. cultural transmission: Japanese monkey (*Macaca fuscata*). A young man took sweet potatoes to wash them in a creek on Kojima Island and the group acquired this behaviour by imitation (Miyadi, 1964); Cocos finch (*Pinaroloxias inornata*) (Werner & Sherry, 1987); matrilineal transmission for food preferences or fishing technique for sea otter (*Enhydra lutris*) (Estes *et al*., 2003);

3. individually animals may also have food preferences. To be convinced, all you have to do is look at them and see what humans eat! Of course, there are cultural differences in the cuisine, but taste and flavours are individual characters.

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ANNEX, Table I a: GLOBAL VIEW AND INDIVIDUAL VARIATIONS IN THE EUROPEAN MINK DIET

	CIRON Male 1			CIRON Female 2			CIRON Female 3			CIRON Female 4			CIRON Male 5		
Nb. Scats	32			191			83			238			158		
Nb. Occurrences	50	**44**	%	222	**212**	%	77	**72**	%	269	**252**	%	160	**152**	%
FISH		**2**	**4.55**		**35**	**16.51**		**10**	**13,89**		**121**	**48.02**		**19**	**12.5**
Unidentified fish				3		1.35	6		7,79	3		1.12	8		5.0
Salmonidae							2		2,60						
Unidentified cyprinids				3		1.35	1		1,30	98		36.43	3		1.88
Phoxinus phoxinus				1		0.45									
Leuciscus burdigalensis										2		0.74			
Rutilus rutilus										17		6.32			
Tinca tinca				3		1.35									
Gobio gobio				3		1.35									
Barbatula barbatula				1		0.45				1		0.37			
Gasterosteus gymnurus										1		0.37			
Cottus perifretum				3		1.35									
Esox lucius				8		3.60	2		2,60				2		1.25
Percidae/Centrarchidae	1		2.00	1		0.45				2		0.74			
Lepomis gibbosus				1		0.45				7		2.60			
Anguilla anguilla	1		2.00	13		5.86	1		1,30				8		5.0
ANURAN AMPHIBIANS		**22**	**50,0**		**85**	**40,09**		**51**	**70,83**		**112**	**44.44**		**5**	**3.29**
Unidentified anurans	2		4.00	21		9.46	5		6,49	12		4.46	3		1.88
Rana sp.	13		26.0	42		18.92	30		38,96	95		35.32			
Bufo sp.	10		20.0	25		11.26	19		24,68	11		4.09	2		1.25
REPTILES (Snakes)										4	**4**	**1.59**	1	**1**	**0.66**
BIRDS		**4**	**9.09**		**47**	**22.17**		**4**	**5,56**		**14**	**5.56**		**75**	**49.34**
Unidentif. Birds				13		5.86	1		1,30	3		1.12	16		10.0
Eggs	2		4.00	12		5.41							5		3.13
Anatidae	2		4.00	10		4.50				9		3.35	22		13.75
Rallidae	1		2.00	3		1.35	3		3,90	2		0.74	34		21.25
Scolopacidae				8		3.60									
Passeriforme										1		0.37	4		2.5
Panurus biarmicus				1		0.45									
Sturnus vulgaris	1		2.00												
MAMMALS		**16**	**36.4**		**45**	**21.23**		**7**	**9,72**		**1**	**0.40**		**51**	**33.55**
Sorex coronatus	1		2.00	1		0.45	1		1,30						
Sorex minutus	1		2.00												
Crocidura russula				2		0.90									
Lagomorphs													1		0.63
Ondatra zibethicus				8		3.60							3		1.88
Clethrionomys glareolus	2		4.00	6		2.70	1		1,30	1		0.37			
Arvicola sapidus				5		2.25	1		1,30				34		21.25
Microtus agrestis				4		1.80	2		2,60						
Microtus sp.				2		0.90	1		1,30				3		1.88
Apodemus sp.	2		4.00	6		2.70	1		1,30				2		1.25
Rattus sp.	11		22.0	1		0.45							9		5.63
Myocastor coypus				12		5.41									
ARTHROPODS														**1**	**0.66**

ANNEX, Table I b: GLOBAL VIEW AND INDIVIDUAL VARIATIONS IN THE EUROPEAN MINK DIET

	CIRON Male 6			CIRON Male 10			EYRE Female 1			EYRE Male 3		
Nb. Scats	16			107			41			143		
Nb. Occurrences	16	**15**	%	111	**109**	%	49	**44**	%	167	**161**	%
FISH		**5**	**33.33**		**14**	**12.84**						
Unidentified fish	3		18.75	2		1.80						
Unidentified cyprinids				2		1.80						
Barbatula barbatula				1		0.90						
Esox lucius	1		6.25									
Percidae/Centrarchidae				2		1.80						
Lepomis gibbosus				1		0.90						
Anguilla anguilla	1		6.25	6		5.41						
ANURAN AMPHIBIANS		**3**	**20.00**		**21**	**19.27**		**3**	**6.82**		**30**	**18.63**
Unidentified anurans	1		6.25	6		5.41	1		2.04	12		7.19
Rana sp.	2		12.5	12		10.81	2		4.08	13		7.78
Bufo sp.	1		6.25	3		2.70				6		3.59
REPTILES (Snakes)				4	**4**	**3.67**						
BIRDS		**1**	**6.67**		**50**	**45.87**		**40**	**90.91**		**38**	**23.60**
Unidentif. Birds				32		28.83	6		12.24	2		1.20
Eggs	1		6.25	9		8.11	2		4.08	20		11.98
Podicipedidae							1		2.04			
Ardeidae										1		0.60
Anatidae				8		7.21	31		63.27	17		10.18
Rallidae				1		0.90	3		6.12			
Passeriforme				1		0.90				1		0.60
Erithacus rubecula							1		2.04			
Parus caeruleus							1		2.04			
MAMMALS		**6**	**40.0**		**17**	**15.60**		**1**	**2.27**		**93**	**57.76**
Sorex coronatus										5		2.99
Neomys fodiens										1		0.60
Clethrionomys glareolus				3		2.70				2		1.20
Arvicola sapidus	2		12.5	3		2.70				25		14.97
Microtus agrestis							1		2.04			
Microtus sp.				2		1.80						
Apodemus sp.				2		1.80						
Micromys minutus										2		1.20
Rattus sp.	4		25.0	8		7.21				60		35.93
ARTHROPODS					**1**	**0.92**						
Hydrophilidae												
Crayfish				1		0.90						
FRUITS				2	**2**	**1.80**						

ANNEX, Table I c: GLOBAL VIEW AND INDIVIDUAL VARIATIONS IN THE EUROPEAN MINK DIET

	ORX Male 3			ORX Female 5			ORX Female 11		
Nb. Scats	15			15			5		
Nb. Occurrences	22	**18**	%	17	**17**	%	6	**6**	%
FISH		**2**	**11.11**					**2**	**33.33**
Percidae/Centrarchidae	1		4.55						
Anguilla anguilla	1		4.55				2		33.33
ANURAN AMPHIBIANS					**2**	**11.76**		**2**	**33.33**
Rana sp.				2		11.76	2		33.33
BIRDS		**10**	**55.56**		**1**	**5.88**			
Unidentif. Birds	1		4.55	1		5.88			
Eggs	4		18.18						
Anatidae	6		27.27						
Rallidae	3		13.64						
MAMMALS		**5**	**27.78**		**14**	**82.35**		**2**	**33.33**
Arvicola sapidus	5		22.73	6		35.29			
Microtus sp.				4		23.53			
Mus domesticus							2		33.33
Rattus sp.				4		23.53			
ARTHROPODS		**1**	**5.56**						
Hydrophilidae	1		4.55						

	TOTAL		
Nb. Scats	1029		
Nb. Occurrences	1167	**1102**	%
FISH		**210**	**19.06**
Unidentified fish	25		2.14
Salmonidae	2		0.17
Unidentified cyprinids	107		9.17
Phoxinus phoxinus	1		0.09
Leuciscus burdigalensis	2		0.17
Rutilus rutilus	17		1.46
Tinca tinca	3		0.26
Gobio gobio	3		0.26
Barbatula barbatula	3		0.26
Gasterosteus gymnurus	1		0.09
Cottus perifretum	3		0.26
Esox lucius	13		1.11
Percidae/Centrarchidae	7		0.60
Lepomis gibbosus	9		0.77
Anguilla anguilla	33		2.83
ANURAN AMPHIBIANS		**336**	**30.49**
Unidentified anurans	63		5.40
Rana sp.	213		18.25
Bufo sp.	77		6.60
REPTILES (Snakes)	9	**9**	**0.82**
ARTHROPODS	1	3	**0.27**
Hydrophilidae	1		0.09
Crayfish	1		0.09
FRUITS	2	**2**	**0.18**
BIRDS		**284**	**25.77**
Unidentif. Birds	75		6.43
Eggs	55		4.71
Podicipedidae	1		0.09
Ardeidae	1		0.09
Anatidae	105		9.00
Rallidae	50		4.28
Scolopacidae	8		0.69
Passeriforme	7		0.60
Erithacus rubecula	1		0.09
Panurus biarmicus	1		0.09
Parus caeruleus	1		0.09
Sturnus vulgaris	1		0.09
MAMMALS		**258**	**23.41**
Sorex coronatus	8		0.69
Sorex minutus	1		0.09
Neomys fodiens	1		0.09
Crocidura russula	2		0.17
Lagomorphs	1		0.09
Ondatra zibethicus	11		0.94
Clethrionomys glareo-lus	15		1.29
Arvicola sapidus	81		6.94
Microtus agrestis	7		0.60
Microtus sp.	12		1.03
Apodemus sp.	13		1.11
Mus domesticus	2		0.17
Micromys minutus	2		0.17
Rattus sp.	97		8.31
Myocastor coypus	12		1.03

ANNEX, Table II a: GLOBAL VIEW AND INDIVIDUAL VARIATIONS IN THE POLECAT DIET

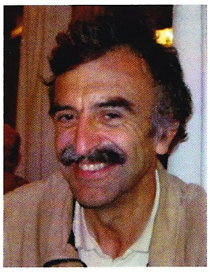
	CIRON Male 1			CIRON Female 3			CIRON Male 4			CIRON Female 5			CIRON Male 11			CIRON Male12		
Nb. Scats		41			48			151			55			31			81	
Nb. Occurrences	39	**37**	%	46	**46**	%	155	**152**	%	72	**71**	%	31	**32**	%	93	**93**	%
FISH																		
Salmonidae																		
ANURAN AMPHIBIANS		**18**	**48.65**		**44**	**95.65**		**142**	**93.42**		**52**	**73.24**		**29**	**90.63**		**6**	**6.45**
Unidentified anurans	3		7.69	10		21.74	34		21.94	9		12.50	4		12.90	3		3.23
Rana sp.				1		2.17	4		2.58	1		1.39						
Bufo sp.	15		38.46	33		71.74	107		69.03	43		59.72	25		80.65	3		3.23
REPTILES		**3**	**8.11**					**6**	**3.95**		**6**	**8.45**		**1**	**3.13**		**1**	**1.08**
Ophidians	3		7.69				6		3.87	1		1.39	1		3.23	1		1.08
Lacertidae										5		6.94						
BIRDS								**2**	**1.32**								**4**	**4.30**
Unidentif. Birds							2		1.29							4		4.30
Eggs																		
Anatidae																		
Sturnus vulgaris																		
MAMMALS		**16**	**43.24**		**2**	**4.35**		**2**	**1.32**		**13**	**18.31**		**1**	**3.13**		**66**	**70.97**
Sorex coronatus																		
Rongeur indét.																		
Talpa europaea																		
Crocidura russula																		
Lagomorphs							2		1.29							59		63.44
Ondatra zibethicus																3		3.23
Clethrionomys glareolus	6		15.38							2		2.78				1		1.08
Arvicola sapidus				1		2.17												
Microtus sp.	5		12.82							2		2.78	1		3,23	9		9.68
Apodemus sp.	4		10.26							9		12.50				1		1.08
Mus domesticus	1		2.56															
Micromys minutus																		
Rattus sp.	2		5.13	1		2.17										3		3.23
Myocastor coypus																4		4.30
INSECTS														**1**	**3.13**		**14**	**15.05**
GASTEROPODES																2	**2**	**2.11**

ANNEX, Table II b: GLOBAL VIEW AND INDIVIDUAL VARIATIONS IN

THE POLECAT DIET

	EYRE Male 4			EYRE Male 6			EYRE Male 11			ORX Male 1			DIVERS C: 2,10; E:10,14			**TOTAL**		
Nb. Scats		39			39			82			58			20			645	
Nb. Occurrences	60	**53**	%	39	**38**	%	90	**84**	%	69	**63**	%	17	**16**	%	728	685	%
FISH					**6**	**15.79**											**6**	**0.88**
Salmonidae				6		15.38										6		0.82
ANURAN AMPHIBIANS		**24**	**45.28**		**7**	**18.42**		**79**	**94.05**		**2**	**3.17**		**14**	**87.5**		**417**	**60.88**
Unidentified anurans	5		8.33	1		2.56	8		8.89	1		1.45	4		23.53	82		11.26
Rana sp.	13		21.67	1		2.56	8		8.89				4		23.53	32		4.40
Bufo sp.	10		16.67	5		12.82	68		75.56	1		1.45	7		41.18	317		43.54
REPTILES		**1**	**1.89**														**18**	**2.63**
Ophidians	1		1.67													13		1.79
Lacertidae																5		0.69
BIRDS		**7**	**13.21**		**1**	**2.63**		**3**	**3.57**		**19**	**30.16**		**1**	**6.25**		**37**	**5.40**
Unidentif. Birds	7		11.67				2		2.22	14		20.29	1		5.88	30		4.12
Eggs	4		6.67				1		1.11							5		0.69
Anatidae										5		7.25				5		0.69
Sturnus vulgaris				1		2.56										1		0.14
MAMMALS		**19**	**35.85**		**24**	**63.16**		**2**	**2,38**		**42**	**66.67**		**1**	**6.25**		**188**	**27,45**
Sorex coronatus	2		3.33												**6.25**	2		0.27
Rongeur indét.	1		1.67													1		0.14
Talpa europaea	1		1.67													1		0.14
Crocidura russula							1		1.11	2		2.90				3		0.41
Lagomorphs				16		41.03				16		23.19				93		12.77
Ondatra zibethicus				1		2.56	2		2.22							6		0.82
Clethrionomys glareolus	9		15.00													18		2.47
Arvicola sapidus	3		5.00	1		2.56				9		13.04				14		1.92
Microtus sp.	3		5.00										1		5.88	21		2.88
Apodemus sp.	1		1.67							1		1.45				16		2.20
Mus domesticus																1		0.14
Micromys minutus										1		1.45				1		0.14
Rattus sp.				7		17.95				12		17.39				25		3.43
Myocastor coypus										7		10.14				11		1.51
INSECTS		**2**	**3.77**													17	**17**	**2.48**
GASTEROPODES																2	**2**	**0.27**

The European mink is the most threatened carnivore in the world and particularly in France. He lives only in the southwestern departments. Data on mink prey were scarce, particularly due to confusion between the faeces of the polecat and those of the mink. A few individuals of both species have been equipped with a transmitter collar in three sites: two rivers, one in the Garonne basin (the Ciron, near Langon), another leading into the Arcachon basin (the Eyre) and a large pond, north of Bayonne (Orx). The faeces were therefore collected per individual. The objective was to have results on the feeding of mink and, above all, the possible competition of the both mustelids. The overlap index of the trophic niche is one third (0.34) considering that prey are quite abundant in the three sites, the competition is relatively low. For the otter, spraints were collected only along the Eyre River. The recovery index is minimal for otters (from 0.03 to 0.07), which mainly consume fish and aquatic insects, few amphibians.However, the data must be criticized: minks and polecats have a different diet per individual. It cannot be excluded that these are individual preferences.



First a naturalist, Roland Libois is foremost a specialist in mammals, to whom he has devoted almost his entire career as a researcher at the Univ. of Liège, where he now heads a research team in zoo-geography. He is the author of a monograph on the stone-marten, a book on threatened mammals in Belgium and on the European kingfisher.

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