

34th European Mustelid Colloquium
14-16 September 2022
Online Conference

Marbled polecat: ©ZooFanatic

34th European Mustelid Colloquium

Book of Abstracts

Vincent Wildlife Trust

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Welcome

We are delighted to welcome you all to the 34th European Mustelid Colloquium — the first to be held online.

Although we're very disappointed that we cannot meet in person for this colloquium as originally planned at the University of Tbilisi, Georgia, we're delighted that so many of you can join us online. The online nature of the conference means that as well as people attending from all across Europe, we're also joined by some delegates from further afield, including the United States and New Zealand. We hope that this online event will provide more opportunities to join in and to meet with colleagues and friends, share current research findings and ideas, and discuss opportunities for future collaborations.

Over the three days of the colloquium, we're looking forward to 32 oral presentations and nine posters, along with a number of networking sessions. We're pleased to welcome our three keynote speakers who, between them, will be covering a variety of topics on mustelid ecology, evolution and conservation, from different geographical and research perspectives.

We are also grateful to the scientific committee, who contributed to planning the colloquium and reviewed the submitted abstracts. The Book of Abstracts was designed by Julia Bracewell (Vincent Wildlife Trust).

We look forward to meeting you all over the coming days and hope you have an enjoyable, productive and inspiring time at the colloquium.

Steve Carter and Lizzie Croose, Vincent Wildlife Trust, UK

Committees

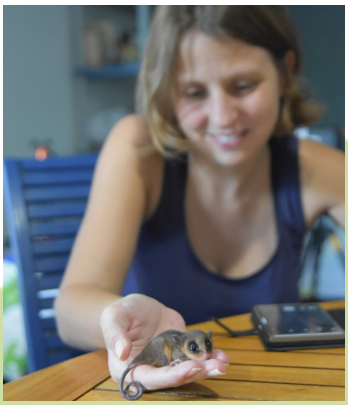
Organising committee

- **Steve Carter** Vincent Wildlife Trust
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- **Julia Bracewell** Vincent Wildlife Trust

Scientific committee

- **Prof Margarida Santos-Reis** University of Lisbon, Portugal
- **Dr Steve Carter** Vincent Wildlife Trust, UK
- **Lizzie Croose** Vincent Wildlife Trust, UK
- **Professor Robbie McDonald** University of Exeter, UK
- **Dr Sandrine Ruette** ONCFS, France
- **Dr Izabela Wierzbowska** Jagiellonian University, Poland
- **Dr Tim Hofmeester** Swedish University of Agricultural Sciences, Sweden
- **Dr Morten Elmeros** Aarhus University, Denmark

Keynote speaker biographies



Dr Anne-Claire Fabre, Naturhistorisches Museum Bern, Switzerland

Dr Anne-Claire Fabre is a mammal curator working at the Naturhistorisches Museum Bern in Bern, Switzerland. She is an evolutionary biologist focusing on the origin and evolution of morphological and functional diversity of organisms. A major goal of her research is to disentangle the impact of the different internal (eg, development) and external (eg, environment, climate) factors shaping the past and current phenotypic diversity of organisms and how it relates to function. To understand the multiple factors shaping the current diversity of form and function in organisms, she uses cross-disciplinary approaches, combining specimen-based work with *in vivo* studies (in zoos and in the field) and quantitative analyses of the musculoskeletal system (bone and muscles) in the context of function (feeding and locomotion), behavior, and life history traits in a comparative phylogenetic framework. She addresses questions such as what factors shape the diversity in form and function? How does development foster morphofunctional diversification? How does variation in form translate into variation in function and behaviour? How can *in vivo* data on extant species shed light on the paleoecology of extinct species? She integrates tools including geometric morphometrics and multivariate and phylogenetic comparative methods to quantitatively link morphology, behavior, and performance in a phylogenetic context in several group of vertebrates (including mustelids).



Dr David Jachowski, Clemson University, South Carolina, USA

Dr David Jachowski is an Associate Professor of Wildlife Ecology in the Department of Forestry and Environmental Conservation at Clemson University. Dr Jachowski has been studying the ecology and conservation of small carnivores in North America for over 20 years, with much of his past research and conservation efforts focused on the critically endangered black-footed ferret. Over the past decade, his lab group has also led studies on the declining eastern spotted skunk, and he is the founder and immediate past chair of the Eastern Spotted Skunk Cooperative Study Group. Most recently, Dr Jachowski and colleagues completed a review of weasels of North America, finding evidence of a precipitous decline in weasels, which has led to the creation of a North American Weasel Study Group that is attempting to identify causes of the decline and develop a continental monitoring strategy for the three weasel species in North America.

Keynote speaker biographies



Dr Malin Aronsson, Swedish University of Agricultural Sciences Uppsala, Sweden

Dr Malin Aronsson is a researcher at Department of Ecology, Swedish University of Agricultural Sciences. Her research focuses on understanding what is influencing abundance and distribution of animals in northern boreal and alpine ecosystems, and its application for wildlife conservation and management. The core of her work is within the Swedish wolverine project, where she conducts individual-based studies of wolverine ecology; including demography, space use, habitat selection, feeding ecology and interactions with other species. Much of these studies have been done in northern alpine areas where depredation on semi-domestic reindeer owned by indigenous Sámi reindeer herders is an important focus for wolverine management. Following the southward expansion by wolverines in Scandinavia, Dr Aronsson and colleagues are now also studying wolverines at the southern periphery of their distribution to understand how they affect, and are affected by, other species as well as human activity. A special focus is to investigate the influence of climate (eg, snow cover and temperature) on wolverine ecology and distribution. By studying wolverines within their entire range, from north to south, the aim is to provide knowledge that will facilitate sound management of the wolverine population, now and in the future.

Colloquium programme

Day 1 — 14 September (Wednesday)		
9:00	Welcome	
SESSION I: Ecology and Evolution		
09:15	Keynote Lecture 1 **Dr. Anne-Claire Fabre** Naturhistorisches Museum Bern, Switzerland	Deciphering the evolution of the incredible morphological and functional diversity in mustelids
10:15	COFFEE BREAK	
10:40	**Salvador Salvador Allué**	Monitoring stoats (*Mustela erminea*) and other small mammals at high altitude under a scenario of climate change
11:05	**Thomas Osinga**	Snow limits polecat (*Mustela putorius*) distribution in Sweden
11:30	**Inês Miranda**	Characterising the selective and phenotypic underpinnings of seasonal camouflage in the least weasel
11:55	LUNCH	
SESSION 2: Lightning Talks		
13:25	**Guillermo Carmona**	First data of red polecats (*Mustela putorius*) from Spain
13:35	**Daniela Teixeira**	Activity patterns of two generalist mesocarnivores in Mediterranean forestry plantations
13:45	**Andrea Marín Sierra**	Relationship between prey-catching behaviour and post-release survival in captive-bred European mink (*Mustela lutreola*)
13:55	**Paddy Sleeman**	Badgers (*Meles meles)* and biodiversity – data on sett ecosystems
14:05	**Lightning Talk Questions**	
14:15	Poster Session and Networking	
15:15	COFFEE BREAK	
SESSION 3: Ecology and Evolution (continued)		
15:40	**Eloy Gálvez López**	Craniomandibular differences between European and American mink: correlations with dietary specialisation
16:05	**Miguel Rosalino**	Badger density and breeding phenology in Mediterranean agro-sylvo-pastoral systems
16:30	**Marcela Alvarenga**	Using museomics to dissect the genetic basis and evolution of winter colour polymorphism in stoats – a good model to study adaptation to climate change
16:55	End	
18:30	Networking	

Colloquium programme

Day 2 — 15 September (Thursday)		
SESSION 4: Research Methods		
9:15	**Jelena Mausbach**	Using detection dogs for mustelid monitoring — insight from field work with *Lutra lutra*, *Mustela erminea*, *Mustela nivalis*
9:40	**Holly Broadhurst**	Optimising environmental DNA (eDNA) approaches for detecting semi-aquatic European mustelids
10:05	**Ruth Hanniffy**	The continued evolution of the camera trap: using the Mostela to monitor the Irish stoat (*Mustela erminea hibernica*) in the west of Ireland
10:30	COFFEE BREAK	
10:55	**Sian Green**	Who's who of pine martens — is individual ID possible when combining camera traps and citizen science?
11:20	**Irene Weinberger**	Where to look — comparing survey approaches for the Eurasian otter
11:45	**Nadine Erath**	Mustelid mugshots: a new camera-tube-lure system as a monitoring tool for European polecats in Sweden
12:10	LUNCH	
SESSION 5: Genetics		
13:40	**Andrew Veale**	The population genomics of stoats in Aotearoa and its use to inform control and eradication efforts
14:05	**Graham Etherington**	Extensive genome introgression between domestic ferret and European polecat during population recovery in Great Britain
14:30	**Alice Mouton**	European mink (*Mustela lutreola*) reference genome and population genomics
14:55	COFFEE BREAK	
SESSION 6: Genetics (continued)		
15:20	**João Pimenta**	Dissecting the genetic determinants of adaptive camouflage in the long-tailed weasel using museum genomics
15:45	**Rebecca Shaw**	Gene family expansions across mustelids
16:10	End	
18:00	**Keynote Lecture 2** **Dr. David Jachowski** Department of Forestry and Environmental Conservation, Clemson University, South Carolina, USA	Addressing the decline of weasels in North America
19:00	**Networking**	

Colloquium programme

Day 3 — 16 September (Friday)		
SESSION 7: Human Dimensions and Conservation Issues		
9:15	**Keynote Lecture 3** **Dr. Malin Aronsson** Department of Ecology, Swedish University of Agricultural Sciences	A predator of the northern wilderness — understanding wolverine ecology for present and future conservation challenges
10:15	**COFFEE BREAK**	
10.40	**Patrick Wright**	A global review of the conservation threats and status of mustelids
11:05	**Sayantani Basak**	A decadal change in public attitudes toward urban stone marten (*Martes foina*): a case study of Krakow, Poland
11.30	**Allison Barg**	Spatial and temporal trends in western polecat road mortality in Wales
11.55	**Sarah Layendecker**	Living in a polluted world — microplastic contamination of the Eurasian otter (*Lutra lutra*)
12:20	**LUNCH**	
13:50	**Poster Session and Networking**	
SESSION 8: Lightning Talks		
14.50	**Lizzie Croose**	Mink on the brink: comparing surveying methods for detecting a Critically Endangered carnivore, the European mink *(Mustela lutreola)*
15.00	**Kyla Johnstone**	Methods to quantify personality traits in mustelids and its application in ecology and conservation
15.10	**Ingrid Marchand**	LIFE VISON, conservation of the European mink in the Charente Basin — a major project
15.20	**Christine Fournier-Chambrillon**	First diet study of the critically endangered European mink (*Mustela lutreola*) in France and Spain using next-generation sequencing technologies
15.30	**Lightning Talk Questions**	
15:40	**Close**	
16:00	**Networking**	

Colloquium Abstracts

Ecology and Evolution



Polecat: ©Helen Haden

Deciphering the evolution of the incredible morphological and functional diversity in mustelids

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Keywords: *evolution; morphological diversity; functional diversity; climate; environment*

Weasels, stoats, polecats, mink, marten, fishers, wolverines, otters, badgers and many others are all members of the hyper-diverse family of mustelids. With over 56 species, mustelids are the largest carnivoran family nowadays. Moreover, mustelids are geographically widespread and can be found on nearly all continents (except Antarctica, Australia and Madagascar) and occupy an extreme range of habitats. As a consequence of their adaptation over geological time to all these different kinds of habitats, they display an exceptional disparity and diversity of form and function with, for example, an incredible size variation (from 45g for the weasel to 45kg for the sea otter).

In this presentation, I will give an overview about the origin and evolution of morphological and functional diversity in mustelids using my research as well as the recent literature on this clade. More precisely, I will talk about their evolution in relation to climate and environmental changes in deep time, the evolution of the morphological diversity in the cranial and forelimb system, as well as present recent work on body elongation.

Monitoring stoats (*Mustela erminea*) and other small mammals at high altitude under a scenario of climate change

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Keywords: *stoat; mountains; climate change; weasel*

At the southernmost limit of its range, the distribution of the stoat (*Mustela erminea*) is often restricted to the highest altitudes in mountain ranges. In the Catalan Pyrenees (NE Spain), stoats are found at altitudes between 1,500 and 3,000m a.s.l. and are thought to be in decline due to changes provoked by global warming that include a fall in the amount of snow cover and its duration. However, little is known about these populations due to the methodological difficulties involved in detecting individuals in rugged terrain with difficult access.

We conducted a pilot study to assess the current distribution of stoats in the Capçaleres del Ter i Freser Natural Park using the *Mostela*, a novel camera trapping device developed by Mos & Hoffmeester (2020) to detect small mustelids. Stoats were caught on camera in four out of 30 sampling points, and weasels (*Mustela nivalis*) in two. Pooling camera captures with sightings from the same year, we report that stoats appeared at higher altitudes than expected. Also, the lowest altitude at which they were recorded coincided with the highest altitude at which weasels appeared, the latter also being found at higher altitudes than expected. Importantly, we also gathered data on the altitudinal distribution of the other small mammals present in these mountains: voles, mice, dormice and shrews.

Given the success of this initial study, four more sampling stations have been deployed in the Catalan Pyrenees. This study reveals the potential of using small mammals as indicators of the progress of climate change in the mountains.

References

• Mos J, Hofmeester TR (2020) The Mostela: an adjusted camera trapping device as a promising non-invasive tool to study and monitor small mustelids. Mammal Research 65:843-853

Snow limits polecat (*Mustela putorius*) distribution in Sweden

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Keywords: *Mustelidae; habitat suitability; Maxent; climate change; snow cover*

Many species show range expansions or contractions due to climate change induced changes in habitat suitability. In cold climates, many species that are limited by snow are showing range expansions due to reduced winter severity. The European polecat (*Mustela putorius*) occurs over large parts of Europe with its northern range limit in southern Fennoscandia. However, it is unknown to date what factors limit polecat distribution. We thus investigated whether climate or land-use variables are more important in determining the habitat suitability for polecats in Sweden.

We hypothesised that 1) climatic factors, especially the yearly number of snow days, drive habitat suitability for polecats, and that, 2) as the number of snow days is predicted to decline in the near future, habitat suitability in northern Sweden will increase. We used a combination of sightings data and a selection of national maps of environmental factors to test these hypotheses using Maxent models. We also used maps of future climate predictions (2021-2050 and 2063-2098) to predict future habitat suitability. The number of snow days was the most important factor, negatively determining habitat suitability for polecats, as expected. Consequently, the predictions showed an increase in suitable habitat both in the current distribution range and in northern Sweden, especially along the coast of the Baltic Sea.

Our results suggest that the polecat distribution is limited by snow and that reduced snow cover will likely result in a northwards range expansion. However, the exact mechanisms for how snow limits polecats are still poorly understood. Consequently, we expect the Scandinavian polecat population to increase in numbers, in contrast to many populations elsewhere in Europe, where numbers are declining. Due to polecat predation, the expansion of the species might have cascading effects on other wildlife populations.

Characterising the selective and phenotypic underpinnings of seasonal camouflage in the least weasel

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Keywords: *Mustela nivalis; targeted enrichment; natural selection; digital photography*

Natural selection is a main driver of adaptation to local environmental conditions. Understanding how it shapes genetic and phenotypic diversity is a key factor for predicting species' adaptive response in the face of climate change. Seasonal coat colour change, from summer-brown to winter-white, is a remarkable phenological adaptation of several boreal species, to maintain camouflage year-round in environments with seasonal snow. Genetically determined polymorphism of winter colour occurs in many of these species, with winter-brown phenotypes allowing local adaptation to milder snow conditions, including in the least weasel (*Mustela nivalis*). Previous work on this species has shown that winter colour polymorphism is associated with genetic variation at the pigmentation gene MC1R [1].

Here, we designed a custom capture assay targeting MC1R and anonymous genome-wide regions to characterise patterns of diversity and natural selection at this locus, in the context of the genomic background. This assay was applied to over 250 least weasel specimens from existing collections, representative of the distribution areas of alternative winter colour phenotypes in Europe and of three transition zones where both winter morphs co-exist, in Sweden, Poland and the Alps. Using a two-tier approach, we 1) use neutral genetic variation to characterise the overall population structure and demographic history, and 2) investigate the patterns of genetic and haplotypic diversity and infer selection signatures in the region of MC1R. In addition, we leverage digital photography analysis applied to least weasel museum skins to characterise phenotypic colour differences associated with alternative winter phenotypes. Our work details the genetic and phenotypic differences associated with a key adaptive polymorphism that might be fundamental to allow rapid adaptation to changing environments.

Reference

• 1 Miranda, I., *et al.*, Museomics Dissects the Genetic Basis for Adaptive Seasonal Coloration in the Least Weasel. Mol. Biol. Evol., 2021. 38(10): p. 4388–4402.

First data of red polecats (*Mustela putorius*) from Spain

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Keywords: *Mustela putorius; red polecat; red color morph; erythrism*

In their normal colour morph, polecats have black guard hair and light-yellow wool hair, except on the face, which is white with a black mask. This gives them a characteristic body appearance, generally very dark or contrasted with yellow where the guard is sparser like in the loin and belly. However, some polecats suffer erythrism, a pigmentation anomaly caused by a recessive gene. These individuals have both the guard hair and the wool hair orange or reddish in colour and are known as 'red polecats'. There are very few records of polecats with this characteristic, and they have mainly been described in Wales (United Kingdom), a well-studied population with elevated inbreeding rate.

We present for the first time data on erythrism in polecats from Spain. Since 2016, we have been collecting citizen science data on roadkilled polecats, which has allowed us to record some specimens with this rare morph, only confirmed after photo-identification of citizen records. So far, six erythristic polecats out of 186 have been recorded, all of them from Valladolid province (central Spain), an area where this species is very abundant. As this polymorphism is associated with a recessive gene, it is striking that we have found it in one of the most abundant polecat populations. Therefore, we think that the continuous population bottlenecks associated with the fluctuations of its main prey (rabbits) and high rate of roadkills may have generated transient high levels of inbreeding.

Activity patterns of two generalist mesocarnivores in Mediterranean forestry plantations

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Keywords: *eucalyptus plantations; Portugal; red fox; stone marten; camera trap*

The Mediterranean landscapes have been altered for human demands for millenniums, especially through the replacement of native forests with plantations. However, even in natural Mediterranean ecosystems, human presence might be constant. To reduce the probability of encounters with humans and their domestic animals, many species tend to change their behavior to become more nocturnal; a period when humans are less active. Red foxes and stone martens are habitat-generalist and tolerant to variations in environmental conditions, but only a few studies are available in Iberia regarding these species' activity patterns in production forests, especially in Eucalyptus plantations, the main forest type in Portugal.

Thus, this work aimed to investigate: 1) the temporal and spatio-temporal activity patterns of red fox and stone marten; 2) how they managed to adapt their activity to distinct human disturbances (ie, human, dogs, and cattle presence); and 3) how activity patterns of foxes diverge between habitats, hunting periods and seasons. Both mesocarnivores have clearly distinct activity patterns, with foxes presenting a higher crepuscular activity, while martens are exclusively nocturnal, indicating that they seem to avoid each other. Both showed a higher overlap with dog activity than with humans or cattle. The activity patterns of foxes vary between seasons and habitats, but not so much between hunting and no-hunting periods.

There is a tendency for foxes to avoid humans. Our study indicates that these two generalist and resilient species tend to avoid humans and their related activities. Therefore, we can infer that specialist or more sensitive mesocarnivores may also present similar patterns. As species can alter to some extent their activity patterns to minimise any disturbance factors (including humans and their activities), evaluating the impacts of anthropic drivers on other mesocarnivores activity patterns should be prioritised to generate information that can support the sustainable management of plantation and hunting.

Relationship between prey-catching behaviour and post-release survival in captive-bred European mink (*Mustela lutreola*)

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Keywords: *behaviour; European mink; reintroduction; survival; conservation breeding*

The purpose of the European mink (*Mustela lutreola*) conservation breeding program is to (re)establish or strengthen remaining wild populations. At the same time, the survival rates of captive-born carnivores released are often low. Starvation is one potential cause of this low survival rate, which might be due to captivity-induced loss of natural hunting behaviours or abilities to locate suitable prey items. Therefore, studying whether pre-release hunting behaviour in captive-born mink affects post-release survival, and whether captive conditions have an effect on either behaviour or survival of released individuals is crucial.

We studied this in 34 European mink born and released in 2018, 2020, and 2021, housed in seven facilities in Spain. Mink in 2020 and 2021 also experienced differential rearing in captivity aimed to promote natural behaviours (eg, increased environmental complexity, social groupings promoting play behaviour). Frequency and duration of hunting-related behaviours (eg, time to catch prey) were studied using camera traps, to assess the effect of sex, enclosure size, and environmental and social factors. All mink were fitted with radio-collars prior to release in the Alava and La Rioja provinces, northern Spain, during natural dispersal periods for the species. Data on post-release survival and distance travelled were obtained from radio-tracking (up to three months post-release), and correlated with hunting behaviours in pre-release enclosures.

Preliminary data show that the frequency of prey-related behaviour is explained primarily by facility of origin, followed by sex, suggesting captive conditions influence hunting behaviour. Analysis of the 2018 data found that the captive behaviours investigated failed to predict post-release survival or dispersal distance; on-going analyses will determine whether this relationship stands, and whether environmental manipulations had any effect on translocation success. However, due to the low sample size and the multiple factors which can affect its survival, it is necessary to continue research in this area.

Badgers (*Meles meles*) and biodiversity — data on sett ecosystems

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Keywords: *ecosystem engineers; berries; elder; other mammals*

Badgers are known ecological engineers. They dig setts by excavating soil and influence local ecology by predation, which often involves digging, as well as dispersing fruits. Passage of bramble (*Rubus sp.*) seeds through the badgers physically changes the seed coat and increases germination of the seeds.

This research has reported that the dispersal of bramble and elder (*Sambucus nigra*) is influenced by badgers. There are suggestions that badgers can 'improve' areas around setts by 'planting' seeds of these and other plants in the nutrient-rich soils. Plants common at setts, such as bramble, elder, nettle (*Urtica dioica*) and thistle (*Carduus sp.*) might be used to locate setts.

The stinkhorn fungus (*Phallus impudicus*) has been found in a non-random distribution around setts in Ireland, and also at setts in England, Scotland, Luxembourg and Italy. Numerous insects are also found at setts, some of which (principally carrion flies) visit the stinkhorn fruiting bodies, dispersing the fungal spores close to the setts.

Other mammals have been reported at setts. From a three-year camera trap study at setts as part of a vaccination programme in Ireland, mammals found included domestic cats (*Felis catus*), dogs (*Canis lupus familiaris*), and cattle (*Bos taurus*), as well as hares (*Lepus timidus hibernicus*), rabbits (*Oryctolagus cuniculus*), mink (*Neovison vison*), and foxes (*Vulpes vulpes*), in addition to small mammals. Otters (*Lutra lutra*) have also been found at setts on the Irish coasts and not just as casual visitors.

Given all this biodiversity at badger setts, does the presence of this large mammal affect the composition and function of the local ecosystem? Recent work on digging by native mammals in Australia has shown that digging does affect the community composition of rhizosphere fungi for a forest canopy species (*Corymbia calophylla*). It would be of interest to see if badgers have similar effects.

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Craniomandibular differences between European and American mink: correlations with dietary specialisation

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Keywords: *European mink; American mink; diet; skull shape; geometric morphometrics*

The American mink (*Neovison vison*) has been described as a generalist predator, particularly in comparison to the European mink (*Mustela lutreola*) which they are relentlessly replacing in Europe. However, dietary studies on both species report a wide overlap in prey types, with the main dietary differences being the relative distribution of each prey type (which also varies geographically). Here we studied how different dietary compositions are reflected in the feeding apparatus of both mink species by analysing their craniomandibular shape across different regions with reported different diets.

We characterized diets for each region based on previous dietary studies using scat analysis, while skull shape was quantified using landmark-based methods. The covariation between dietary variables and skull shape was analysed using two-block partial least squares. The resulting main axis of shape variation was associated with a dietary shift from amphibians and invertebrates towards mammals and birds, and represented a shift from long, flat skulls to bulkier, shorter skulls with round faces.

Surprisingly, the latter configuration mirrors that of a polecat skull, a small mammal specialist. Overall, our results show the strong association between form and function in the musteline skull, and we propose that this dietary axis of shape variation might be one of the main drivers of skull diversity in this subfamily. Further studies should investigate whether a similar trend is present in *Felinae*, another hypercarnivorous subfamily for which longer and flatter skulls can be associated with diets rich in aquatic prey (eg, *Prionailurus spp.*).

Badger density and breeding phenology in Mediterranean agro-sylvo-pastoral systems

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Keywords: *camera trapping; Meles meles; density; social organisation; reproduction*

European badgers (*Meles meles*) are one of the most widespread mesocarnivores in Europe. Nevertheless, there is an asymmetry regarding the knowledge of their socio-ecology, with a bias towards southern European populations. Furthermore, these regions present demanding environmental conditions, which are expected to deteriorate due to the forecasted global changes, and that will result in conservation challenges. In such context, knowledge regarding group composition, density, and breeding phenology for many populations inhabiting Western Iberia is still limited.

In this study, we addressed these topics for a population inhabiting an agro-silvo-pastoral system in central-west Portugal. We monitored 34 setts monthly and used camera trapping to intensely survey 12. Badgers followed the general pattern described for the species, with group sizes of 2–4 adults, and an intermediate population density of 0.49–0.73 badgers/km^2. These values are higher than those estimated for other Mediterranean environments but lower than for central-western populations.

Furthermore, mating events occurred mostly in November/January and cub emergence in March/April, with an average of 1.8 cubs/sett. These characteristics indicate that the studied population has adapted its ecology to the landscape context, where a surplus of human-related resources and mild weather conditions allow badgers to reach higher densities than in many southern European populations and to reproduce earlier than their northern counterparts.

Using museomics to dissect the genetic basis and evolution of winter colour polymorphism in stoats — a good model to study adaptation to climate change

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Keywords: *stoats; museomics; adaptation genomics; climate change; seasonal coloration*

The stoat (*Mustela erminea*) is one of three species of the *Mustelidae* family that exhibits seasonal coat colour (SCC) moult, from summer brown to winter white coats. SCC is one of the most remarkable adaptations to seasonal environments, allowing camouflage year-round in habitats with snow cover during winter. Such adaptations are threatened by the continuing and future decline of snow cover caused by climate change. However, this trait is polymorphic within species, with individuals from regions with less winter snow presenting brown fur throughout the year.

Identifying the genetic variants associated with SCC and their evolutionary origin may shed light into the ability of this species to cope with current and future climate change. In this study, we collected specimens with scored winter colour phenotype in collections of natural history museums from Ireland, where stoats remain brown in winter, and from two transition regions, where both morphs coexist, in Great Britain and central Europe.

We performed whole-genome resequencing, accessing the genomes from the 85 individuals sampled at ~1x coverage. Population genomic analysis shows how population history and structure relate to winter colour morph distribution. We, therefore, scanned the genome for regions associated with winter colouration by performing divergence and admixture analyses and identifying associated genetic variants. Then, scanning the genome for selection patterns will provide an understanding of whether previous adaptations underlie the persistence and dispersion of alternative variants in natural populations of the species. Our research dissects the genetic basis of a relevant phenotypic polymorphism, which can then be used to develop predictive models of adaptation under future scenarios of climate change.

Colloquium Abstracts

Research Methods



Otter: ©Frank Greenaway

Using detection dogs for mustelid monitoring — insight from field work with *Lutra lutra*, *Mustela erminea*, *Mustela nivalis*

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Keywords: *conservation detection dogs; monitoring; spraints; Lutra lutra; Mustela sp.*

In times of worldwide species decline, innovative and non-invasive monitoring methods, especially for elusive species, are essential to gain much needed knowledge for species conservation. One such upcoming monitoring methods, the use of detection dogs, is an aspiring and successful method used in wildlife monitoring (Dahlgren *et al*. 2012).

Dogs have an extraordinary ability to detect and differentiate scent, making them often more efficient and less invasive than traditional monitoring methods during wildlife monitoring (Grimm-Seyfarth *et al*. 2021). The use of scat detection dogs is nowadays well established in wildlife monitoring. However, variation in success rate caused by differences in target species characteristics and habitat have seldomly been looked at. Here, we contrast training, feasibility, field operationality and the success rate of a presence/absence monitoring of *Lutra lutra*, *Mustela erminea* and *Mustela nivalis* in Switzerland, using spraint detection dogs.

Furthermore, we compare the monitoring performance of detection dogs to other traditional monitoring techniques. The training time and success rate varied substantially between target species, most likely because of different spraint sizes and humidity as well as target species diet differences. *Lutra lutra* monitoring was reliably feasible using dogs after a training time of 4-5 months. However, training and monitoring *Mustela sp*. using detection dogs was more challenging.

When comparing detection probabilities for all three species, dogs often outcompete human observation rates and will be presented. Taking specific habitat, training prerequisites, species specific traits and costs into consideration, spraint detection dogs are a very promising tool for non-invasive mustelid monitoring, but only if performed by experts in the field.

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Optimising environmental DNA (eDNA) approaches for detecting semi-aquatic European mustelids

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Keywords: *environmental DNA; metabarcoding; carnivores, mammals*

Mammalian populations are declining globally and there is an urgent need for accurate information on species distributions to provide effective conservation management. Environmental DNA (eDNA) metabarcoding (detecting multiple species simultaneously) has been proven to be an effective tool for the detection of terrestrial and semi-aquatic mammal communities and has the potential to provide rapid biodiversity assessments from traces of genetic material extracted from water, soil, and air. Semi-aquatic mustelids, including otters (*Lutra lutra*) and European mink (*Mustela lutreola*), would seem like the ideal candidates for eDNA-based monitoring from water bodies.

Here, we report on multiple eDNA metabarcoding studies using river water in England, Scotland, and Spain to gather information on the distribution and diversity of mammalian populations. While mustelids like otter and mink have been captured regularly on camera traps, they are often not detected using eDNA metabarcoding or require a large number of eDNA samples to be processed in order to detect them within a riverine system. To investigate if this issue is related to using a broad, multi-species eDNA approach, we tested a newly developed single-species digital-droplet polymerase chain reaction (ddPCR) approach targeted for the otter and compared results obtained from the same eDNA metabarcoding studies. ddPCR outperformed metabarcoding in detecting otters at sites where they are known to be present (spraint and camera traps).

To test the potential of this approach to monitor otters at a national scale, ddPCR and metabarcoding is currently being undertaken in 60 rivers as part of the National Otter Survey in England. Otters were detected using ddPCR at multiple rivers and comparisons will be performed against established traditional surveying techniques. We will discuss the implications of these findings for monitoring rare, elusive, and invasive mustelids using eDNA.

The continued evolution of the camera trap: using the Mostela to monitor the Irish stoat (*Mustela erminea hibernica*) in the west of Ireland

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Keywords: *Irish stoat; Mostela; pine marten; camera trap*

The Irish stoat (*Mustela erminea hibernica*) is a subspecies endemic to Ireland and the Isle of Man. The species is believed to have a widespread distribution in Ireland, however there is no reliable information on the population and the difficulty in detecting and monitoring stoats has been widely researched in Europe. Croose *et al*. (2021) undertook a study in 2019 in the west of Ireland to compare the efficacy of two camera trap methods to detect the Irish stoat: the *Mostela* (comprising a camera trap and an 8cm tracking tunnel inside a wooden box) was compared with an external camera trap deployed outside the box. Both methods were tested for 12 weeks at 12 sites and successfully detected the target species, however there was no statistical significance in detection probabilities between the two methods.

We repeated this study in 2021 with a larger 10cm tracking tunnel inside the box, a modification that resulted in significant increases in detection probability in the Netherlands (Mos & Hofmeester, 2020). In this presentation, we evaluate preliminary results and detection probabilities for the Irish stoat based on both designs and discuss further applications for this research. We also assess the applicability of this study design for monitoring other mammal species, in particular detecting range expansion of the non-native invasive greater white-toothed shrew (*Crocidura russula*) and subsequent impact on the native pygmy shrew (*Sorex minutus*) where both species overlap.

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Who's who of pine martens — is individual ID possible when combining camera traps and citizen science?

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Keywords: *pine marten; camera traps; citizen science*

Individual identification of animals from camera trap footage can provide valuable biological insights, such as population density, population structure and behavioral patterns, but these methods have so far predominantly been applied to big cats with variable coat patterns, such as tigers and leopards. Pine martens (*Martes martes*) too have unique coat pattern markings on their bib, making it possible to ID them to individual level. However, processing camera trap footage is time-consuming, and takes even longer when trying to include individual ID. To gain assistance with classifying camera trap footage, researchers may turn to citizen science. Citizen science classifications can be used to identify species in camera trap data sets with a high level of accuracy, but there has been very little research into whether citizen scientists can be successful at the considerably more challenging task of individual ID.

We placed camera traps at bait stations in the Forest of Dean in the territories of known pine martens to collect a mixture of photo and video footage. We then uploaded the footage to the citizen science platform 'MammalWeb' for classification. Citizen scientists were asked to identify the species present in the footage and, if there was a pine marten, choose from a selection of individuals with additional options including 'Unknown pine marten' and 'New pine marten'. Here we present the results of analyses examining a) The likelihood of an individual ID being provided for video and photo footage; and b) The accuracy of citizen science classifications for both video and photo footage. We will then go on to discuss the implications of these results and whether it is possible to gain meaningful ecological insights from the data.

Where to look — comparing survey approaches for the Eurasian otter

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Keywords: *monitoring; bridge; citizen science; detection dogs; experts*

The availability of presence and absence data collected using standardised methods is crucial in nature conservation. For rare and elusive species, survey methods need to be especially efficient. The standardised method used for monitoring of the Eurasian otter is walking along 600m transects along waterbodies (Reuther *et al.*, 2000). This survey is often carried out by experts, but also volunteers and lately detection dogs have been involved. Regionally, the standardised method is sometimes replaced by controlling for spraints exclusively underneath bridges. However, little is known about difference in efficiency and quality between the two methods applied.

The aim of this study was to understand sprainting behaviour of otters in anthropologically altered habitat in order to maximise the efficiency of a survey. For this, we carried out surveys on 51 transects with 152 bridges. Each transect was walked independently but at the same day by an expert, a volunteer and a detection dog with its handler. Information on the location of spraints was collected, compared and analysed. Altogether 175 spraints were found. Mean distance between spraints was 132m (min=3m, max 538m). Interestingly, the distance between two spraints was larger when one of the locations was a bridge (147m±118) and was even larger when two suitable bridges were involved (252m±187). However, not all suitable bridges were marked by otters and detection probability varied among volunteers, experts and dog team. With this study, we confirm that the bridge survey has a high potential to monitor otters. However, the quality of the overall result of a survey by replacing transects with bridges is dependent on the number of suitable bridges within each transect.

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Mustelid mugshots: a new camera-tube-lure system as a monitoring tool for European polecats in Sweden

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Keywords: *Mustela putorius; population status; monitoring; face mask*

European polecat (*Mustela putorius*) populations are reported to be declining in a large part of its range. The species is listed in Annex V of the Habitat Directive, which requires periodical monitoring and reporting of its conservation and distribution trends. However, many countries lack monitoring data for polecats and suitable monitoring methods are missing. In Sweden, the only available data come from 1) hunters that report their bags and 2) sighting reports by the general public, while systematically collected data are missing. Therefore, a robust method and systematic monitoring is needed to get updated data about the polecat distribution and population size.

Here, we present a new camera-tube-lure system specifically developed to monitor the European polecat (*Mustela putorius*). The aim of the system is to get 'mugshots' of polecats that allow individual identification based on differences in facemask shape and size. We tested the method in spring and autumn 2021 in four study sites in southern Sweden and related the probability of detecting polecats to different landscape features. These included the distance to the nearest building, distance to the nearest main road, the total length of hedgerow in a 45m radius buffer around each camera, and an index of cover (score from 1-10) from a polecat perspective.

We successfully photographed polecats in all four sites. However, it was hard to identify individuals from the images and automatic recognition software failed to give concluding results. Furthermore, in contrast to our expectation, polecat detections were highest close to main roads, while the other habitat variables did not influence polecat detection probability. Overall, we conclude that our camera-tube-lure system was effective in detecting polecats but that further developments are needed to enable recognition of individuals needed for density estimation.

Colloquium Abstracts

Genetics



Stoat: ©Frank Greenaway

The population genomics of stoats in Aotearoa and its use to inform control and eradication efforts

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Keywords: *stoat; genomics; eradication; dispersal*

In Aotearoa (New Zealand), the stoat (*Mustela erminea*) is an invasive species that was introduced to control rabbits in the late 19th century. However, it has since had significant deleterious effects on the indigenous avifauna. New Zealand is currently attempting to eradicate a suite of small, introduced pest mammals including stoats as part of its ambitious 'predator free 2050' goal. We do not yet have the tools to do this, and one research area promoted as a possible solution is the use of genetic tools.

We have now assembled a chromosome level genome of the stoat as a first step to investigate how genetics can be used to help achieve this goal. In this talk, I will focus on both the genome assembly, and the population genetics that we are doing to help understand stoat movement and trappability. Across several large landscape scale stoat eradication programs, we have used Genotyping-By-Sequencing (GBS) to genotype >500 individuals at >30,000 genetic markers scaffolded on the genome, enabling extreme fine-scale relatedness between individuals to be determined. This has revealed long distance >40km dispersal events, along with trap aversion and population persistence despite intense trapping pressure.

We are using this information to model stoat populations and to improve eradication programs. We have also developed and used forensic genetic markers to follow invading individuals using trace samples like scat. We are currently extending this research to weasels (*Mustela nivalis*). Overall, we are learning both fundamental ecology about stoats, and elucidating applied ways to control them from these genetic studies.

Extensive genome introgression between domestic ferret and European polecat during population recovery in Great Britain

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Keywords: *European polecat; domestic ferret; hybridisation; introgression; genomics*

The European polecat (*Mustela putorius*) is a mammalian predator which occurs across much of Europe east to the Ural Mountains. In Great Britain, following years of persecution, the European polecat has recently undergone a population increase due to legal protection and its range now overlaps that of feral domestic ferrets (*Mustela putorius furo*). During this range expansion, European polecats hybridised with feral domestic ferrets producing viable offspring.

Here we carry out population-level whole genome sequencing on eight domestic ferrets, 19 British European polecats, and 15 European polecats from the European mainland and find high degrees of genome introgression in British polecats outside their previous stronghold, even in those individuals phenotyped as 'pure' polecats. We quantify this introgression and find introgressed genes under selection that may assist in cognitive function and sight.

European mink (*Mustela lutreola*) reference genome and population genomics

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Keywords: *European mink; Mustela lutreola; genomics*

The European mink (*Mustela lutreola*) is considered as critically endangered in the IUCN Red List, and is already extinct in large parts of its ancestral range. A chromosome-scale reference genome has been recently produced during the ERGA (European Reference Genome Atlas) pilot project, from an individual sampled in 2006 in Dordogne (France) in the framework of the first National Action Plan for European mink. A fibroblast cell culture was derived from a skin biopsy on this animal, and then cryopreserved in liquid nitrogen in the Paris National Museum of Natural History cell collection. This frozen sample was used to generate fresh cell cultures for the production of high-quality DNA that was subsequently sequenced and assembled into a high-quality reference genome.

This reference can now be used for genomic studies of this species that presents a very high risk of inbreeding depression, especially in the western part of its geographic distribution. Inbreeding depression is a critical concern for conservation efforts as it is common in small, declining or fragmented populations. One way to measure the extent of inbreeding is to scan genomes for runs of homozygosity (ROH). This method is becoming more commonly used to estimate inbreeding and could become a new index for conservation status in wild animals. For this study, we selected two European mink from France (LIFE VISON et PNA Vison), two from Romania, two from Estonia and two from Spain for whole genome re-sequencing (>25x), each genomic sequence being compared to the reference genome. We expect to find long stretches of ROH that would indicate recent events of inbreeding. The results might have a direct impact on the current conservation program for the European mink.

Dissecting the genetic determinants of adaptive camouflage in the long-tailed weasel using museum genomics

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Keywords: *evolutionary genomics; coat colour; standing variation; museomics; climate change*

Understanding biological adaptations is a major endeavour of evolutionary biology. Natural history museums hold remarkable catalogues of this immense variety of adaptive phenotypes, and our modern ability to generate genomic data from archived specimens makes them invaluable resources to dissect the genetic underpinnings and evolution of local adaptations. Here, we use museum genomics to study the genetic basis and evolution of winter coat colour polymorphism in the long-tailed weasel (*Neogale frenata*), a crucial phenological adaptation for crypsis in habitats seasonally covered with snow. We produced whole-genome and targeted enrichment sequencing data for specimens from natural history collections, spanning two winter coat colour transition regions on Western and Eastern United States.

We found that winter white or brown morphs are determined by a genomic region surrounding a pigmentation gene. Genotyping results confirmed the association of the genomic region and identified three different alleles, one corresponding to the ancestral state determining winter white morphs, and two others with derived deletions in the coding region of the gene, corresponding to winter brown morphs in the western and eastern sampled regions. Testing for common allele frequencies changes in both regions and by applying a topology weighting method we show that both winter brown variants share a common evolutionary history.

Our results shed light onto the mechanisms involved in the evolution of a remarkable adaptation in the long-tailed weasel, and put in context with the repeated evolution of similar trait polymorphism across species, more generally onto the alternative pathways for recurrent evolution of adaptive traits.

Gene Family Expansions across mustelids

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Keywords: *mustelids; gene families; comparative genomics*

Mustelids are the largest, most diverse order in the family carnivora. Species within this order are found across a variety of habitats and exhibit varying physiological and morphological adaptations within their environments. Despite this, 31 of the 64 mustelid species documented on the IUCN website are listed as decreasing in population size. Past and recent demographic events have contributed to shape those species' genomes. As such, the expansion or contraction of gene families within and across lineages can often be related to significant demographic events but could also be associated to evolutionary adaption in response to the environment, as well as driving diversity across morphological and physiological traits.

Here, we use the GeneSeqToFamily workflow to generate 1:1 orthologues, as well as to investigate gene family gains and losses across seven mustelid species (European polecat, steppe polecat, black-footed ferret, domestic ferret, beech marten, Eurasian otter and stoat) and three outgroups. We generated 8678 1:1 orthologues across mustelid lineages and identified 16 gene families that show mustelid specific expansion. We also identified several gene losses related to fertility in the black-footed ferret. We aim to further investigate the associated phenotypes of these gene family gain or loss to understand the implications of these within mustelid species.

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Addressing the decline of weasels in North America

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Keywords: *weasel; decline; cooperative study group*

North America is home to three weasel species, each of which has recently been found to have undergone a decline over the past 60 years, raising concern for potential new range gaps and the viability of populations in portions of their historical range. To address declines in mustelids in North America by improving research, monitoring and conservation efforts, two models have become apparent. First, a policy-based approach, where a species is petitioned and then listed as threatened or endangered by government agencies and then receives dedicated funding from the government to support research and monitoring and develop recovery strategies. Second, a cooperative study group approach, whereby biologists work together to iteratively advance communication, knowledge and conservation actions. The latter approach being distinct in that it proceeds rather than follows policy decisions and has been shown to be extremely effective in rapidly advancing conservation for another small carnivore, the eastern spotted skunk.

The cooperative study group model is now being applied to weasels in North America through the newly formed Weasel Working Group. In 2021, this group of biologists from across North America began working to iteratively research and develop dedicated monitoring approaches for weasels that can be replicated across range states and provinces to fill important knowledge gaps about their distribution and relative abundance. In addition to this outcome-oriented goal, numerous process-oriented goals have already been achieved in terms of raising awareness, knowledge sharing, and establishing long-term collaborations that past experience suggests will contribute to advancing conservation of these imperiled species.

Colloquium Abstracts

Human Dimensions and Conservation Issues



Pine marten: ©Jason Hornblow

A predator of the northern wilderness — understanding wolverine ecology for present and future conservation challenges

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Keywords: *wolverine; depredation conflict; habitat fragmentation; climate change*

The wolverine (*Gulo gulo*) is the largest terrestrial member of the mustelid family, inhabiting the taiga and tundra of Eurasia and North America. Due to their solitary lifestyle, low reproductive rate and large territories, wolverines occur at low population densities. Moreover, as their distribution is mainly restricted to remote and harsh environments, they are often portrayed as a secretive creature of the northern wilderness. There are conservation and management concerns in most areas where the wolverine occurs; from habitat fragmentation to depredation on livestock. Also, global warming is considered as a potential threat to wolverine populations in the future.

In this presentation, I will take you through the history and context of wolverine conservation in Scandinavia, as well as the Swedish wolverine research project where long-term, mainly individual-based, studies have provided an opportunity to investigate wolverine population dynamics, life history, and behaviour. Following a long history of human persecution, the wolverine was legally protected in Sweden in 1969. At this time, it was estimated that only about 100 individuals remained in the northern mountains. Since then, and especially the last decade, wolverines have recolonised their former range and today the estimated population size is ca. 1,000 individuals in Scandinavia (ca. 640 individuals in Sweden).

The main wolverine management concern is caused by their predation on semi-domestic reindeer owned by indigenous Sámi people. Balancing a viable wolverine population while managing the depredation conflict requires knowledge. This motivated the start of the Swedish wolverine project in 1993. Considering the initial lack of knowledge, the first research focus was to gain basic information on population dynamics and spatial behavior. Subsequently, we focused on understanding mechanisms influencing wolverine density and distribution, as well as predation and interactions with other predators. Following the southward recolonisation, a current focus is the importance of snow cover and temperature for wolverines. Therefore, we are now investigating wolverine reproduction, denning behavior and feeding ecology (eg, diet, predation and food caching) in the southern boreal forest.

A global review of the conservation threats and status of mustelids

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Keywords: *carnivores; IUCN Red List; literature review; mammals; Martes; Mustelidae; population trends*

The family *Mustelidae* is the largest among the order Carnivora. While we know a great deal about certain species, there is still a lack of information about many mustelids. We first investigated the International Union for Conservation of Nature (IUCN) Red List species-level assessments for each mustelid species. Then, we undertook a systematic review of the scientific literature with the aim of identifying the primary threats and subthreats reported, and which species are most studied. Threats are defined by the IUCN as 'the proximate human activities or processes that have impacted, are impacting, or may impact the status of the taxon'.

We analysed 1,003 published articles. For each article, we collected year of publication, geographical zone of each study, species studied, and the threats and subthreats identified. The majority of species (62%) were classified as Least Concern on the IUCN Red List, but 31 out of 63 species were found to be declining globally and only two species were increasing. The species studied and location of studies were biased, with 72% of studies undertaken in North America or Europe and focusing on very few species. A high proportion of species distributed predominantly in the tropics were categorised as declining, and threats linked with hunting, fishing, and logging were identified as the most common for mustelids by the IUCN Red List and in the scientific literature. Differences in the proportion of threats affecting each subfamily were also reported.

The nature of threats varies in different parts of the world and between species and it is essential to undertake more research with a strong focus towards species in highly biodiverse regions. A greater understanding of threats such as wildlife pet trade, emerging diseases, and climate change must also be central to prevent declines.

A decadal change in public attitudes toward urban stone marten (*Martes foina*): a case study of Krakow, Poland

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Keywords: *human-wildlife conflicts; Poland; questionnaire survey; stone marten*

Stone martens (*Martes foina*) are common occupants of urban environments across continental Europe. Conflicts between humans and martens arise when the animals den under the roofs of inhabited buildings or damage car engine components. Therefore, there is an increasing demand for measures that will reduce such human-wildlife conflicts (HWC). Simultaneously, Europe is undergoing dynamic land-use changes by expanding urban habitat, driving wildlife species to colonise conurbations, resulting in an increased likelihood of HWC. Understanding people's attitudes towards wildlife is essential to managing these conflicts. This study assessed people's attitudes towards stone martens, identified the types of conflict that existed, preferences for managing conflict situations, and determined changes in perceptions over a decade. A questionnaire survey of residents of Krakow, the second-largest city in Poland, was conducted in 2010 (n=721) and repeated in 2020 (n=887).

Our results revealed that the stone marten was frequently observed in 2010 (n=256) and 2020 (n=394). However, there was very strong evidence that encounters with the species increased over the decade ($p<0.01$). There was a significant increase ($p<0.01$) in conflicts with stone marten from only 66 incidents reported in 2010 to 134 incidents in 2020 (an increase of 103%). There was strong evidence that car destruction problems increased over the decade ($p<0.01$). However, respondents preferred non-lethal methods to mitigate conflicts. In 2010, 54% (n=389) of the respondents were unfamiliar with any unit or institution in Krakow that could mitigate conflicts with the species, which increased to 91% (n=808) by 2020.

Therefore, the study provides valuable information and knowledge on changes in attitudes of people towards urban stone martens that can help with their management in urban areas. The study highlights the importance of incorporating perception data along with a multi-stakeholder approach, including wildlife professionals, in the planning and design of mitigation measures to minimise conflicts.

Spatial and temporal trends in western polecat road mortality in Wales

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Keywords: *wildlife-vehicle collisions; mitigation; terrestrial carnivores; conservation*

Roads impact wildlife in a number of ways. Indirect effects, such as barrier effects caused by linear features in the environment, restrict animal movements and fragment populations. Roads also have more direct effects in the form of injury and mortalities associated with wildlife-vehicle collisions (WVC). WVCs are considered one of the most important sources of anthropogenic terrestrial vertebrate mortality worldwide. Western polecats, (*Mustela putorius*), are small-medium-sized mustelids that are native to Asia and Europe. The British population has a historical stronghold in Wales. Polecats are seldom recorded outside of focal studies, however, and road mortalities represent the most common source of data on the species in the UK.

However, little is known about the factors that increase the risk of collision. We used regression modelling techniques to explore seasonal patterns in collisions and to identify environmental and road characteristics associated with polecat road casualties in Wales. Polecat road casualties had a bimodal distribution, occurring most frequently in March and October. Mortalities were more frequently recorded in areas with more roads, higher traffic volume, and a more fragmented landscape. They were also found in proximity to rabbits and grassland habitats, and at low elevations. The results of this study provide a framework for understanding the impacts of roads on polecats in their historic stronghold and developing mitigation measures for this and similar species.

Living in a polluted world — microplastic contamination of the Eurasian otter (*Lutra lutra*)

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Keywords: *Eurasian otter; microplastic; river Inn; spraints; FTIR*

The worldwide use of plastics by humans leads to an increase of plastic emissions into the environment. This causes several problems as this material is prone to accumulate pollutants while also releasing additives in the breaking down process. Harmful effects of microplastics — plastic particles sized <5mm — have already been observed in aquatic organisms like fish and mussels (Holm *et al*. 2013, Wesch *et al*. 2016) which represent part of the Eurasian otters' (*Lutra lutra*) diet. In 2018, Smiroldo *et al*. were the first to prove the presence of microplastics in otter spraints. The focus of this study was to sample otter spraints along the river Inn and get an overview of the particle load and its chemical composition.

Furthermore, it was investigated which specific environmental predictors of anthropogenic land use might impact the level of pollution. At first, a laboratory protocol was developed to detect microplastics efficiently and reliably in otter spraints. After field sampling in five different locations along the course of the river Inn, the spraints were freeze dried and then subjected to the Fenton reaction. Visual, ATR and FTIR analyses resulted in findings of microplastic particles such as road abrasion, fibres or particles in almost every sample. This indicates that microplastic pollution might be a bigger concern than so far anticipated.

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Mink on the brink: comparing surveying methods for detecting a Critically Endangered carnivore, the European mink (*Mustela lutreola*)

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Keywords: *European mink; monitoring; detection; environmental DNA; camera trapping*

Monitoring rare and elusive species is critical in guiding appropriate conservation management measures. Mammalian carnivores are particularly challenging to monitor directly, due to their generally nocturnal and solitary lifestyle, and relatively large home ranges. The European mink (*Mustela lutreola*) is a Critically Endangered small and semi-aquatic carnivore and is one of the most threatened mammal species in Europe. In northern Spain, the European mink population is monitored regionally using different methods and approaches, which makes assessing the status of the population on a national scale difficult. As such, there is an urgent need to 1) assess the efficacy of surveying methods, and 2) recommend a standard monitoring methodology that can be deployed rapidly and inexpensively over large areas of the mink's range.

We deployed four methods — camera trapping, hair tubes, live trapping and environmental DNA (eDNA) from water samples — to compare the probability of detecting European mink when present at 25 sampling sites within five 10kmx10km squares, and the economic cost and time required for each method. All four methods successfully detected European mink but the probability of detection varied by method. Camera trapping and hair tubes had the joint highest probability of detection, with camera traps detecting European mink at the most sites. However, eDNA and live trapping detected mink at a wider landscape scale than camera trapping and hair tubes.

For future European mink monitoring programmes, we recommend a combination of at least two methods to gather critical information on distribution, occupancy and conservation status.

Methods to quantify personality traits in mustelids and its application in ecology and conservation

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Keywords: *personality; assays; methods; stoat*

Animal personality (ie, behavioural variation among individuals within a population) has wide-reaching implications for ecological and conservation outcomes. While the link between personality, fitness, and life-history traits are well established, only recently have we considered how personality may influence the success of wildlife management efforts, such as detectability during monitoring, susceptibility to interact with control devices, or survivorship following translocation or reintroduction.

Developing and conducting simple assays to quantify personality does present a challenge, as quantifying traits requires resources and time, with no guarantee that assays will generate repeatable behaviour. In mustelids, there are no records of personality being quantified in free-living or wild-caught animals. Here we present assays conducted on wild-caught stoats (*Mustela erminea*), that can be replicated for other wild-caught or captive species. Our approach can also be modified for field research. We provide justification for the utility of our approach for other species and context on how traits identified with our assay could influence population research and management outcomes.

LIFE VISON, conservation of the European mink in the Charente Basin — a major project

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Keywords: *European mink; critically endangered; Life Project; radiotracking; Charente Basin*

The European mink (*Mustela lutreola*), is a wetland-dependent small mustelid and is the most endangered small carnivore in Europe. Since 2011, the IUCN has listed this species as 'Critically Endangered' at the national and global levels. In France, it was only present in seven departments in the southwest at the end of the 20th century, but nowadays, the last populations seem particularly fragmented. Habitat destruction, degradation and fragmentation, expansion of the invasive American mink, and road kills are the main factors which have led to the species' decline. The five-year LIFE VISON project, coordinated by the LPO, in partnership with the Charente-Maritime Departmental council and the GREGE, was launched in September 2017 to respond to the immediate threats that the European mink faces in its last stronghold area in France: the Charente Basin. This territory remains a strategic area for priority conservation actions as it is still free of American mink population.

The main objective of the project, which fits with the National Action Plan actions with a more complete implementation, consists on maintaining and, ideally, increasing the European mink population in the Charente Basin. After four years of implementation, the LIFE VISON project shows major progress both in knowledge acquisition and conservation actions thanks to a strong mobilisation of teams, partners and local actors. In particular, since February 2020, nine European mink (six males and three females) have been radiotracked through an intra-abdominal transmitter for about four to seven months, three individuals being tracked twice. The data collected through the daily monitoring provide essential information on several fields: diurnal resting sites used throughout the year, female breeding sites and behaviour during this critical period, home range size, spatial behaviour and mobility of the species. Once again, the European mink has surprised us more than once!

First diet study of the critically endangered European mink (*Mustela lutreola*) in France and Spain using next-generation sequencing technologies

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Keywords: *Mustela lutreola; diet; southwestern population; faeces; COI gene*

As part of the LIFE VISON project in southwestern France and conservation programme in La Rioja regional government in Spain, the diet of the critically endangered European mink (*Mustela lutreola*) was studied using 365 and 49 faeces respectively. In southwestern France, faeces were collected in 2020 and 2021 on precisely identified resting places of nine radio-tracked European mink, in Charente River Basin (Charente and Charente-Maritime departments). A few samples were also collected incidentally in the vicinity of the resting places. In Spain, faeces were collected in 2021 from at least two radio-tracked individuals, with the help of eco-detection dogs, in Ebro River Basin (Tiron-Oja subcatchment) in the province of La Rioja. Similarly to France, most of the faeces were collected in resting sites.

Genetic identification of both host and prey species was performed using new generation sequencing methods and bioinformatics tools. These 'metabarcoding' techniques are based on the high-throughput amplification and sequencing of short, highly variable fragments of the cytochrome oxidase 1, CO1, gene. The DNA sequences obtained after amplification were assigned to their taxonomy by comparing them to different databases (private mammal database and public databases, GenBank and BOLD).

The objectives of the data analysis will be to study the variability of the diet by type of habitat: Atlantic region in France (open marshes, wide major bed), and Mediterranean habitat in Spain (small rivers, streams, channels), by season, and if possible, by sex and individually, by comparing the species richness as well as the occurrence of each item (=frequency of appearance of each item in the samples). These comparisons will be particularly interesting as the three females in France and the two in Spain were partly monitored during the gestation and the breeding periods.

Colloquium Posters



Marbled polecat: ©ZooFanatic

Where are mink? Distribution of the European and American mink in France

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Keywords: *European mink; Mustela lutreola; American mink; Mustela vison; distribution*

The French population of European mink (*Mustela lutreola*) is one of the last five still present in Europe. Despite successive conservation programmes led by the French ecology ministry since 1999, its distribution is still dramatically decreasing. Moreover, no standardised monitoring has been carried out between 2004 and 2015. In order to update the distribution map and target priority conservation actions on the last cores of the species, prospection campaigns have been implemented since 2016 as part as of the new French conservation dynamics (National Action Plans and LIFE VISON). It includes various complementary direct and indirect detection methods (DREAL *et al.*, 2021a, DREAL *et al.*, 2021b, LPO *et al.*, 2017).

In parallel, in order to target fighting actions, monitoring campaigns of the invasive American mink (*Mustela vison*) have also been implemented, this species being one of the main threats for the European mink. Thus, a specific database compiles all sightings of European mink, American mink and doubtful sightings. The data comes from all the partners who work on French conservation programmes on the European mink, including incidental and radiotracking data. At 31 December 2021, more than 5,000 data were integrated, with the mention of the quality of the observation: certain, doubtful, invalid.

We present here an updated distribution map of the European mink in France using all presence data collected, with exceptional data including few European mink records in areas after 15 years without any data. These events confirm the complexity of monitoring this species. The compilation of American mink data also allow us to present its current neighbouring presence. We will take this opportunity to thank all the partners working on these monitoring actions for their huge and essential involvement.

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Habitat selection by fisher (*Pekania pennanti*) in Quebec deciduous forest

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Keywords: *Pekania pennanti; habitat selection; GPS collar; forestry; Quebec*

The fisher (*Pekania pennanti*) is a North American mustelid. Found in Canada and the United States, it has declined sharply in the US due to habitat alteration by agricultural intensification, urbanisation and forestry development. The fisher is associated with dense forest characteristics and closed canopies. Indeed, the structural complexity of this forest type provides resting structures and maternal dens. Thus, fishers are considered sensitive to forest management and are an indicator of forest health. The Ministère des Forêts, de la Faune et des Parcs in Quebec, eastern Canada, targets fisher as a forest management sensitive species in the yellow birch maple forest. Forests are composed of both hardwood and softwood species in this bioclimatic area. Softwood forests appear to be a suitable environment for fisher in winter, retaining some of the snowfall and thus reducing the energy cost of moving fisher.

One of the goals of this project is the creation of a forest management tool, accounting for forest structure and composition available on forestry maps, in the form of a habitat quality model for fisher. The first step of the project is to characterise habitat selection by fisher at the stand scale. Between November 2021 and March 2022 we captured and fitted GPS collars (Iridium TGW-4170-4 and GlobalStar TGW-4065-4, Telonics, Mesa, Arizona, USA) on 30 fisher — 13 females and 17 males — in the Témiscamingue region of Quebec. The monitoring period covered the winter (December-March) and the calving seasons (March-April). We present here the preliminary results of the GPS tracking in terms of home range size and habitat selection.

Individual recognition on camera trap images as a successful method to map and monitor the population structure of pine marten in the North Holland Dune Reserve

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Keywords: *pine marten; camera trap; population density; Netherlands*

In the 19th and 20th centuries, rabbits, foxes, polecats and weasels were frequently hunted in the dunes near Castricum in the Netherlands. Pine martens (*Martes martes*) have never been reported, either alive or dead, by gamekeepers. The forests in the North Holland Dune Reserve are widely used for daytime recreation such as walking, running and cycling. The first sighting of a pine marten occurred in 2006 and following this, a pine marten inventory was created. Since 2020, a method has been used that provides information on the distribution of individual martens and their home range size. The main aim is to estimate the size of the pine marten population.

Twelve camera traps were used and rotated in weekly sessions to monitor every 4ha of a 1700ha forest during 2021. A lure was used in front of each camera to bring the pine martens into the correct position to allow the unique bib pattern to be manually identified. Additional data from others, as well as historical knowledge, was also used to help identify individuals.

A total of 69 different pine martens were identified and their home range estimated. Seven males aged more than three years old occupy home ranges from 100 to 200ha; 16 adult females and 22 juveniles occupy home ranges from 40 to 100ha; seven young males aged one year old and four young males aged two years old occupy 40 to 200ha. The home range of a further 13 individuals was difficult to determine. Dispersal of juvenile martens to other places was also detected. This study has provided detailed knowledge on the social structure and dynamics of the pine marten population in this area. This study will also be carried out in 2022 and beyond.

Utilisation of Mostela boxes and citizen science to update the distribution of least weasels (*Mustela nivalis*) in Virginia, USA

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Keywords: *cat predation; distribution surveys; North America*

Least weasels (*Mustela nivalis*) are the smallest carnivore in the world and are elusive. Much of their life history is poorly understood in the United States, especially Virginia. Recent studies have indicated population declines of members of the *Mustelidae* family throughout North America. We report on the first utilisation of the Mostela camera trapping system in the United States. Beginning in October 2019, we initiated a long-term study of least weasels at a historical location in Montgomery County, Virginia where least weasels had not been observed in over 30 years. We also updated the distribution of least weasels in Virginia utilising citizen science reports while noting the method of observation.

Lastly, we compared the collection date for specimens to determine if observations in Virginia followed the national trend of declining observations. We observed 11 least weasels along Doc's Branch on Virginia Tech property in Montgomery County from October 2020-April 2022. Citizen science observations expanded the known distribution into three additional counties and increased the total number of Virginia specimens to 50. Trapping for research and pet (dog and cat) kills were the two most common methods for observation. Least weasel observations have increased since the 1930-1960s, with the greatest number of observations (n=17) from 2020-2022.

Status, distribution and ecological interactions of a non-native population of *Mustela furo* in Madeira Island

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Keywords: *Invasive mammal; ferret; introduced species; Mustela furo; Madeira*

Invasive mammals are major drivers of ecological change, being especially detrimental in oceanic islands, where they constitute a key threat to native taxa. Ferrets (*Mustela furo*) — a domesticated animal derived from the polecat (*Mustela putorius*) — have historically been used for hunting rabbits and rodents, and are increasingly kept as companion animals. Escaped individuals have formed multiple self-sustaining populations outside their native range, where they are an important threat to native wildlife, in particular to ground-nesting birds. The species is known to have occured in Madeira Island for more than one century. However, information regarding feral ferrets in the island is scarce, outdated and obscure.

Here, we present over 30 records, including photographic evidence from a large-scale camera trap study, confirming the occurrence of an established population with a wide distribution. Furthermore, we provide the first insights into the tropic interactions of the species in Madeira, including predation on other invasive mammals and endemic and threatened species. We discuss the possible ecological and economic impacts of this non-native carnivore in Madeira and other oceanic islands.

How was genetic diversity transferred with translocations from *ex situ* to *in situ*? A case study of the European mink translocation to Hiiumaa Island in Estonia

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Keywords: *Mustela lutreola; captive population; island population; population genetics*

The European mink (*Mustela lutreola*) is one of the most endangered small carnivores, listed as critically endangered on the IUCN Red List. Tallinn Zoo started a conservation breeding operation in 1980, which in 1992 was shaped into the European mink EEP programme to maintain a demographically and genetically healthy population in captivity. Since 2000, mink have been translocated on a yearly basis from the breeding facility in the zoo to Hiiumaa Island (Estonia) until the formation of a wild island population in 2016. Maintaining a healthy genetic structure was a priority, so genetically the least valuable animals, according to calculations made by a population management programme, were used for translocation.

This study aims to assess the amount of genetic diversity passed from an *ex situ* population on to the island population. Comparisons of genetic diversity were made by mitochondrial, microsatellite and nuclear markers. In addition, our results were combined with the pedigree data from the European mink EEP studbook to further evaluate the flow of genetic diversity from the founder population to the established wild population.

According to the results, the allelic richness of the island population was similar to that of the founder population and no evidence was found that its genetic structure had diverted from the founder population. It seems that the formation of the island population has been a gradual process of no more than the last seven yearly translocations. Results show that one of the key factors for the success is the repeated translocations over the years. The study also revealed that DNA-based analyses can have an important role in fine-tuning pedigree analyses for conservation breeding management.

Non-invasive monitoring of reproductive and stress hormones in the endangered European mink

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Keywords: *cortisol metabolite levels; European mink; glucocorticoids; progesterone metabolite levels; testosterone metabolite levels*

The management policy and methods of handling animals in captivity are key factors that can hinder the success of the *ex-situ* reproduction of European mink (*Mustela lutreola*). Since the maintenance of animal welfare in captive environments is important for the success of *ex-situ* conservation programmes, we aimed at non-invasively measuring sex and stress hormones as indicators of physiological stress, reproductive condition, and animal well-being. Faecal samples from 12 captive individuals located in FIEB centre (Foundation for Research in Ethology and Biodiversity, Spain) were collected from October to February and the quantification of faecal hormone metabolites was done by enzyme immunoassays. Faecal cortisol, testosterone, and progesterone metabolite levels (FCM, FTM and FPM respectively) and their interrelationships were analysed, as well as the effects of individual factors (sex and age) and environmental factors (season, stay duration and centre of origin).

Positive correlations were observed between FCM, FTM and FPM as a result of the well-known interaction between the reproductive and stress axes. Higher FCM levels were observed in males than in females — this result could be explained by sex-specific relationships with glucocorticoids. In addition, males also exhibited higher FTM levels than females, likely due to testosterone's role in male characteristics and its association with male aggressiveness in mammals. Individuals from FIEB showed lower FCM levels and stay duration did not increase FCM values.

Based on these outcomes, the overall breeding success reached at FIEB in recent years and the few studies addressing the reproductive and stress physiology in this endangered species, the hormones' values obtained could serve as reference helping to assess and secure animal welfare and the management of reproduction in both captive and natural environments.

Can social media help address knowledge gaps in the distribution of the marbled polecat?

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Keywords: *Vormela peregusna; online; conservation culturomics; mustelids*

The marbled polecat (*Vormela peregusna*) is a small mustelid that occurs from the Balkans to Mongolia and listed as Vulnerable under the International Union for Conservation of Nature's (IUCN) Red List. There are currently no efficient methods to survey or monitor populations at a broad scale and most records come from opportunistic sightings. However, the elusive nature and unique pelage of the species often results in a lot of interest from members of the public when sighted, with observations often being published on social media platforms. Such records from social media can provide an extensive source of freely available information on the species that could be used to inform the species distribution.

In this study, we collected marbled polecat records from five social media platforms in a systematic way which included a manual and automated search targeting the western range of the species. We identified 131 unique marbled polecat sightings in the form of videos and photos, originating mostly from Facebook, Instagram and Twitter. The records confirmed the species' presence in 92 50km grid cells within the study area and were sufficient to perform further habitat suitability modelling and alpha hull range estimates.

This technique was well suited to clarify broad distribution patterns of marbled polecat (ie, more widespread than expected in Türkiye and the Caucasus), but did not detect the species in areas where its presence was most uncertain. The results of the modelling work, however, can be used to target further dedicated survey work for the species. The framework used in this study can be applied for other rare or under-studied species for which few records are readily available to provide more detailed information on distribution and occurrence patterns.

Where does the marbled polecat live in Bulgaria?

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Keywords: *Vormela peregusna; distribution; Bulgaria; habitat preference*

Data on 77 registrations of the marbled polecat (*Vormela peregusna* Guldenstaedt, 1770) (Carnivora: *Mustelidae*) for the first two decades of the 21st century were used for modelling the distribution of the species in Bulgaria. Approximately one-third of the registrations were victims of road traffic. MaxEnt model based on Corine Land Cover types and some topographic variables shows that the marbled polecat has a broad niche, preferring various types of open and shrubby habitats — arable land, shrubs and anthropogenically-affected open areas. The average habitat suitability in the Natura 2000 zones where the species is protected is 0.22, which is lower than the national average (0.3).

The preference for anthropogenically disturbed areas is the reason for this discrepancy. The zones in the network tend to cover relatively undisturbed areas with a well-preserved forest cover, generally not very suitable for the species. A comparison was made with a MaxEnt model of the marbled polecat's optimal prey, the European souslik (*Spermophilus citellus Linnaeus*, 1766), based on the same eco-geographical variables. It has a much narrower spatial niche, which indicates that the distribution of this mustelid is not necessarily related to that of its optimal prey.

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