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## **XII Congresso Italiano di Teriologia**

**Cogne, 8–11 Giugno 2022**

edited by

Roberta Chirichella and Damiano G. Preatoni

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edited by  
Roberta Chirichella and Damiano G. Preatoni

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**Mercoledì 8 Giugno 2022**

XII Congresso Italiano di Teriologia

### 100 years of the Park: from the protection of an umbrella species to the monitoring of animal biodiversity

Bruno BASSANO

Ente Parco Nazionale del Gran Paradiso



A001

XII Congresso Italiano di Teriologia

### First national survey of the Italian wolf population: observers' network, sampling strategy and spatially explicit modelling to estimate distribution and abundance

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A002

Despite the recent expansion of the Italian wolf population, a proper long-term conservation of the species is limited by a high administrative and management fragmentation at a national scale, and by a lack of solid information on its population. Monitoring is the basis of every conservation policy, and the absence of a homogeneous and simultaneous national survey for estimating population parameters indeed limits the development of correct conservation policies. In the Alps, this shortcoming has been filled by the coordination of LIFE projects (LIFE WolfAlps and LIFE WolfAlps EU). However, in peninsular Italy, despite the presence of high-quality data in many Apennine areas, a homogeneous and national coordinated monitoring approach was missing. Therefore, upon a formal request by the Ministry for Ecological Transition, the Italian Institute for Environmental Protection and Research (ISPRA) set up a scientific working group to define a sampling strategy and its operational tools for implementing a first national survey in Autumn 2020 – Spring 2021. In the Alpine regions the project has been fulfilled through the LIFE WolfAlps EU.

The definition of the monitoring strategy was based on a detailed analysis of the scientific literature, that yielded a sampling design aimed at estimating the national distribution and abundance of the species in 2020–2021. For efficient planning of surveys, we clearly identified and defined the objectives, the target population, and the corresponding spatial domain. A careful analysis of the population level approaches adopted in other countries was also carried out. A Network of qualified personnel was then trained and charged to carry out data collection through shared sampling protocols and using common criteria for data interpretation, to ensure consistency in data collection. Occupancy modelling of data gathered in the peninsula and spatially explicit

capture-recapture analyses separately implemented for the Alps and the Apennines then allowed to assess the wolf distribution and abundance.

In peninsular Italy, the qualitative and quantitative analysis of previous data led to the classification of the sampling units (10 × 10 km grid cells) into four strata, used as a basis for an extensive, spatially balanced probabilistic sampling to estimate of wolf distribution through occupancy modelling. A contemporary intensive sampling was assisted by non-invasive genetic analyses and carried out in areas randomly selected in the 11 Regions of the Italian peninsula to obtain an estimate of the local density through spatial capture-recapture techniques. In the Alpine regions, all the cells of known occurrence were considered for data collection. The National Network of observers for wolf monitoring in peninsular Italy was coordinated by ISPRA, with the support of Federparchi and a group of contracted experts and it was mainly composed by volunteers and technical staff belonging to public and private entities. Carabinieri of the former Italian State Forestry Corps also played a fundamental role at the national level, and in the Alps, the coordination of data collection activities was carried out in the framework of LIFE WolfAlps EU project.

The 2020–2021 survey produced a reliable annual estimate of the distribution and abundance of the species based on a single scheme, and using data collected specifically for this objective. It should represent the reference of a multi-year long-term monitoring plan at the national scale. For this objective to be truly achievable, the collaboration of several operators active on the local scale is fundamental, in full consideration of the logistical problems that might emerge during the first application of the approach.



### Moderatori

Leonardo ANCILLOTTO, Marco SCALISI

XII Congresso Italiano di Teriologia

### The challenge of preserving bats and the ecosystem services they deliver in a rapidly changing world

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MO01

Bats are a highly speciose order of mammals, numbering over 1400 species. Besides delivering important ecosystem services in the tropics such as pollination and seed dispersal, most bat species worldwide are insectivorous and often suppress pest insects, playing a pivotal role in natural ecosystems as well as human-managed environments. Bats are highly sensitive to human action, which explains the global population decline recorded for many species. These mammals are jeopardized by habitat alteration or destruction, and urban sprawl eating into bat habitat wipes out most bat species except the few ones that may cope with the extreme conditions found in cities. New threats, including the spread of wind turbines, artificial illumination, and climate change pose further conservation challenges.

Here I concentrate on what it costs to be a bat in the Anthropocene, identifying the life traits that allow a few species to

tolerate urbanisation or even thrive in urban cities. I will cover case studies regarding “losers” that succumb to human impact and “winners” that cope with the new environmental challenges posed by humans, ranging from tolerance to warmer climates to the exploitation of artificially lit sites. I will also analyse how stressors such as artificial illumination and climate change may alter interspecific competition dynamics, leading to unexpected ecological scenarios. Finally, I will highlight the importance of investigating the often neglected “common species” due to their overwhelming role as ecosystem service providers. Such species also offer insights into the life history traits that make a difference in how successful a bat species will prove in human-dominated ecosystems and inform conservation actions targeting threatened bats. In other words, I will show how understanding “winners” may help preserve “losers”.

XII Congresso Italiano di Teriologia

### Are ibex becoming more nocturnal in response to changes in environmental conditions?

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MO02

Monitoring and predicting how heat-sensitive species would respond to the new challenges imposed by global warming is a major task for ecologists. Endotherms have developed physiological and behavioural mechanisms to cope with fluctuations in climate conditions. In particular, it has been shown that behavioural thermoregulation could play a key role in the response to climate change. Thermoregulation accounts for a large portion of the energy spent by endotherms in warm conditions. As a result, the trade-off in energy allocation is expected to be driven more by their ability to dissipate heat and avoid hyperthermia rather than by their ability to harvest energy from the environment. Large mammals living in the Alpine area are expected to be more affected by climate change as this area is recognized to be a hot spot where the increase in temperature is more pronounced.

Alpine ibex (*Capra ibex*) is responding to global warming by retreating to and concentrating in fewer locations at higher elevations, where vegetation quality is low. It has been shown that during warmer days ibex eat more in the morning and evening but, overall, they spent less time foraging. Previous studies have suggested that ibex is not able to behaviourally compensate for the reduced forage productivity found at the top of mountains neither by adjusting their foraging time nor their feeding strategies, at least during diurnal hours. But they may be able to compensate for reduced food intake during warmer days by shifting their activities during the cooler nocturnal hours. We tested this hypothesis by analysing a large dataset of fine temporal scale activity data acquired by using accelerometers fitted on GPS collars of 27 ibex (18 males and 9 females, for a

total of 11274 monitoring days) in the Gran Paradiso National Park, Italy. We investigated the activity rhythms of males and females throughout the year and the influence of climate, particularly air temperature. We then separately analysed activity rhythms during diurnal and nocturnal hours and investigated the relationship between nocturnal activity and the meteorological conditions during the previous diurnal hours.

Overall females were found to be more active than males, but this difference vanished when considering nocturnal hours only. Interestingly, we found that nocturnal activity was primarily driven by maximum temperatures of the previous day, rather than by those recorded during the night. After days with high maximum temperatures, both males and females increased their nocturnal activity, arguably to compensate for scarce diurnal food intake. Ibex did not seem to take advantage of rainy days to facilitate their thermoregulation and increase foraging intake, but rather they decreased activity with increasing precipitation. Our findings suggest that ibex may cope with warmer temperatures by becoming more nocturnal. This finding excites new scientific questions on changes in anti-predatory behaviour and on the selection of resources during the night. Moreover, the increase in nocturnal activity could limit our ability to detect ibex during the day. In turn, this behavioural adaptation may negatively impact the performance of management activities, such as population estimates from the census, with increasing global warming. Similar behavioural adaptation should be investigated in other mammals and taken into consideration for future management and conservation activities.

**Organic farming and nature reserves emphasize ecosystem service delivery by bats**Ancillotto L.<sup>1</sup>, Scaramella C.<sup>1</sup>, Rummo R.<sup>1</sup>, Migliozzi A.<sup>1</sup>, Garonna A.<sup>1</sup>, De Benedetta F.<sup>1,2</sup>, Bernardo U.<sup>2</sup>, Dartora F.<sup>3</sup>, Agostinetto G.<sup>4</sup>, Tommasi N.<sup>4</sup>, Galimberti A.<sup>1</sup>, Russo D.<sup>1</sup><sup>1</sup>Wildlife Research Unit, Università degli Studi di Napoli Federico II, Dipartimento di Agraria, Portici, Italy.  
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MO03

The effectiveness of organic farming in promoting biodiversity has been widely documented, yet most studies have been undertaken in temperate agroecosystems with a focus on birds, insects, and plants. The potential benefits of organic farming for biodiversity may concern many species at risk. There is growing evidence that many animal species act as major providers of ecosystem services in agroecosystems, and European bats, being specialised insectivorous mammals largely occurring in farmland, play a major role in consuming insect pests. Understanding the potential mutual benefits between bats and agriculture is a fundamental step to preserving biodiversity and the ecosystem services it delivers.

Here, we 1) test the effects of organic farming and landscape structure on bats, 2) determine which pest insects are consumed by bats in agroecosystems, and 3) highlight the role of protected areas in fostering ecosystem services beyond their boundaries. First, we applied robust sampling designs to compare bat activity at paired organic and conventional farms by using passive acoustic monitoring schemes, disentangling the effects of farmland management and fine-scale landscape structure in shaping bat occurrence and activity levels. We then sampled droppings from temporarily captured bats from two protected areas in central Italy, applying DNA metabarcoding techniques to identify preys and assess whether bats in natural habitats deliver ecosystem

services to nearby agroecosystems.

We found that bats prefer organic over conventional farms, with a scale-independent effect of local farm management on foraging activity (but not species richness), which was consistent across bat species and functional guilds. Fine-scale landscape features had variable effects on bat species and guilds, but the positive influence of linear landscape elements on bat activity was consistent between management options. Bats caught in protected areas belonging to three focal species featured crop and forest pests in their diets that accounted for 10–80% of individual's prey richness, with differences among species and between sexes.

We show that organic farming promotes bat foraging, but whether this translates into positive demographic effects has yet to be further investigated. Establishing that organic agriculture elicits greater bat foraging activity as found in our study anticipates that the economic benefit bats provide to farming will be especially important for this management type, likely replacing or at least largely compensating for the non-use of pesticides. We also demonstrate the key role of parks and the natural habitats they protect in preserving essential ecosystem services that trespass their boundaries, highlighting that joining efforts between wildlife managers and farmers constitutes a win-win alliance.

**Meta-analysis of spatial and temporal behaviour of the European brown hare in its native range**Mori E.<sup>1</sup>, Carbone R.<sup>2</sup>, Viviano A.<sup>1</sup>, Calosi M.<sup>3</sup>, Fattorini N.<sup>3</sup><sup>1</sup>Consiglio Nazionale delle Ricerche – Istituto di Ricerca sugli Ecosistemi Terrestri, Via Madonna del Piano 10, 50019 Sesto Fiorentino (FI), Italia<sup>2</sup>Università degli Studi di Parma, Parco Area delle Scienze 11a, 43124 Parma, Italia<sup>3</sup>Dipartimento di Scienze della Vita, Università degli Studi di Siena, Via P.A. Mattioli 4, 53100 Siena, Italia

MO04

The European brown hare *Lepus europaeus* is the most widespread hare species of the world, being native to Eurasia and introduced as a game species to other continents. Therefore, this lagomorph is an important species for both management and conservation. We aimed at summarising the spatiotemporal behaviour of this species in Eurasia, by taking advantage of 51 selected studies spanning over the last 40 years. To reach this goal, we used meta-analytic approaches to (i) investigate ecological factors influencing home range size; (ii) test preference across major habitat types and (iii) provide a quantitative synthesis of activity patterns of the brown hare.

Temporally-adjusted home range size of hare populations decreased with increasing cropland cover (cereal and non-cereal crops), suggesting that home range size gets smaller with increasing food availability. Hare populations where a higher number

of males with respect to females was sampled showed larger home ranges, as expected for polygynous mammals. Hares preferred cropland and grassland compared to other habitat types for foraging, where the majority of trophic resources for this species occurs, and avoided human settlements. However, most habitat types were used proportionally to their availability, and the overall strength of hare habitat selection was not intense. Hares were mainly nocturnal, with the lowest activity during daytime (about one third than that at night), and showed moonlight avoidance, probably to limit encounters with nocturnal predators. Open habitats and especially croplands are paramount for this lagomorph, but the proportional use of most habitat types and temporal modulations in activity also suggests considerable plasticity in the use of space and time by brown hares.

## Towards a better understanding of bat diversity in Alpine regions by broad-scale acoustic surveys

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MO05

In recent decades, Alpine landscapes have been characterised by considerable land-use changes. On one hand, agricultural areas at high elevation and in remote regions have frequently been abandoned, whilst those in favoured regions, e.g., the bottoms of the main valleys, have often been intensified. Additionally, urban sprawl has been growing in some areas of the Alps. All these trends have massive consequences on biodiversity. A better understanding and prediction of current and future biodiversity patterns is therefore of primary interest in the Alpine space. Understanding animal community responses to human disturbances is crucial to developing and applying appropriate conservation strategies from the local to the global scale. Among mammals, bats are a highly specialised species-rich group showing a quick response to land-use changes, while guaranteeing ecosystem functioning and services such as nutrient cycles and insect pest control in agroecosystems.

In 2019 the province of South Tyrol established a long-term standardised biodiversity monitoring programme, focusing on a set of animal and plant groups to evaluate biodiversity responses to global changes (especially, land-use and climate changes). In this context, our study aimed at exploring how and if land-use, landscape structure and topographic variables affect bat activity patterns (total activity and foraging activity) and community composition. We collected acoustic data using bat detectors (Batlogger A+) from late May to October in the years 2019, 2020, and 2021 across 192 sampling sites covering the main habitat types and elevational ranges in South Tyrol (7400 km<sup>2</sup>). The sampling sites were selected using a stratified selection approach, covering natural, semi natural and anthropized habitat types. Within the single strata of habitats, sites were mostly selected randomly. Bat activity was recorded on three consecutive nights, the recorded bat passes were identified to the species or genus level and were then used to estimate bat activity, species richness and taxonomic diversity.

To determine the driving variables, we collected spatial data for each sampling site based on the Land-Use/Land-Cover (LULC) map of the province and a digital elevation model (DEM). Combining QGIS and FRAGSTATS we used: i) landscape composition and landscape configuration metrics; ii) distance variables to water bodies or roads; and iii) elevation. These variables were correlated with bat activity, species richness and taxonomic diversity using generalized and linear models (GLMs and LMs).

Overall, the highest bat activity was observed in riparian forests followed by settlements, wetlands, vineyards, and apple orchards (Kruskal-Wallis test,  $p < 0.001$ ). In contrast, foraging activity is higher in wetlands whereas it is almost absent in Alpine rocky habitats, deciduous and coniferous forests (Kruskal-Wallis test,  $p < 0.001$ ). Total bat and foraging activity decreased with increasing elevation ( $p < 0.001$ ), similarly to species number ( $p < 0.001$ ). Such decreases with elevation are not surprising, as only a few bat species are adapted to cold conditions and low food availability.

At intermediate elevations, the main drivers for bat abundance and their richness are habitat type and landscape structure. According to our models, the highest diversity is found close to water sources, in heterogeneous landscapes, and at low and medium elevations. As expected, water bodies are an important landscape feature, providing drinking water and abundant flying insects. While bat diversity declines as urban density increases, our model shows high values of diversity for sites close to roads probably due to the high availability of prey attracted by streetlamps. However, the effect of different types of roads on species diversity or foraging activity should be better investigated.

Our results highlight the need to preserve heterogeneous landscapes and a high landscape structuring to retain most of the bat biodiversity, which in turn assures ecosystem functioning and supports basic ecosystem services such as insect pest control. Overall, we found clear differences between the total activity and feeding activity, indicating that some habitat types are primarily used as feeding sites. Moreover, wetlands play a key role in connecting adapted areas and they are a highly suitable foraging habitat. In suboptimal landscape mosaics, suitable areas can be relatively important for highly mobile species such as bats, as they may be able to avoid some of the negative aspects of urban landscapes and successfully exploit relatively small favourable habitats.

The evaluation of mitigation or conservation measures in specific areas such as small, protected areas should be addressed, as they are crucial in a highly anthropized matrix such as some South Tyrolean valley bottoms. In the future, a better understanding of small-scale effects may build a solid basis for Alpine bat conservation and management, fill knowledge gaps for specific/single protected areas, and support bat-friendly landscape planning.

## Camera-trapping, artificial intelligence and hierarchical ecological modelling to assess mammalian communities: a multi-area case study towards an Italian network of standardised monitoring sites

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MO06

Assessing and monitoring changes in biodiversity is critical to species and ecosystem management, which are efforts of primary societal relevance. The SDG 15 calls for urgent action to prevent the extinction of threatened species and the 2030 EU Biodiversity Strategy places emphasis on expanding the network of protected areas (PAs), with an explicit commitment to monitor them appropriately. While emerging technologies have increased the efficiency of data acquisition and analytics, monitoring efforts are still fragmented and heterogeneous. Here, we propose the combination of camera-trapping, artificial intelligence (AI), and hierarchical ecological modelling as a powerful and novel approach to standardise the study and monitoring of mammalian species and communities.

We describe the approach proposed using its first application across a pool of four mountainous PAs in central and northern Italy sampled in 2020, as a pivotal effort towards a nation-wide network of areas that implements standardised monitoring. The workflow adopted consists of (1) the deployment in each area of a systematic protocol deploying 60 camera-trap sites sampled for at least 30 days, (2) the AI-aided filtering of images and species classification through a new web-based platform (*Wild.AI*), and (3) the analytics based mainly on occupancy framework. Here, in particular, we applied a multi-region, multi-species occupan-

cy model that includes the modelling of species' functional traits to study the effect of humans' photographic rate at camera trap sites and of the distance of camera sites to the closest settlement on the occupancy and diel activity patterns of mammals across the four PAs. We analysed the effects on diel activity by modelling the detection events of each species in each area during nocturnal, crepuscular and diurnal periods.

We deployed an effort of 8619 camera days at 204 sites effectively sampled. These yielded 86017 independent detection events at 30-min interval, of which 42% were of wildlife, with 9–16 species detected per area, and 58% of humans, detected at 98% of sites. We found that the average community occupancy probability was not significantly affected by potential anthropogenic disturbance, while diurnality was negatively affected, predicting that species became more nocturnal at sites more intensively used by hikers. Moreover, nocturnality and crepuscularity were negatively affected by increasing distance to settlements. The cost-effectiveness, generation of comparable results, ability to monitor both priority species and whole communities, relevance to inform management decisions and to measure indicators of global targets are key values of the proposed approach, indicating a clear avenue for its wider adoption at national level.

## Infrastructures and next generation EU: mitigation and preservation areas for European mammals

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MO07

As a response to the economic crisis due to the COVID-19 pandemic, on July 2020 the European Council agreed on a massive recovery plan for the European Union denominated Next Generation EU. The first medium- and long-term purpose of such plan is guaranteeing a better future for next generations of European citizens. In this framework, there are several objectives focusing on promoting energetic transition and territorial cohesion through the development of different infrastructures. This plan implies unprecedented challenges in terms of building and upgrading roads, railways, powerlines, windfarms and solar plants, all of them infrastructures that entail well-known negative impacts on mammals. In order to limit such impacts, a careful planning of this forthcoming infrastructure development would be of paramount importance. In this study, we provided an example of preliminary evaluation of present and potential impacts of the planned infrastructure development on European mammals.

More concretely, based on the principle that any infrastructure-related impact depends on the interaction between species exposure and vulnerability, we overlapped the spatial distribution of current infrastructures and the distribution areas of the mammals

that the IUCN listed as threatened by Roads and railroads, Utility and service lines, and Renewable energy.

As a first result, we highlighted areas with high concentration of current infrastructures and mammal species threatened by them. We denominated such regions as Priority Mitigation Areas, where the current infrastructures and their upgrades, but also new infrastructures, should be urgently mitigated in order to limit their impact on local communities of vulnerable mammals. As a second result, we also highlighted areas with low concentration of current infrastructures but high concentration of mammal species threatened by them. We denominated such regions as Priority Preservation Areas, where future development should be avoided or at least carefully planned.

This kind of approach, based on large-scale information but also on easily accessible data, entails clear limitations, but it also represents an interesting first evaluation of the potential negative impacts of infrastructure building and upgrading by providing an identification of priority areas where we should focus our next steps for planning conservation strategies for European mammals.

## The role of mass media on bats conservation, lessons by the COVID-19 pan(info)demic

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The mass media represent one of principal news referring sources for the public. In the internet era, reading news on the Web has become usual in the people daily life and the information delivered by the media gained the capacity to reach a global audience within a very short time. For those reasons, the way the online reports are framed by the media may substantially shape public's risk perception, promoting or discouraging tolerance towards wildlife. At the early stage of the COVID-19 pandemic, bats were suggested as the most plausible reservoir of the virus, and this became a frequent topic in the news reports, potentially strengthening a negative view of this ecologically important taxa. We studied how media framed bats and bat-associated diseases before and during the COVID-19 pandemic by assessing the content of 2651 online news reports published across 26 countries in 7 languages, to understand how quickly a biased negative representation of bats by global press may undermine

conservation efforts. The COVID-19 outbreak generated global media attention on bats as disease reservoirs. Our results showed that the overabundance of poorly contextualized news reports on bat-associated diseases increased the persecution toward bats at the onset of the COVID-19 pandemic. However, the subsequent interventions of conservationists, allowed positive messages on bats to resonate across global media, likely stemming an increase in bat persecution. Our work highlights the modus operandi of global media concerning attractive biodiversity topics, which has broad implications in species conservation. Knowing how the media acts is fundamental for anticipating the spread of (mis)information and negative feelings towards wildlife. Collaborating with journalists by exchanging experiences and engaging in dialogue should be central in future conservation programs.

## A new double-observer-based survey method to estimate population size in the Alpine ibex (*Capra ibex*)

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M009

The double observer (DO) is a common census technique to estimate the abundance of wild animal populations while accounting for the issue of imperfect detection, but it can be costly to perform in large or mountainous areas. Block counts are therefore still generally preferred in mountain ungulates and are commonly used across the Alpine arc to monitor Alpine ibex (*Capra ibex*) populations, but abundance underestimations are likely to be frequent. Therefore we here propose a new census method that could reliably estimate ibex abundance at a fraction of the monitoring cost of a Double Observer survey and without the need for individually tagged animals. Our new method, the Double Observer Adjusted Census (DOAS), is based on total block counts adjusted with only a few DO surveys in a small proportion of the total area to estimate detection probability and was here tested on simulated Alpine ibex populations in Gran Paradiso National Park (GPNP).

We simulated ibex populations with a real-case range of parameters and including a group size effect on detectability and allowing for possible size miscounts during the observations. We then compared on these populations the reliability of block counts, Double Observer in the entire area and our DOAS, testing also three different methods to estimate detectability from DO data: the commonly used Lincoln-Petersen frequentist approach,

a recently emerging Bayesian approach with BBRecapture R package and a Bayesian hierarchical model developed by us that considers the possible effect of each subarea on detection probability.

Our method proved to be solid and was able to estimate 94–97.5% in mean of the actual population from just a few subareas (around 10–15% of the total area), with a similar performance as a complete DO survey in the entire area, while block counts largely underestimated the population. We also found different performances of the various approaches to estimate detection probability, with Bayesian methods that led to constant overestimations at high detectabilities while the frequentist approach, via a Lincoln-Petersen-derived mark-recapture, proved to be more reliable but was less accurate at low detectabilities.

Our results suggest that the application of the DOAS approach, thus adjusting total block counts with detectability estimated from DO surveys in a subset of the area, is a viable survey strategy that can potentially highly increase the goodness of abundance estimations in the Alpine ibex with a low additional survey effort respect to the current census methods. The DOAS can also be potentially useful in various wild species traditionally counted with total block counts.

### Energy flux and species richness in rodents along elevation gradient in the Alps

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Understanding how species distribution varies along spatial gradients is a fundamental research topic in ecology and a critical point in conservation biology. The average number of species per unit area decreases in many taxa, moving from the tropics to northern latitudes. According to a productivity hypothesis, energy constrains species richness via trophic cascades: higher water-energy availability increases primary production and, therefore, more consumers. Alternatively, species distribution could be determined by their physiological requirements (physiological tolerance hypothesis) with respect to the energy input. Thus, the level of tolerance to low temperature or thermoregulatory needs may decrease species richness in cold habitats. As a general pattern, moving along latitudes, in cold climates at high latitudes in the northern hemisphere and more limited in the southern hemisphere, the ambient energy input is most often the primary explanatory, indicating the importance of temperature as a driver of species richness. On the other hand, moving south increases the number of studies where water availability resulted the strongest predictor. The latitudinal transition from energy to water limitation in the northern hemisphere extends over 45 deg of latitude.

Mountains encompass a significant variance of climatic conditions and habitats at small spatial scales, which challenge species' adaptability. The decline in species in mountain areas is generally not monotonic with increasing altitude, except for

limited cases (e.g. reptiles and bats). Population densities and species richness may change with changing energy availability, e.g. across elevational gradients in mountain areas. In this work, we tested assumptions of the energy limitation hypothesis, analyzing the elevational variation of energy flux and species richness and abundance in a rodent community. The relationship between species richness, body mass, field metabolic rate, and elevation was hump-shaped, with a peak at intermediate altitudes. Available water content showed a mild hump-shaped relationship with increasing elevation, whereas energy flux significantly increased with increasing productivity. An increase in energy flux was also related to the rise in rodent density and species richness. Our results supported the assumptions of the energy limitation hypothesis. Accordingly, both available water content and species richness co-varied with altitude. Species richness was correlated to water availability but not temperature, supporting the productive hypothesis in explaining the energy limitation effect. Thus, primary productivity represents a constraint to rodent species richness, as they are mostly primary consumers. The local energy availability limited rodent population densities and species richness in mountain areas. Therefore, the alteration in vegetation structure along an elevational gradient provoked by the ongoing global change may result in changes in rodent communities and, in turn, in their predators.

## Impact of habitat modifications on the age specific survival trajectories and distribution of Alpine marmot



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GPM02

The Alpine marmot (*Marmota marmota*) is a medium size burrowing rodent characteristic of high altitude prairies. This species has a wide distribution in the European Alps and, by being territorial and with diurnal activity, it is easy to observe and monitor. Marmots have a pivotal role in the Alpine ecosystem for multiple reasons: they dig and use underground hibernacula and galleries with multiple entrance all over their territory, they forage actively during most of their daytime in the active season, choosing selectively the species to eat; also, marmots represents a main prey for predators such as foxes and eagles. Sociality is another main feature of this species, which lives in family groups where dominants mainly defend the territory against intruders, and all members hibernate socially during the winter.

Both for the availability and quality of trophic resources and for the visibility against predator attacks, Alpine prairies are the most suitable habitat for this species. Nowadays, this habitat is undergoing changes, due to the rise of temperature and the abandonment of cattle grazing during the summer; the rapid, visible and measurable effect is the change in the tree line, which is rising up in elevation. This process creates a lower availability of the preferred habitat for Alpine marmots. Modification in distribution of the species is thus expected, as well as adaptations to the new conditions.

With the data collected through the long-term project of the Gran Paradiso National Park in Valsavarenche, we are studying marmots' dynamics to detect potential variation in their habits and

distribution. Within this project, researchers mark and monitor marmots during the whole season, and they collect individual data during the whole life of a marmot. The project started in 2006 and up to now it includes 363 marked marmots belonging to 17 different families and inhabiting two different areas, one close to the forest boundary and the other of Alpine prairies.

Bayesian survival population analysis showed a different trend for the two areas included in the long term project: unexpectedly, marmots living in marginal areas had higher survival compared to those living in the Alpine prairies. By means of confirmatory path analysis, we detailed this results extrapolating how social dynamics may affect this variation, indicating a potential benefit of living in areas with less neighbors, resulting in lower intra-specific competition. We also analyzed seasonal survival: we found no variation between sites but a lower survival after the summer period than after the winter season. Distribution analysis comparing old data from censuses done by the Park rangers in 1987–1989 with more recent data, highlighted the variation in the elevation range occupied by this species, providing evidence of some attempts of adaptations to the new conditions.

All these results taken together suggest that marmots are modifying their use of the habitat and their distribution, and that sociality and predation shape Alpine marmots dynamics. We conclude raising the question: when the most suitable habitat becomes a limited resource, where is the limit of the benefit of being social in this warming world for alpine marmots?



## Beneath the snow and the rocks: the winning strategy of the snow vole in harsh environments

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GPM03

The snow vole (*Chionomys nivalis* Martins, 1842) is a Rodent of the Cricetidae family with a particular ecology and biology. It lives in stony environments, it has a promiscuous mating system and, unlike most other voles, it probably adopts a K reproductive strategy. The species has so far been little studied in the Alps, also because low local densities make sampling challenging and demanding. In particular, long-term studies on the dynamics of its populations have never been attempted. Since 2010, a study has been launched in the Gran Paradiso National Park to clarify some aspects of its ecology. The study aimed at estimating the occupancy in sample sites and monitoring its change over time, with respect to climatic conditions too.

The data on the species were collected in different sample areas, in the High Orco Valley (2010–2012) and the Cogne Valley (2014–2018), by capturing and (in some sessions) marking and recapturing the animals, using folding Sherman traps. The data were then analyzed with specific software (MARK, Density, R) to estimate the abundances or densities of the animals, the probability of presence and the selection of the microhabitat, and to obtain estimates of the occupancy. To investigate the correlation between occupancy and climatic-vegetation variables, we related the occupancy estimates to the normalized vegetation index (NDVI) and the Palmer index (PDSI), through the use of the Pearson correlation coefficient. Data on the sex, age and weight of the animals were recorded. During 2017, biological samples were also collected for analysis of the parasitic load.

The results confirmed that the species is present in the Park's stony areas, up to 2900 m, probably with variable densities. In

Valle Orco the estimated abundances showed marked variations over time too (from  $3 \pm 1$  to  $27 \pm 9$  animals  $\pm$  std. err.), and data also suggested that the winter mortality in the species is reduced. On the contrary, in Cogne the occupancy estimates suggest an overall stability, with limited (non-significant) inter-annual fluctuations consistent with the reproductive pattern, with the largest proportion of occupied sites in late summer. Overall, the trend appears stable over the years, and a positive and moderate correlation between occupancy and NDVI can be observed. As the NDVI value increases, the occupancy values also increase, as expected. Finally, the species is not particularly selective at the microhabitat level. However, for the Cogne study site, our occupancy models suggested that the species positively selects areas with scarce vegetation cover and small rocks, in accordance with previous studies on the species.

Our data confirm the peculiarities of the snow vole. The species can survive the severe high-altitude winters thanks to its adaptation to living under the snow cover, which provides refuge from predators and shelter from the cold. In the summer, the key to the survival of the snow vole at high altitudes seems linked to the macrohabitat selection. The species is strongly dependent on the rocky areas. Similar to the snow cover in winter, stony environments probably ensure climatic micro-stability in the summer. This stabilizing function could be performed more or less effectively depending on the size of the rocks within the stony ground, but the most limiting factors (e.g., climate and predation risks) are selected for most strongly at a larger spatial scale.

**Giovedì 9 Giugno 2022**

### Moderatori

Leonardo ANCILLOTTO, Marco SCALISI

XII Congresso Italiano di Teriologia

### First Atlas of Italian Mammals

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MO10

The Italian Mammal Society, namely Associazione Teriologica Italiana (ATIt) is completing the first atlas of Italian mammals that is expected to be released in 2022, both in Italian and in English. The Atlas is based on the check list of native and alien species regularly occurring in the country published in 2019. About 119 ATIt members contributed as authors and to distribution data revision and integration for 140 species accounts, including 18 marine and 16 allochthonous species (five of which listed in EU regulation 1143/2014). The Atlas is based on 1073190 occurrence records derived from different sources and platforms, rasterized as 10×10 km grid cells. Data sources included citizen science initiatives that ATIt promoted or supported on various platforms (e.g. iNaturalist project “Mammiferi d’Italia” <https://www.inaturalist.org/projects/mammiferi-d-italia>, [ornitho.it](http://www.ornitho.it), CS-MON <http://www.csmon-life.eu>), data provided by national parks, museums, research institutions, private institutions, na-

tional inventories, regional atlases, and original observations provided by the authors. All occurrence records were checked by authors as still valid in 2021. Species accounts include information on taxonomy, global and Italian distribution, habitat and ecology, and conservation status. As no systematic surveys were run for the atlas purposes, the final maps evidenced gaps for some species/areas that need to be filled in the future. Gaps of knowledge were especially evident for the regions Marche, Puglia, and Basilicata, whereas data deficient species included mainly bats and small mammals. The large bias towards a restricted number of highly visible and easily identifiable species that resulted from citizen science data were largely corrected by data obtained from authors and scientific institutions. Our results underlined that, at least for the highly diversified and elusive mammals, citizen science initiatives need to be integrated with data collected by research specialists, hopefully based on robust survey designs.

**Valuing cultural ecosystem services: the case of the apennine brown bear**Tattoni C.<sup>1,2</sup>, Galaverni M.<sup>3</sup>, Pollutri A.<sup>3</sup>, Preatoni D.G.<sup>1</sup>, Martinoli A.<sup>1</sup>, Araña J.E.<sup>2</sup><sup>1</sup>Unità di Analisi e Gestione delle Risorse Ambientali - *Guido Tosi Research Group*, Dipartimento di Scienze Teoriche e Applicate, Università degli Studi dell'Insubria, Varese, Italy<sup>2</sup>TiDES, Institute of Sustainable Tourism and Economic Development, University of Las Palmas de Gran Canaria, Spain<sup>3</sup>WWF Italia, Roma, Italy

MO11

Human-carnivore conflicts can be viewed also as a consequence of the unequal distribution of the costs and benefits that predators brings at the local, national or global scale. Large carnivores existence is valued globally, for cultural, aesthetic, or spiritual reasons but this value is difficult to estimates in monetary terms. The costs of damages and management, instead, impact the residents and are easier to quantify. An effective communication of the benefits provided by large carnivores has been demonstrated to increase their acceptance at the local level, especially where nature based tourism is present. Large carnivores in general are reported to maintain biodiversity and support various Ecosystem Services (ESS) and several examples can be found in the literature. Bears play an important role in the ecosystem as seed dispersers, contribute to the cycle of organic matter and control populations of insects and provide recreation opportunities (bear-watching). These ecological functions produce benefits that are difficult to quantify economically on the market and to communicate to the general public, whereas the benefits of bear watching are easier to estimate. In Italy, where bear tourism is very limited, it is still not possible to measure its economic impact. Nevertheless the cultural importance of the bears was analysed in a few works: many alpine villages have a bear in their coat of arms and many business activities boast this mammal in their name or logo and hundreds of name-places are distributed throughout the Italian peninsula

In this work, we propose to estimate the value of the Apennine brown bear as destination promoter. This bear is endemic of central Italy and, beside its ecological value, it can be considered an icon of the area that could attract tourists in search

of nature and wilderness. Content analysis of traditional media was coupled econometric techniques to assess the effect of the Apennine brown bear in making the location more apparent to potential visitors, by: 1) measuring the Apennine brown bear's value in terms of indirect advertising in major Italian newspapers and television channels; 2) examining the emotion represented by those contents, and 3) comparing the results with the management costs.

During the period of investigation, from 2015 to 2020, we encountered 166 appearances of the Apennine brown bear on TV and 283 articles in the newspapers of national relevance. The national media's attitude toward the Apennine brown bear from was generally positive, with the TV showing a more positive attitude (84%) than the press (64%). The Apennine brown bear's value as a destination image was calculated as the advertising equivalent of the bears' appearances in the press and on television. We calculated how much would have costed to buy the same printed space occupied by the bear on the page for the press or a spot of the same duration on TV. The 11 million euros in advertising equivalent much outweighed the compensation (53500 Euro) for damages and management sustained within the same time period. These findings support the adoption of the Apennine brown bear on the label of certified local products, as proposed by the LIFE ArcPROM project (LIFE18 NAT/GR/000768), because those who do so would profit indirectly from the Apennine brown bear's media visibility. This evaluation of cultural value could contribute to the discussions with managers and stakeholders quantifying one of the many benefits supplied by the bear.

## Coupling density and occupancy estimations to assess abundance and conservation status of an endangered mammal across its range

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MO12

The current decline of mammals worldwide makes quantitative population assessments particularly important, especially for range-restricted and threatened species. However, scientifically sound abundance estimations are difficult for elusive or otherwise difficult to detect species. Hence, alternative metrics requiring only presence/absence data, such as occupancy, are desirable. While calibration of these metrics with independent density estimates are required, they are rarely performed. We aimed to contribute an example of such approach by coupling density with occupancy estimates to assess abundance and conservation status of an endangered primate.

We targeted the IUCN-Endangered Sanje mangabey (*Cercocebus sanjei*) across its entire range in the Udzungwa Mountains of Tanzania. First, we estimated spatially-explicit occupancy from systematic camera trapping to assess occurrence in relation to environmental and anthropogenic variables in two disjoint forests with different management regimes. We then calibrated these estimates to density estimates from a systematic acoustic survey and used the occupancy-density relationship to derive

group density across the species range. We found significant occupancy-density relationships for the two forest blocks where this primate occurs. Occupancy was higher in the northern forest in the National Park than in the southern Nature Reserve and increased in montane and interior forest zones. Accordingly, we predicted an average density ( $\pm$ SE) of  $0.28 \pm 0.07$  groups/km<sup>2</sup> in the National Park and  $0.22 \pm 0.05$  in the Nature Reserve. In view of the much larger area of the reserve, the average predicted individual abundance was  $1652 \pm 422$  and  $2205 \pm 544$  in the northern and southern forests, respectively, with the mangabey abundance in the reserve that resulted higher than previously found.

Given the elevated past disturbance and poorer protection status of the Nature Reserve, our results provide for optimism, although occupancy analysis clearly highlighted the vulnerability of this primate to human disturbance. Our approach appears valuable for spatially-explicit density estimations of poorly sighted species, and in turn it provides for sound assessments of the vulnerability and identification of priority areas for the conservation of threatened populations.



### Moderatori

Paola BARTOLOMMEI, Lucas A. WAUTERS

XII Congresso Italiano di Teriologia

### Climate changes and ungulates, impacts and perspectives

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EOO1

Climate changes are more and more impacting biodiversity and human activities. Ungulates within animal communities are dominant species with a recognized role as ecosystems engineers, therefore, their population dynamics variations and distribution changes can deeply affect the environment, it is therefore interesting to evaluate how climate changes can impact the species belonging to this group in order to understand the future trends we are expecting to experience. Climate changes, with specific reference to increasing temperature, can impact ungulates in relation to their feeding opportunities both promoting mismatch between vegetation and parturition times, but also promoting changes in the plant species composition and productivity within ecosystems. Moreover, heat tolerance can vary a lot among species inducing activity shift or/and altitudinal changes. Finally, a warmer temperature and a less predictable weather can further impact species linked to specific environmental factors limiting or favouring their survival. Warming climate can definitely be beneficial to species like wild boar that shows a particular plasticity in its reproductive biology and is linked to

pulse resource availability, that seems in turn to be increased by present temperature trends. However, it seems plausible that extreme changes could have a detrimental impact also on this very adaptable species. Mountain ungulates on the contrary seem to suffer all the aforementioned damages from the changing climate, showing many biological characteristics that are vulnerable to increasing temperature with limited benefits linked to the reduction of snow cover. However, this trend is not always consistent among species and among geographical areas. More specifically, even in this group, characterized by a widespread stenothermic adaptation there are species that, thanks to their ecological plasticity can better cope with the present changes and in perspective may result more resilient even if with a different abundance and distribution among environments. In this talk I will examine these themes with the support of the research done by our group in the last 20 years and of the European scientific community in order to provide future scenarios together with conservation and management issues.

## First telemetry data on golden jackal (*Canis aureus*) in Italy: insights on the species' spatial ecology

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E002

Understanding the spatial ecology and habitat requirements of a colonizing species is the main step to gain information on the species' behaviour which is useful to delineate adequate management and conservation strategies. The golden jackal (*Canis aureus*) has been showing a notable expansion in Europe over the last five decades and, in Italy, the highest population densities are reported in Friuli Venezia Giulia (hereafter, FVG) Region. Here, reproductive packs exert a pivotal ecological role as a source population for the colonization of the other Italian administrative Regions. Among the many factors which have been described as important for its expansion, the ecological plasticity (i.e., the capability to take advantage of different habitats) has been considered as crucial. However, few studies of habitat selection have been conducted using bio-logging technology (e.g., GPS collars). In the last 20 years, this technology has been frequently used and improved, enabling researchers to deeply investigate the ecology and behaviour of cryptic species, including carnivores. Using the first telemetry data obtained from collared individuals in Italy, the goal of our study was to investigate the spatial ecology of the golden jackal, with special focus dedicated on home-range estimation and habitat selection. Our results should provide better understanding on the ecology of a colonizing species in the light of its expansion within a highly anthropized environment, such as the Italian lowland.

Our study was conducted mainly in FVG, the north-easternmost administrative Italian Region, covering an area of 7921 km<sup>2</sup> with 1.2 million inhabitants. We fitted eight individuals (three females, five males) with radio- (VHF) (n=1) or satellite (GPS) collars (n=7) in 2019–2021. Two individuals were defined as dispersers, since they moved from their pre-reproductive territories (>20 km far away) toward new areas. Four jackals were live captured with Belisle snares or box traps, and the latest four were recovered and released after vehicle collisions. We acquired a minimum of two locations per day from the VHF monitoring, meanwhile the GPS fix schedule was set to acquire 3–4 locations per day. We performed the 50% and 95% home-range estimation through a minimum convex polygon (MCP) for the VHF collared jackal; and 50% and 95% utilization distributions (UD) home-range using a kernel density estimator with plug-in bandwidth selection for the GPS collared jackals. We used the Corine Land Cover 2018 reclassified into 11 land cover categories, to investigate the degree of habitat selection through selection ratios at the third-order of selection (Design III) within 50% and 95% UD on the seven GPS collared jackals. All computations were performed through the Software R (v. 3.5) and using `ks` and `adehabitatHS` packages.

The monitoring periods for each individual were highly variable, from a minimum of 36 days to a maximum of 342 days. Overall, we obtained 3827 locations, of which 67 were VHF locations.

50% and 95% MCP home-ranges for the VHF collared individual were 0.18 km<sup>2</sup> and 1.01 km<sup>2</sup>, respectively. A high variability was shown in both the 50% and 95% kernel UD, with a mean home-range of 3.24 km<sup>2</sup> (min=0.15 km<sup>2</sup>, max=14.84 km<sup>2</sup>) for 50% and 31.22 km<sup>2</sup> (min=2.22 km<sup>2</sup>, max=135.92 km<sup>2</sup>) for 95% UD. The pattern of global habitat selection by golden jackals significantly deviated from random both within 50% UD ( $\chi^2=143.96$ , df=22,  $p<0.001$ ) and 95% UD ( $\chi^2=649.77$ , df=22,  $p<0.001$ ). Within 50% UD, jackals selected coniferous forests and avoided areas without vegetation. Within 95% UD, jackals selected cultivations with natural elements, while they avoided mixed forests. However, contrary to the 95% UD, at 50% UD habitat selection at individual level was not statistically significant for all individuals.

Home-range estimation through the 50% and 95% UD with kernel methods showed high variability most likely due to the different monitoring periods and individual variations (resident vs dispersal). However, 50% and 95% home-ranges were in line with other published studies with the exception of a young female who showed an extremely large home-range (135.92 km<sup>2</sup>) due to dispersal patterns. Interestingly, the VHF collared individual displayed its 50% and 95% MCP home-ranges within those of its putative father (GPS collared). The habitat selection analyses provided interesting results: 50% UD were inspected through field surveys and were mainly related to resting sites; as expected jackals selected for natural vegetated areas and avoided areas without vegetation, as they cannot provide shelter. At 95% UD, habitat selection highlighted how jackals can exploit human resources since they selected for agricultural areas (all agricultural areas covered 35.10% of the overall land cover types, whereas vegetated natural areas covered 54.79%). Indeed, as reported by different studies in Europe, agricultural areas can provide abundant food resources. At the individual level, those jackals who showed non-random selection had different patterns due to the different ecological conditions. It is noteworthy that one individual showed selection at both 50% and 95% UD for anthropic land cover types (i.e., urban areas, crops and complex cultivations), as it was feeding very close to human settlements and roads. At the same time, all the other individuals avoided urban areas at the 95% UD individual level. In conclusion, we point out the ecological plasticity of golden jackal which enables the species to exploit different habitats, even near human settlements, which might be one of the main factors which has been promoting the expansion in Europe in the last decades. Moreover, GPS collars provide high quality data collected over time useful to deeply investigate different topics (e.g., habitat suitability), compared to other limited techniques (i.e., camera-trapping and jackal-howling).



## Effects of humans and domestic cats on the occurrence of the European pine marten on Elba Island



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E003

The European pine marten *Martes martes* is widely distributed throughout Europe, and can be found on several islands in the Mediterranean region. However, the status and distribution of these insular populations is poorly known. We investigated pine marten's spatial distribution on Elba Island, where the species is the only wild carnivore present, in response to vegetation type and elevation. We also assessed whether and how martens' response to distances from roads and settlements was conditional on marten's co-occurrence with humans and domestic cats. Between February-July 2020, we collected camera-trap data at 77 locations throughout Elba Island (elevation range: 35–720 m asl), sampling for at least 30 trap days at each site. Using single-season multi-species occupancy models, we found evidence that martens' occupancy was generally high across vegetation types and elevation. Furthermore, distance from roads was an important predictor of the species' occurrence, with its effect varying greatly, conditional on humans or cats' presence.

Distance from roads positively affected marten's probability of occupancy only in sites where humans occurred, and it was constant otherwise. Additionally, martens' occupancy was positively affected by distance from roads both in the presence and absence of cats but probabilities were higher at sites where cats co-occurred, indicating a potential selection for locations with similar characteristics by both the species. Our study shows that the presence of humans can modify martens' response to human infrastructure; these findings can have important management implications and help identify important areas to ensure species' persistence. In lack of natural competitors, pine marten has the plasticity to occur across all environments and elevation available on the Elba Island, but the presence of humans reduces the probability that some specific areas are occupied. Finally, the causes generating the patterns in co-occurrence of domestic cats and martens deserves further investigation.

## Seasonal and environmental determinants of small mammals and their zoonotic potential across a wide latitudinal and altitudinal gradient

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E004

The functional role and position of a species within the environment is strongly governed by the interplay between species internal state, abiotic and biotic environmental conditions, as well as by multi-species interactions (predation, competition and parasitism). In this work we have implemented a multi-factorial niche-based approach to evaluate the consequences and patterns of environmental, climate and anthropic changes on small mammal populations and assemblages, considering also the cascading effects on parasite loads and thus on emergence of zoonotic and non-zoonotic diseases.

To achieve this goal, we carried out a treatment-control experiment with supplemental *ad libitum* food accessible all-year-round to woodland rodents at two latitudinal extremes i.e. Norway (from 2013 to 2015) and Italy (from 2019 to 2021). Secondly, we assessed the composition of small mammal assemblages across a wide altitudinal gradient (from 500 to 2500 m a.s.l.) in the Italian Alps (2019–2020). In both studies, we live-trapped small mammal species using a capture-mark-recapture approach. In Italy only, we counted the tick burden on rodents and collected biological samples (ear biopsy, blood sample) and molecular and serological screenings were subsequently performed for rodent- and vector-borne pathogens assessment. Within this work, we captured a total of 917 small mammals in Norway and 830 in Italy. In the latitudinal comparison, only bank vole (*Myodes glareolus*) was sampled in Norway, while two mice species (*Apodemus sylvaticus* and *A. flavicollis*) and bank vole in Italy. Within this comparison, we found that individual rodent survivorship seemed to be governed by seasonal cycles and overridden by food availability only when unfavourable conditions occurred. Conversely, local population size generally increased with supplemental food availability, unless when both mice and voles were sympatric (in Italy only). In this case, the dominant species (i.e., *Apodemus* spp.) performed better both on survival and population size respect to the subordinate one (i.e., *M. glareolus*). In Italy, rodent abundance and spatial aggregation registered at sites provided with supplemental food favoured

also tick burden on rodent hosts, especially on heavier animals. Beyond exploitation of rodent hosts, ticks were also favoured by less-limiting climatic conditions, indeed we sampled them at 2000–2500 m a.s.l., the highest altitude at which ticks were recorded in central Europe. At those altitudes, representing the cold and remote edges of small mammal distribution, we monitored the distributional overlap of snow vole (*Chionomys nivalis*), field voles (*Microtus* spp.) and unexpectedly of bank vole, which occupied also woodland habitats in sympatry with mice. Further, we also detected an altitudinal pattern among vector-borne pathogens, with *Borrelia* spp. infection at low altitudes, while *Anaplasma phagocytophilum* and *Babesia microti* mainly occurred at high altitudes. Beyond these common vector-borne pathogens, we also found *Hepatozoon* spp. along the entire altitudinal gradient and on snow voles for the first time. These findings suggest that modifications in rodent demography and community structure, as well as host-parasite association, were favoured by homogeneous and human-disrupted areas such as at ungulate feeding stations. In these areas, if tick density in the environment is supportive, the presence of both rodents and deer may favour the completion of tick life cycle and enhance pathogens circulation among hosts. Moreover, the generalist species (e.g. *M. glareolus*), that occurred along a wide altitudinal range in sympatry with more specialist (e.g. *Apodemus* spp.) and climate-sensitive ones (e.g. *C. nivalis*), may be prone to upward distributional shifts and further promote the geographic expansion of arthropod vectors. This may also facilitate the spread and transmission of zoonotic pathogens under a climate change context. Overall, this study suggests that the multiple extrinsic and intrinsic environmental facets and biotic interspecific forces governing small mammal demography and communities should be considered ensemble using a multi-factorial approach, especially in perturbed ecosystems. Further, changes in small mammal populations and communities seem to alter host-vector-pathogen interactions, increasing the risk of transmission of infectious diseases both on wildlife and humans.

**Prey richness and diet breadth of large terrestrial carnivores**Ferretti F.<sup>1</sup>, Lovari S.<sup>1</sup>, Lucherini M.<sup>2</sup>, Hayward M.<sup>3</sup>, Stephens P.<sup>4</sup><sup>1</sup>Research Unit of Behavioural Ecology, Ethology and Wildlife Management - Department of Life Sciences - University of Siena, Italy<sup>2</sup>Grupo de Ecología Comportamental de Mamíferos, Laboratorio de Fisiología Animal, INBIOSUR (Instituto de Investigaciones Biológicas y Biomédicas del Sur), Universidad Nacional del Sur - CONICET, San Juan, Bahía Blanca, Argentina<sup>3</sup>Conservation Biology Research Group, School of Environmental and Life Sciences, University of Newcastle, Callaghan, Australia<sup>4</sup>Conservation Ecology Group, Department of Biosciences, Durham University, South Road, Durham, UK

E005

Ecological and evolutionary theories suggest contrasting expectations about the response of foragers to variation in the diversity of food resources. A greater resource diversity is expected to occur in richer systems. Under these conditions, consumers would be expected to specialise on the most profitable resources, increasing their selectivity. Conversely, foragers may be expected to take advantage of a greater diversity of food resources by increasing their dietary niche, leading to a broader diet breadth. We have tested these alternative predictions on large terrestrial carnivores. These mammals have a great relevance for ecosystem processes, and their persistence is strongly favoured by availability of large prey. However, information on the effects of richness of large prey on their diet breadth is scarce.

We have collated data on food habits of large terrestrial carnivores from literature to estimate site-specific and species-specific indices of diet breadth. For each study (N=505), we estimated the Levins Index and an additional index specifically focused on large prey (weighing more than 10 kg), i.e. the number of large prey used with a frequency greater than 5% (hereafter, Large Prey Index). We also derived from literature the local richness in number of prey species larger than 10 kg. First, for each species, we averaged diet breadth indices and prey richness across studies and modelled species-specific values against prey richness through linear models. Second, for each species we modelled site-specific indices of diet breadth against local prey richness. Third, for three carnivores with a large distribution range encompassing different continents (i.e., the grey wolf, the leopard and the puma), we conducted separate analyses for different continents, to test whether the relationships between diet breadth and prey richness were consistent across ecosystems showing very different prey/predator communities.

At the inter-specific level, carnivores living in prey-richer areas showed a broader diet breadth than those living in prey-poorer ones. However, carnivores living in prey-richer areas used a

lower proportion of available prey species than those living in prey-poorer areas, suggesting an increased selectivity in the former than in the latter. At the intra-specific level, only seven species (the tiger, the lion, the jaguar, the spotted hyaena, the puma, the grey wolf and the Eurasian lynx) showed broader diet breadth along with increasing local prey richness. These carnivores include the largest terrestrial predators, and they were usually dominant species in the areas from which data were available. For three species (the leopard, the cheetah and the African wild dog) the diet breadth showed no variation, whereas for two species (the snow leopard and the dhole) it decreased, along with increasing prey richness. Both the wolf and the puma showed consistent increase of diet breadth with prey richness across continents, whereas the leopard showed it only in Asia but not in Africa.

Carnivores living in prey-richer environments have a broader diet breadth but, at the same time, may show a more selective behaviour than those living in prey-poorer areas. In turn, a greater selectivity would increase interspecific dietary partitioning in areas that are also expected to host a greater number of carnivore species. The largest and dominant carnivore species are expected to encounter little competition in expanding their dietary breadth with increasing local prey richness, whereas the dietary niche of sub-dominant large carnivores would be limited by competition with larger, dominant predators. These findings are supported by inter-continental patterns found in the leopard, which seems to behave as a “subordinate” carnivore in Africa (where it usually coexists with larger and gregarious predators such as the lion and the spotted hyaena, besides some other species), and as a “dominant” carnivore in Asia (where its principal competitor is the tiger, i.e. a solitary and relatively rare predator). Over evolutionary time, food partitioning may have been particularly important in shaping the dietary niche of smaller, inferior competitors than that of larger, dominant ones.

## Evidence for density-dependent effects on body composition of grizzly bears in the Greater Yellowstone ecosystem

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E006

In large mammals, individual performance and local population density are intrinsically linked through a feedback mechanism that leads to demographic changes. Density-independent factors, such as resource availability or landscape changes, also influence this feedback process by lowering carrying capacity and increasing density dependence. Although studying the link between individual performance, population density, and environment in long-lived species is crucial for understanding ecological processes in today's fast-changing world, the availability of long-term data often limits the capacity to research such mechanisms in free-roaming animals.

In this study, we tested whether density-dependent factors influenced changes in grizzly bear (*Ursus arctos*) lean body mass and fat percentage, both measures of individual performance, during years of environmental changes in the Greater Yellowstone Ecosystem. For this purpose, we used longitudinal morphometric data from over 400 grizzly bears captured for research purposes between 2000 and 2020. We used lean body mass measurements of individual grizzly bears to fit population-level, sex-specific growth curves, and fat percentage to estimate body fat accumulation over the active season (May to October). Thus, we tested the effect of local population density on growth and

fat levels, as determined by a spatio-temporally index based on grizzly bear telemetry data, while controlling for ecosystem variability and human-caused disturbance.

Individual lean body mass was negatively related to population density, especially among young females, indicating a performance-density relationship across life-stages and sex. In contrast, despite significant landscape-level changes over the last two decades, our findings revealed that grizzly bear body fat levels and rate of accumulation were unaffected by population density. This suggested that sufficient food resources were available on the landscape to accommodate successful, plastic shifts in feeding tactics in the face of perturbations and competition.

In a relatively human-free ecosystem, the Greater Yellowstone Ecosystem provided a unique environmental context for investigating demographic dynamics while controlling for human-caused disturbance. In particular, our findings shed light on the ecological feedback processes that influence individual performance within a population that is experiencing demographic and ecosystem-level changes. We further emphasize the value of long-term research and protected areas for examining ecological relationships in an increasingly human-dominated world.

## A wild personality: individual risk-taking behaviors of wild boar

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E007

Personality theories predict animals will exhibit sets of correlated risk-taking behaviors, i.e., a constant willingness to take risks across different situations. While personalities were mostly investigated under artificial experimental conditions, it is unclear whether wild, free-ranging animals spontaneously exhibit correlated risk-taking behaviors.

To investigate this issue, we merged a large dataset of spatial positions of 43 free-ranging wild boar (*Sus scrofa*) with the spatial distribution of human-related risks. The monitored individuals were sampled from two Italian populations living in extremely different environmental conditions (food availability, weather, natural predators) but sharing man as first cause of mortality. We measured four different risk-taking behaviors at both the population and the individual level (human avoidance, site-fidelity, selection for covered habitats, and mobility).

In the two populations we detected a similar risk-taking syndrome, with wild boar clustering in two groups sharing homogeneous sets of risk-taking behaviors. Contrary to the theoretical expectation which predicts an individual exhibition of consi-

stant risk-taking strategies, we observed a compensation among pairs of risk-taking behaviors. The individuals that could be considered risk-avoiders, on account of strong site-fidelity and human avoidance, were risk-prone in terms of a low selection for covered habitats and a high mobility. The other group of wild boar exhibited an opposite behavioral strategy, characterized by a low site fidelity and a scarce human avoidance, but also by a high selection for covered habitat and a low mobility.

Our results suggest that wild and free-ranging animals may adaptively exhibit strategies trading-off different risk-taking behaviors. The similarities of risk-taking strategies among the two monitored populations, sharing only man as the main cause of mortality and differing for all the other environmental conditions, suggested that the observed syndrome was likely caused by humans by means of an unintentional selection. The novel findings on the personality of wildlife may provide innovative lines for the management of the pest species, as wild boar, in several European contexts.

## Wildlife response to human functional disturbance: a case study during the Anthropause



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E008

Animal species are subject to two main different forms of anthropogenic disturbance, i.e. structural (e.g., presence of barriers or habitat fragmentation) or functional (e.g., actual human presence for hunting or recreational activities). With specific reference to the latter, animals adopt a series of behavioural adaptations to cope with human disturbance, for example by switching their activity patterns towards night-time to minimize the risk of being hunted, or to reduce the temporal overlap with human activities, especially in highly anthropized environments. Examining the degree of behavioural plasticity of animal species in relation to modifications of anthropogenic disturbance is therefore essential to fully understand the impact of humans on animal behaviour, and the capability of the animal species to adapt to human pressure. In this context, the reduction in human activities during COVID-19 lockdowns, which has been particularly severe in some Countries as Italy, constitutes an unprecedented semi-experimental condition to examine the responsiveness of animals to a dramatic alteration of human pressure, namely the "Anthropause". We investigated this aspect in an anthropized area of Italian Alps, with the specific aim to analyse the adaptive response of three mammal species, namely roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*) and European badger (*Meles meles*) to the variation in functional disturbance that occurred during the Anthropause.

We performed our assessment in a peri-urban area of the Eastern Alps (Valle di Cembra, Trentino Alto-Adige), focusing on the patterns of visits by these three species to eight artificial foraging sites, which have been monitored by means of camera traps both during the lockdown (9 March–4 May 2020) and in the same period in 2019, the latter being used as a baseline for our empirical evaluation of animal responsiveness to alteration of human pressure. We have used an artificial intelligence (AI) algorithm (YOLOv4), combined with manual observation, to analyse over 130000 pictures collected in 2019 and 2020. We have analysed the circadian pattern of visits to the feeding sites

by means of circular statistics (daily trend), while we have used Generalized Additive Mixed Models (GAMMs) to investigate the trend of use of feeding sites by the three target species over the period of analysis (i.e., 9 March–4 May 2020 compared with 9 March–4 May 2019).

We found that all the three species increased their number of visits to feeding sites in 2020 compared to 2019. We did not detect any temporal circadian alteration in the patterns of visits from 2019 to 2020, with badgers and red deer remaining strictly nocturnal, while roe deer exhibited the typical peaks of visits at dawn and dusk, with the rest of activity concentrated in nightly hours. Instead, the trend of visits to feeding sites over the examined period changed both for roe deer and badger, but not for red deer. While the pattern of visits to these anthropogenic resources was mainly dictated by seasonality in 2019, in 2020 we observed a clear link with the intensity of the lockdown, i.e., an increase of visits over the strict lockdown period, followed by a reduction when some mining activities occurring in the immediate surroundings restarted.

The absence of a clear change in the circadian pattern of visits, i.e., without an increase in daytime visits during lockdown — often time reported by several unusual observations of wildlife in that period — suggests that the adaptation towards nocturnality in these species is likely a fixed behavioural trait, which a relatively short alteration of human disturbance has not been able to release. The response obtained in badger and roe deer relative to the trend during the observation period denotes the high plasticity of these species, which have increased the use of a resource linked to anthropogenic risk in the absence of cues of anthropic functional disturbance (for example noises quarries or forestry works). Taken together, these results confirm what has already been observed in numerous other studies, namely that the response of wildlife to the so called Anthropause is articulated and complex, depending on the characteristics of the species and the time scale at which the analysis is performed.

## Leave it or take it: effects of seed size and individual variability on acorn choice and management by different-sized sympatric rodents

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E009

Seed management by hoarding rodents and the related decision-making process represent a major focus in several studies in the context of plant-animal interactions. In fact, acting both as seed dispersers and consumers, scatter-hoarding rodents can affect population dynamics of many plant species. Their foraging decisions, by determining the seed fate, can ultimately affect plant reproductive success and life-history traits. Scatter-hoarding behaviour towards the optimised seed choice and consists of a series of trade-offs. Animals choose seeds and decide how to manage them primarily basing on the evaluation of several seed traits like seed size, nutrition content and defensive compounds, and other factors like perceived risk of predation and individual variation in behaviour. While seed size is considered an important factor affecting seed management by rodents, the influence of individual variability and interspecific variation between different-sized sympatric rodents in scatter-hoarding behaviour have been largely overlooked, although they can potentially determine multiple foraging decisions. Through a semi-natural experiment, the present study aimed to investigate seed management by different-sized sympatric hoarding rodents in relation to seed size and the role of individual variability at determining seed choice and fate. As our model we used a plant-

disperser assemblage widely distributed in Europe: Turkey oak *Quercus cerris* together with wood mouse *Apodemus sylvaticus* and yellow-necked mouse *A. flavicollis*, key consumers and dispersers of acorns. We found that seed choice and fate partially varied among individuals and was significantly influenced by seed size in both species, often with species-specific effects on seed management. More specifically, the probability of a seed to be consumed significantly increased with acorn size for the yellow-necked mouse, unlike the wood mouse. Seed removal probability significantly increased with acorn size and with the acorn size/rodent size ratio for both species, which removed acorns of comparable weights despite their differences in body size. Finally, the probability for seeds to be consumed after removal rather than in situ sharply increased with acorn size for both species. Wood mice also tended to disperse more acorns at increasing seed size. Our study highlights the relevance of jointly analysing crucial factors that can affect seed choice and management. Individual variability and seed size played a relevant role in foraging decisions of scatter-hoarding rodents with a species-specific response to such factors, underlying the importance of considering interspecific variation in studies on seed management by rodents.

## Effects of an invasive alien species on coping style and behavioural syndrome in a native squirrel

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E010

Free-living animals cope with threatening environmental perturbations through a suite of behavioural and physiological responses, which can be integrated within a coping style. Proactive (bold, active-explorative and social) individuals are predicted to exhibit lower hypothalamic-pituitary-adrenal (HPA) axis reactivity than reactive ones (shy, less active-explorative, less social). This relationship may be influenced by human-induced rapid environmental change (HIREC), such as the introduction of invasive alien species (IAS). Expression of personality traits and occurrence of behavioural syndromes has been demonstrated to be affected by rapid environmental changes such as urbanization and pollution. However, few studies highlighted that interspecific competition caused by an IAS disrupts behavioural syndrome in a native species and affects its physiological stress response. In this view, potential effects of IAS on native species coping style urged considerations.

Here we explored the association between personality traits and one integrated measure of HPA axis activity in Eurasian red squirrels (*Sciurus vulgaris*), both in sites uncolonized (natural populations) and colonized (invaded populations) by an IAS, the Eastern grey squirrel (*Sciurus carolinensis*). We used faecal glucocorticoid metabolites (FGMs) as an integrated measure of adrenocortical activity, and measured the levels of four personality traits (exploration, activity, activity-exploration and social

tendency) with an open field test (OFT) and a mirror image stimulation (MIS) test.

We predicted that behavioural and physiological responses would covary and that activity, exploration and social tendency would be associated forming a behavioural syndrome in natural populations. Conversely, we expect that this relationship would be disrupted in sites colonized by the IAS. Our findings showed that there was no correlation between FGMs and personality traits, neither in natural nor invaded populations. However, our results highlighted that in sites where the native species does not compete with the IAS, personality traits were correlated indicating a behavioural syndrome, which was disrupted in invaded populations.

This study is one of the few that show how the impact of an IAS, acting as environmental stressor, influence native species' behavioural syndrome, but does not affect the relationship between physiological stress and behavioral responses (coping style). This add further insights on the global widespread problem of IAS and highlight that physiological stress responses in free-living animals may be more complex. Indeed, future studies integrating multiple stress response measures and behavioural traits are needed to add knowledge on the interspecific competition between native and invasive species mechanisms in wild populations.

**Genomic damage in grey squirrel population living in urban and agricultural areas**Bonaldo I.<sup>1</sup>, Wauters L.A.<sup>2</sup>, Bertolino S.<sup>1</sup>, Santovito A.<sup>1</sup><sup>1</sup>Università di Torino, Via Accademia Albertina 13, 10123 Torino.

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Animal and human populations are increasingly exposed to a high range of environmental pollutants, increasing the genomic instability of these populations, with consequences on their health and life expectations. Many wild mammals are expanding their range, colonizing urban and suburban areas. In occupying human-altered environments, these species are increasingly exposed to various environmental pollutants that may increase their genomic instability affecting the baseline values of cytogenetic markers. A method to search for genomic damage was developed for humans to provide insights into the genotoxic effects of factors related to lifestyle. The assay has been successfully used to evaluate the impacts of environmental stressors, such as atmospheric pollution, dust particles, pesticides and heavy metals, on human health. These xenobiotic factors are equally likely to affect animal populations living in the same environment.

Our laboratory is developing protocols to apply this method to different wild populations, e.g. mammals (rodents and ungulates), amphibians and invertebrates. These studies will produce information on the health status of animals living in human-dominated landscapes and will inform on the quality of these environments. We propose a research aimed to evaluate the existence of a genomic damage gradient between Eastern grey squirrel *Sciurus carolinensis* populations living in urban areas compared to populations living in agricultural landscapes.

We used the buccal micronucleus test for measuring genomic damage and for detecting both potential clastogenic (chromosome breakage) or aneugenic (chromosome lagging due to dysfunction of mitotic apparatus) effects of different xenobiotics. In particular, micronuclei (MNi) originate from acentric chromosome fragments or whole chromosomes that fail to segregate correctly during mitotic division and appear in the cytoplasm of interphase cells as small additional nuclei. Chromosomal instability was also measured by scoring nuclear buds (NBUDs), representing the elimination process of amplified DNA and excess chromosomes from aneuploid cells.

In every population, we collected a sample of exfoliated cells by gently scraping the buccal mucosa of trapped animals. The buccal swap was then stored in a fixative. In the lab, cells were separated by centrifugation and dissolved in a fixative; the solution was seeded on a slide to detect micronuclei with microscopic analysis at 1000× magnification.

The study population included 96 subjects sampled in two urban and two agricultural areas. The first urban area (Central area,

N=30) was located near the city centre, in a large green area close to the river Po. The second urban area (High traffic area, N=28) was located in a small area attached to a road with a high vehicular traffic (six lanes: three on each side) and close to an exit from the ring road that is widely used to access the city. The other two areas were small private parks southwest of Turin surrounded by intensively agricultural fields. In these areas, we sampled 23 (Area A) and 15 (Area B) animals, respectively. One thousand cells per individual were observed to evaluate the frequencies of MNi and NBUDs, for a total of 96000 analyzed cells.

Results showed that the two agricultural area samples did not significantly differ between them in terms of MNi (Mann-Whitney  $U=152$ ,  $p=0.555$ ), NBUDs ( $U=145.5$ ,  $p=0.425$ ) and total genomic damage ( $U=132.5$ ,  $p=0.235$ ); therefore, they were pooled in a single sample representative of the agricultural landscape. Conversely, the Central area had significantly lower values both with respect to the High traffic ( $U=280$ ,  $p=0.012$ ;  $U=263.5$ ,  $p=0.011$  and  $U=230$ ,  $p=0.002$  for MNi, NBUDs and total genomic damage, respectively) and the agricultural Area A ( $U=200$ ,  $p=0.003$  and  $U=215$ ,  $p=0.015$  for MNi and total genomic damage, respectively) and Area B ( $U=119$ ,  $p=0.003$  and  $U=130.5$ ,  $p=0.020$  for MNi and total genomic damage, respectively). Interestingly, the High traffic area samples did not significantly differ in terms of cytogenetic markers frequencies with respect to agricultural samples, suggesting an effect of vehicular traffic in determining high levels of genomic damage, comparable with those present in agricultural areas.

Our results show that anthropic activities, in terms of vehicular traffic in the urban areas and the use of pesticides in the rural areas, could affect mammal populations in terms of increased levels of genomic damage. The animals in the Central area had much less genomic damage compared to the animals living in the heavily trafficked peripheral area. In recent decades, urban policies have discouraged vehicular traffic in the city centre (e.g. limited traffic and pedestrian areas), moving it to the suburbs. It is known that, in humans, increased levels of MNi are related to increased risk of different types of cancer and other pathologies, such as neurodegenerative and reproductive diseases. Based on this assumption, we can imagine that even in wild mammals, increased levels of genomic damage could be correlated with a reduction in vitality and fitness.

**Rodents in the Alps: the effect of elevation on physiologic and behavioural traits**Melcore I.<sup>1</sup>, Demitri A.<sup>1</sup>, Gargano N.<sup>1</sup>, Boratyński Z.<sup>2</sup>, Bertolino S.<sup>1</sup><sup>1</sup>Dipartimento di Scienze della Vita e Biologia dei Sistemi, Università degli Studi di Torino, Via Accademia Albertina 13, 10123 Torino<sup>2</sup>Association BIOPOLIS, CIBIO-InBIO Associate Laboratory, Research Center in Biodiversity and Genetic Resources, University of Porto, Porto, Portugal

E012

High altitude animals are exposed to extreme conditions, such as low ambient temperatures, hypoxia, lower plant diversity and coverage and reduced seeds production. These factors can create challenging environments, affecting animals' physiological and behavioural traits. Despite the large body of evidence describing the adaptations of high-altitude species, surprisingly few studies have tested differential adaptations at individual and species-level along an elevation gradient in rodent populations. The aim of this study was to analyse the variation within and between species of physiological and behavioural parameters in response to elevation and habitat characteristics. The study area was located in the Gran Paradiso National Park. We identified 12 trapping sites distanced at least 5 km from each other, spanned across an elevational gradient, from 400 to 1822 m a.s.l. Each trapping location consisted of a line of 30 live-traps. Trapped species were *Apodemus flavicollis*, *A. sylvaticus*, *A. alpicola* (determined through genetic analysis) and *Myodes glareolus*. Animals' sex, body measurements, and fur coloration were recorded. Adult animals were transported to a nearby laboratory where body temperature measurements and arena test experiments were conducted for physiological and behavioural analyses.

During the two-years of data collection, we captured 683 individuals (330 females and 355 males), out of which 333 belonged to the genus *Apodemus* and 350 to *M. glareolus*. We found that rodents body temperature increased with elevation ( $\beta \pm SE = 0.023 \pm 0.007$ ,  $z = 3.53$ ,  $p < 0.001$ ) and was higher in females than in males ( $\beta \pm SE = 0.004 \pm 0.001$ ,  $z = 3.85$ ,  $p < 0.001$ ). For most of the studied species, the effect was independent from variation in air temperature, habitat composition and body size or body condition, suggesting other mechanisms behind the detected pattern. During the behavioural experiments, the latency

time and distances travelled differed between the four species. However, environmental covariates and body temperature had no clear effect on either latency time or distances travelled at the species level.

This results show that there are differential physiological and behavioural responses between species, but the mechanisms underlying these detected patterns are not clear. It could be hypothesized that thermoregulatory mechanisms are related to mild tissue hypoxia and greater ventilation of individuals from higher elevation. If true, it would suggest that even weak but chronic hypoxia can influence fitness in small endotherms, possibly affecting their aerobic capacity performance. Another factor that may have affected the body temperature in the high-altitude animals could have been the weak air temperature difference along the elevation, which was lower than expected (7.7 °C to 9.1 °C for 1400 m altitudinal range). This may have made it difficult to detect the thermal environmental effects experienced by highland species adapted to lower temperatures. The behavioural findings may also suggest that, beside the individuals' plastic behavioural response, widely discuss in literature, there may be an evolutionary basis underlying the overall behavioural traits of the study species, which could possibly be determined at the genetic level.

A comprehension of the physiological and behavioural adaptations of species could become even critical considering climate change scenarios where the warmer temperatures in high altitudes are expected to become more frequent, and the structure of the vegetation is changing. Integrative studies on behavioural habitat selection, physiological mechanisms and their selective benefits will explain how rodents adapted to extreme highland environments and shed light on the possibility to adapt to increasing air temperatures.



**Self-medication in the crested porcupine: does it occur?**Viviano A.<sup>1</sup>, Huffman M.A.<sup>2</sup>, Senini C.<sup>3</sup>, Mazza G.<sup>4</sup>, Scarfò M.<sup>5</sup>, Mori E.<sup>1</sup><sup>1</sup> Consiglio Nazionale delle Ricerche – Istituto di Ricerca sugli Ecosistemi Terrestri, Via Madonna del Piano 10, 50019 Sesto Fiorentino (FI), Italy<sup>2</sup> Department of Ecology and Social Behavior, Inuyama Campus, Kyoto University, 41-2 Kanrin, Inuyama, 484-8506 Aichi, Japan<sup>3</sup> Department of Veterinary Medicine Sciences, University of Bologna, Via Tolara di Sopra 43, 40064 Ozzano dell'Emilia (Bologna), Italy<sup>4</sup> CREA Research Centre for Plant Protection and Certification (CREA – DC), Via Lanciola 12/a, 50125 Cascine del Riccio (Firenze), Italy<sup>5</sup> Dipartimento di Scienze della Vita e Biologia dei Sistemi, Università di Torino, Via Accademia Albertina 13, 10123 Torino, Italy

E013

Dietary selection is a fundamental process in the maintenance of healthy homeostasis. From the possible items available in the environment, choices must be direct to assure a proper balance of nutrients for energy, growth, maintenance, and reproduction. Animals also sometimes select plants for their medicinal properties. This constitutes what is called the medicinal diet, and consists of items with bioactive, physiology modifying properties. In primates and other species investigated thus far, it has been found that 15–25% of the plant items consumed have antiparasitic properties and it has been suggested that this is a dietary strategy for the passive prevention or control of parasite infection. We investigated the dietary habits of three non-overlapping populations of crested porcupine (*Hystrix cristata*) in Central Italy and identified medicinal food species and their potential antiparasitic benefits. The three study areas were characterized by contrasting degrees of natural and agricultural landscapes. In total, 43 food items were recorded based on macro- and microscopic fecal analyses of radio-tracked individuals in study areas 1 (N=22 spp.) and 2 (N=24 spp.) and stomach contents from 17 necropsied road-kill specimens in study area 3 (N=11 spp.). The variation in ingested species could be attributed to differences in human land use patterns, affecting the relative accessibility to cultivars and wild growing plants. The relative proportion of plants in the diet with antiparasitic properties varied considera-

bly between study areas 1 (72%), 2 (48%), and 3 (12%). The highest percent of medicinal foods were found in the study area with the highest human dominated land cover, as well as in the area with the highest infestation of ectoparasites (*Pulex irritans* and *Ixodes ricinus*). As predicted, a preliminary link between the ingestion of plants with recognized antiparasitic properties and parasite infection prevalence seasonality was noted. The seasonal consumption of medicinal foods in all three areas coincided with the months of highest parasite infection prevalence detected in necropsied individuals in the cold and rainy months in study area 3. This study adds to our general understanding of factors influencing dietary selection, the impact of anthropogenic land-use factors on it and presents the first evidence for a possible link between medicinal food consumption and parasite infection seasonality in European crested porcupines.

As a brief side note, we also report on an unusually high period of bark consumption on black elders *Sambucus nigra* L. recently documented in the autumn and winter of 2021, possibly in response to the most severe drought in this area in over 30 years. Elderberry has a soft cortex, which may have been consumed because the soil was too hard to dig up the roots. Elderberry shows diaphoretic and diuretic properties, effective against respiratory infections.

## Age-, sex- and site-dependent variation of antioxidant defenses in ibex from different areas of Western Italian Alps

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E014

In recent years, a growing interest has been addressed to understand the role of oxidative stress in ecology of free-living individuals. Oxidative stress is defined as the imbalance between pro-oxidant and antioxidant molecules in favor of the former. Organisms can suffer an oxidative stress condition because of an overproduction of pro-oxidants due to diverse stressors and/or a deficiency of antioxidant molecules. Pro-oxidants overproduction can be generated in response to changes in metabolism, somatic growth, seasonal changes in environmental conditions (e.g., temperature and food availability), reproduction, intra- and inter-specific competition, as well as exposure to pollutants. Oxidative stress has been individuated as one of the major causes of physiological aging, which is defined as the progressive accumulation of deleterious effects in cells and tissues that increase the risk of disease and death with increasing age. Thus, to prevent the detrimental consequences of oxidative stress, organisms have evolved diverse antioxidant mechanisms to counteract the generation of pro-oxidant molecules and to prevent oxidative damage and aging. Antioxidant defenses rely on endogenous non-enzymatic, diet-derived antioxidant molecules (e.g., glutathione, vitamins, and carotenoids), which counteract pro-oxidant toxicity through their scavenging action, and a complex enzymatic system that through the activation of superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPx) promote the degradation of pro-oxidants and protect the organism from oxidative stress. The decline or failure of antioxidant defenses ultimately leads to oxidative stress and loss of cellular homeostasis, resulting in a cost to the organism in terms of health status, survival and reproductive fitness. To date, a limited number of studies have examined the variation in antioxidant defenses across individuals of different sexes and ages in wild populations of vertebrates, and none was focused on ungulates. Thus, the aim of this cross-sectional study was

to investigate age- and sex-dependent variation in antioxidant defenses in wild individuals of ibex (*Capra ibex*). The total non-enzymatic antioxidant activity (TAC) and the activity of the main antioxidant enzymes, i.e., SOD, CAT and GPx, were measured in blood from male and female individuals of different age (1–16 years-old) collected in four areas on the Western Italian Alps (i.e., Parco Nazionale Gran Paradiso, Regione Autonoma Val d'Aosta, Parchi delle Alpi Cozie and Parco Naturale Alpi Marittime).

Despite no significant variation in antioxidant defenses occurred depending on age classes of individuals (i.e., sub-adults, adults and old), a significant covariation of non-enzymatic and enzymatic defenses with individual age was noted. Significant sex-dependencies were noted for TAC and GPx activity. In particular, independently of age class and study area, males showed a lower TAC, but a higher GPx activity than females. These results should suggest that the lower non-enzymatic antioxidant defenses of males can be compensated by a higher enzymatic antioxidant activity. Interestingly, a significant site-dependent variation in antioxidant defenses was noted for TAC, and CAT and GPx activities. Whilst non-enzymatic antioxidant defenses measured in individuals from the Parco Naturale Alpi Marittime were higher than those of individuals from the other study areas, enzyme activities showed an opposite trend, suggesting that individuals from this area can acquire a higher amount of dietary antioxidants that can prevent the activation of enzyme defenses to protect them from oxidative stress. These findings should suggest the necessity to investigate whether environmental variables, including differences in temperature, precipitations and vegetation phenology to understand changes of antioxidant defenses and to study potential relationships with life-history traits of wild populations.

Moderatrice

Laura SCILLITANI

XII Congresso Italiano di Teriologia

### The pivotal role of protected areas in supporting mammal research: the example of Alpine ibex

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GLAMM01

One of the main purposes stated in the Italian law on protected areas (art. 1, LN 394/1991) is the promotion of education and scientific research activities. Despite this law having been operative for more than 30 years, only a few protected areas have supported the development of scientific research on threatened species, mainly because of the scarce economic availability. On the other hand, some protected areas have spent a lot of effort, economic and not, to favor the implementation of scientific research. The studies on Alpine ibex are paradigmatic on this topic: the recent history of this species together with the full support of some protected areas have made possible the development of a scientific basin which have produced a large increase of knowledge about this species. In turn, the increase in scientific

findings made available information useful for the conservation and management of the species.

In this talk, combing through the scientific literature on Alpine ibex and taking advantage of a long collaboration with some Alpine protected areas, I will try to describe the new results about ibex biology, which shed light on novel perspectives for the conservation of this flagship species. More in general, I will use the ibex experience to point out the role of protected areas in promoting, stimulating, and supporting the scientific research on wild mammals: only a synergic collaboration between protected areas and scientific bodies will ensure a significant advancement of scientific knowledge and will avoid the wastefulness of public economic resources.

**Apennine chamois: a conservation success story yet to be completed**

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GLAMMO2

The Apennine chamois (*Rupicapra pyrenaica ornata*) is a taxon of considerable conservation value and is strictly protected by national and international legislation. In the Holocene this subspecies was probably distributed from the Sibillini Mountains to the Pollino. In the last centuries Apennine chamois have progressively disappeared from most of their range, surviving only in the area of the present Abruzzo, Lazio and Molise National Park (PNALM). Here the number of individuals has decreased up to a few tens of individuals during the last world war, with a consequent considerable loss of genetic variability.

In 1921 the Park was established, by private initiative, to protect the Apennine chamois. Afterwards, the Park started many conservation actions, the most important of which were the creation of integral reserves and the enlargement of the borders (in 1979 the Marsicano massif was included and in 1990 the Mainarde chain). Starting from 1970, industrial cutting was limited, high altitude pastures were requisitioned and managed to avoid or limit syntropy with domestic animals, studies and monitoring were started and, following the results of some studies on disturbance, a regulation of tourism in the summer period was implemented. Thanks to the presence and commitment of the Park, the historical population of chamois has survived and increased, reaching 500 individuals in 1990. Despite the success of the conservation actions, the status of the subspecies was still classified as "endangered" in the IUCN red list, due to the low number of individuals belonging to a single population and the reduced extension of the range.

For these reasons, at the beginning of 1990, the Abruzzo National Park promoted a program for the reintroduction of the chamois with an operation called "2000×2000×2000" (2000 chamois over 2000 meters by the year 2000). The idea was to create two new colonies in the Maiella and Gran Sasso areas, at that time not yet officially established as parks. The reintroduction operation, carried out by the Park with the support of the WWF, although opposed by many, began in July 1991 with the first release on the Maiella of animals coming partly from the wild and partly from captivity. The following year there were the releases on the Gran Sasso and several operations to reinforce the two new nuclei in the following years.

The adoption of the National Action Plan for the Apennine chamois in 2001, in addition to identifying as a new ambitious conservation goal the creation of two more colonies on the Sibillini Mountains and in the Sirente Velino Massif, consolidated

the idea that this goal could be achieved only if the protected areas of the Apennines operated as a network of different competences. In 2008, PNALM, in agreement with the Monti Sibillini National Park, started the constitution of the first colony, which was prematurely interrupted due to health problems that emerged in the historical population. The Majella National Park and the Gran Sasso Monti della Laga National Park took up the challenge, giving life to the project LIFE09 NAT/IT/000183-Coornata, which continued the reintroduction operations and implemented many of the actions provided for in the Action Plan with the scientific support of several Italian and foreign universities. The close collaboration between the protected areas of the Apennines, on several occasions also extended to other protected areas of the Alps, was crucial to achieving the goal of creating five colonies. No less important was the presence of considerable technical expertise gained by the staff of the parks, essential to ensure the full functionality of the operations of reintroduction, in all their phases, as well as monitoring and management actions and post-release conservation actions. The Life Coornata Project was also an opportunity to test new techniques of capture and handling of animals, to develop shared and standardized monitoring protocols and to increase the knowledge on the ecology of the species and its threats (e.g. health aspects, interaction with other ungulates both wild and domestic).

Today the Apennine chamois is present in 5 colonies, with a total number of 3500 individuals. The overall objective of the National Action Plan has been largely achieved and the threat of extinction has been reduced from "endangered" to "vulnerable" by IUCN.

The success of a century of conservation of the Apennine chamois is intrinsically linked to the role played by the protected areas of the Apennines, first and foremost the Abruzzo, Lazio and Molise National Park, and for this reason the species can be considered a sort of "ambassador" of the Italian parks, a tangible example of the crucial role that the professionalism, experience, knowledge of the territory and motivation of the staff of the protected areas, can play in the conservation of biodiversity.

The conservation of the Apennine chamois is a success story, but it is waiting to be completed. The goal is to further improve its status and expand its range outside of protected areas. Climate change, increased wildlife tourism and interaction with deer and domestic livestock are the new challenges to be faced. We in the protected areas are on board, are you?

## Strategies, limits and prospects of the action of the Appennino Tosco Emiliano National Park for the conservation of the wolf in the Apennines

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GLAMMO3

The importance and role of protected area for wolf conservation in Italy are still lively debated. Although it is evident that no national or regional park is large enough to ensure the conservation of a viable wolf population, it is reasonable to assume that even the simple hunting ban regime has certainly favoured the species. Reproductive family units were protected inside the parks acting as source populations from which young dispersing wolves contributed to connect metapopulations. The contribution of protected areas and their immediate surroundings has presumably gone beyond the direct protection of family units, favouring the presence of prey populations as well as an effective repression of poaching. The attention paid to the application of prevention measures from predation, to an accurate assessment and the adequate and timely compensation for damage certainly promoted the mitigation with traditional economic activities and, consequently, it encouraged the acceptance of the return of the predator, and coexistence with humans. Lastly, despite limits to interpretation and scope, protected areas implemented several monitoring programmes of local populations and researched into the biology and ecology of the species. The effort that the pro-

tected areas made on the communication and information sides is undeniable, and they were able to reach various stakeholders and segments of society.

The Appennino Tosco-Emiliano National Park, after being established in 2001, started immediately to act towards wolf conservation, being aware of the limits linked to its extension and shape of its perimeter, the fragmentation of the administration, the human and economic geography of its territory as well as new, modern and insidious threat factors. This contribution aims to be a simple report of the strategies and solutions that the National Park has adopted and developed in over twenty years of activity on the wolf conservation front in the northern Apennines. Possible transferability and reproducibility over a vast area of the good management practices developed here would require further calibration and refinement. With this in mind, the solutions adopted will be presented and discussed also in the light of their real scope, the results obtained, the interpretative limits on their effectiveness and sustainability in the long term as well as the operational difficulties encountered.

Venerdì 10 Giugno 2022



In the last years, technical advances and new conceptual approaches are revolutionizing the use of genetic data for the study of wildlife populations. These data are increasingly important to tackle key topics, both for population genetics and for other themes. In this essay, I perform an overview of case studies showing how genetic tools can help our understanding of wildlife populations, with a special focus on mammals.

First, knowledge about the phylogenetic history, genetic variation and ecological requirements of lineages can help to identify evolutionary significant units requiring conservation priority. Despite multiple challenges, the identification of evolutionary significant units can get strong advantages from the integration of neutral and adaptive genetic information with ecological data. Second, the availability of a large number of markers covering the whole genome allows accurate reconstructions of the demography of populations, for instance to identify the history of invasive or of threatened species. Furthermore, DNA metabarcoding enables the rapid and cheap identification of organisms even in absence of large remains, and can help wildlife research in multiple ways. For instance, the metabarcoding of DNA extracted from gut contents or faeces allows the identification of diet items, providing unprecedented (and unexpected) information on diet

analysis. In addition, DNA of terrestrial organisms (both plants and mammals) can be extracted from lake sediments, enabling the long-term reconstruction of the changes of populations through historical times. This also enables to understand how interspecific interactions (e.g. interactions between herbivores and plant communities) changed through time and determined the long-term trajectories of ecosystems.

The emerging genetic approaches have opened new avenues to biodiversity studies, and further leaps forwards will likely occur in the future. The availability of a growing panel of techniques can improve the effectiveness of monitoring, and resources devoted to tedious activities could be redirected, with the possibility to obtain results that would have not been conceivable one decade ago. Integrated research, combining field activities with state-of-the-art molecular tools, requires the contemporary presence of multidisciplinary competences, and can only be achieved through the collaboration among field biologists, ecologists, molecular biologists, and bioinformaticians. Such collaborative efforts can greatly improve our understanding of the complex relationships between organisms, and our ability to assess the impact of human activities.

**Genomic variation of Italian wild boar populations: the effect of human manipulations**Scandura M.<sup>1</sup>, Fabbri G.<sup>1</sup>, Caniglia R.<sup>2</sup>, Iacolina L.<sup>3,4</sup>, Mattucci F.<sup>2</sup>, Mengoni C.<sup>2</sup>, Pante G.<sup>1</sup>, Apollonio M.<sup>1</sup>, Mucci N.<sup>2</sup><sup>1</sup>Department of Veterinary Medicine, University of Sassari, Sassari, Italy<sup>2</sup>Unit for Conservation Genetics (BIO-CGE), Italian Institute for Environmental Protection and Research (ISPRA), Ozzano dell'Emilia, Italy<sup>3</sup>Faculty of Mathematics, Natural Sciences and Information Technologies, University of Primorska, Koper, Slovenia<sup>4</sup>Department of Chemistry and Bioscience, Aalborg University, Aalborg, Denmark

GOO2

In the past decades, the wild boar (*Sus scrofa*) has strongly increased numerically and extended its range in Europe, even as a result of human management. In Italy, native populations have been heavily influenced by hunting, translocations, and introductions of non-native individuals that created a genetic patchwork despite range continuity.

Several genetic studies attempted to highlight a different origin of localized demes but experienced difficulties in reconstructing the historical admixture among individuals from different geographical origins or from domestic and wild sources. The availability of swine genome data, the discovery of single nucleotide polymorphisms (SNPs), and the development of the Illumina Porcine SNP60 BeadChip provided a molecular tool to characterize wild boar populations, identify their geographic origin, and detect hybridization between domestic and wild individuals, or admixture among native and introduced stocks. In this study, we genotyped Italian wild boar populations with the Porcine SNP60 BeadChip to (i) assess their levels of genomic variation; (ii) describe their genomic structure, and (iii) investigate their origin (native vs non-native or wild vs domestic).

A total of 98 wild boar (WB) individuals were sampled in six administrative regions spanning the Italian peninsula from north to south (Aosta Valley, Liguria, Tuscany, Latium, Basilicata, and Calabria); in addition rural domestic pigs were sampled in the Pollino area, where wild individuals were also sampled. DNA was extracted using the Qiagen DNEasy Blood and Tissue kit and genotyped using the Illumina Porcine SNP60 BeadChip v2 at AIA. We also used publicly available genotypes, including 128 wild boar from most of the European distribution range, 36 genotypes from the Italian populations of Sardinia and Tuscany, and 103 domestic pigs from both commercial and Italian local breeds. Data were filtered for locus and sample quality resulting in a final dataset of 367 individuals genotyped at 47,809 autosomal SNPs. Genetic diversity was described through genome-wide statistics like heterozygosity and minor allele frequency; population structure was studied using dimensionality reduction, multivariate analysis and ancestry assignment approaches.

Finally, possible past admixture events or domestic gene introgression into native populations were assessed using different alternative approaches. Genomic analyses revealed a strong differentiation between domestic and wild individuals with only a few sporadic traces of introgression of domestic or European demes in the wild Italian populations. Italian genotypes were genetically separated from all other European conspecifics, with the exception of Aosta Valley which showed a strong genetic similarity with western European wild boar populations. The best genetic partition of the other Italian populations corresponded to four discrete groups, namely: Sardinia (Group 1), Maremma (southern Tuscany, Group 2), Castelporziano Presidential Estate (Latium, Group 3) and Liguria, northern Tuscany, and Calabria-Basilicata (Group 4). Northern Tuscany samples were split into two separate groups, corresponding, respectively, to coastal and Apennine areas. The first one (i.e. San Rossore Estate) regrouped in close proximity with genotypes from Castelporziano Presidential Estate and Maremma, while the second one (i.e. Tuscan Apennine) with those from Liguria and Calabria-Basilicata.

Overall, our results show the presence of a prevailing native component in most of the Italian populations, despite the effects produced by demographic fluctuations and human manipulations. We found limited evidence of past introgression from both non-Italian wild boar and domestic pigs. The genetic differentiation found in the individuals from Sardinia, Castelporziano Presidential Estate and Maremma Regional Park with respect to the other Italian populations was expected because of the long-lasting isolation, reduced population size, and genetic drift. Differently, the unexpected mismatch between genetic and geographic distance in the Apennine populations (Liguria, Tuscany, and Calabria-Basilicata) revealed the effects of multiple management events (translocations, reintroductions, etc.) that interested the Italian wild boar in the past decades. Future genomic studies, including ancient DNA analysis, could better clarify the evolutionary history of the Italian populations and help identify the possible effects of past gene flow from other European wild populations and domestic stocks.



## To be or not to be a hybrid? Genome-wide approaches to distinguish anthropogenic hybridization from natural gene flow in European canids

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GO03

After centuries of demographic declines and geographic contractions, many European carnivore species are now recovering naturally. Wild canids represent a clear example of such a positive tendency, with many wolf (*Canis lupus*) populations recolonizing part of their historical ranges, and some jackal (*C. aureus*) populations re-expanding through Europe in both remote and urbanized areas. However, this trend is increasing the risk of poaching due to conflicts with human activities, ancestral fear towards predators, and anthropogenic hybridization, especially in human-dominated regions with the widespread presence of stray dogs (*C. l. familiaris*).

This scenario suggests the need to i) design sound conservation and management measures and ii) develop appropriate molecular tools to distinguish human-induced hybridization from natural intra- and inter-specific gene flow. Therefore, we exploited existing genomic resources to select a panel of single nucleotide polymorphisms (SNPs) to i) discriminate Iberian, Italian and Dinaric wolf populations, where there are increasing signs of

gene flow after protracted isolation, dogs, and golden jackals, and ii) identify their first two hybrid generations.

Pairwise  $F_{ST}$  analyses among the five canid groups allowed us to choose 192 SNPs that clearly distinguished all simulated first-generation (F1) hybrids and all first backcross (BC1) individuals. The applicability of the selected 192 SNPs in future conservation management projects was tested by evaluating their genotyping performance on Fluidigm platforms for both invasively and non-invasively collected samples. Our results showed that 178 SNPs performed successfully with high amplification and low error rates, continuing to correctly categorize the five canid groups and all simulated hybrids.

The identified SNPs represent a powerful molecular tool to distinguish inter-species hybridization from natural population admixture in European wild canids and design timely conservation management actions accounting for their ongoing expansion dynamics.

## Secondary contact in European mole (*Talpa europaea*) populations: genomic admixture and implication for phenotypic evolution

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GOO4

A better understanding on how selection and stochastic processes affect biological diversity is essential to elucidate the mechanisms driving adaptation and speciation. The expectations from theory suggest that genetic admixture between formerly isolated populations or species can generate phenotypic novelty. To date, this has largely been considered from the perspective of interspecific hybridization at contact zones. However, it is likely that this process occurs more commonly between natural populations of the same species, and thus its importance in phenotypic evolution may have been underestimated. Hence, the identification and study of secondary contact combining genetic and phenotypic approaches may provide useful information on the evolution of natural populations.

In this study, we employed a population genomics approach using next-generation sequencing (NGS) combined with geometric morphometrics (GMM) to study the population structure and phenotypic evolution of the common mole *Talpa europaea*. Previous studies based on mtDNA markers revealed two well distinct lineages, one present in all Europe and in northeastern Italy, while the second one is found exclusively in central and northwestern Italy. According to these data, northeastern Italy could represent a putative secondary contact zone between the two *T. europaea* lineages, a hypothesis that needed further verification.

By using NGS we gather evidence of a secondary contact zone in South Tyrol. We first evaluated the level of admixture of Italian and European lineages and the degree of genetic diversity, and its correspondence with phylogeographic lineages as

defined by mtDNA. By using restriction-site associated DNA sequencing (RAD-Seq) we obtained genome-wide SNPs for 52 mole specimens. Furthermore, we investigated the impact of secondary contact on the morphology of the mandible of *T. europaea*. We used GMM to study the mandible shape and size of individuals from different areas of Europe and Italy including South Tyrol, the putative contact zone. We took photographs of the right mandibles from 100 specimens, on which we collected 40 landmarks. Successively, we investigated trait shift, morphological variance and biomechanical performance in all sampled populations including secondary contact zone. Biomechanics indexes were calculated by combining linear measurements of in-lever, out-lever and their ratios.

Our results provide a further insight into the genetic population structure of the common mole. The European lineage appears genetically more homogeneous respect to the Italian lineage. The population from South Tyrol shows a higher affinity with the European lineage, but signatures of introgression from the Italian lineage was also detected. Generally, we found a good congruence between genomic and morphological data. Significant shape divergence between the mandible of the two lineages of *T. europaea* was identified and the phenotypes observed in the contact zone fall in an intermediate position, as expected from genetic admixture. However, the alteration of phenotypic variance could suggest that genetic admixture can also increase the range of phenotypes expressed hence provide a wider basis on which selection can act.

## Evidence of adaptation to local environmental conditions in an insular population of wild boar

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G005

The Sardinian population of wild boar (*Sus scrofa meridionalis*) has evolved in almost complete isolation on the Mediterranean island since its arrival in the early Neolithic. Climate and land use across the island vary despite the relatively limited extension (ca. 24000 km<sup>2</sup>). High temperatures and dryness are limiting factors for the development and reproduction of the species, both directly with the risk of dehydration and difficulty for the piglets to thermoregulate, and indirectly by reducing the primary productivity and consequently food availability. Hence, the environment can have contributed to create the morphological differences we observe today in the island (e.g. wild boar from southwest Sardinia having the smallest body size recorded in Europe), and could sustain the genetic structure that has been previously observed using a limited set of neutral markers. We aimed at detecting patterns of adaptation to local environmental characteristics in the Sardinian wild boar.

Ninety-six genotypes were analysed at more than 48000 autosomal single nucleotide polymorphisms (SNPs), while the environment was characterized by bioclimatic variables and land use data downloaded from free online databases. We studied the neutral population structure with principal component analysis (PCA) and ancestry assignment, and then we applied three methods to look for local adaptation: an outlier analysis based on PCA and two landscape genomics methods, one relying on a univariate and the other on a multivariate approach. We finally performed annotation on the latest release of the pig genome (Sscrofa11.1) of the candidate loci and tested for gene ontology enrichment analysis to check whether any molecular function or

biological process seemed to be particularly targeted by selection. The main genetic structure separated north- and south-west from the east of the island, then internal substructure emerged in the eastern side. These results point at hierarchical structuring of the population. Fifty SNPs were identified as outlier loci implied in local adaptation by at least two methods and thus were considered good candidates. Sixty-one genes were found within 100000 base pairs windows around the outliers. Gene ontology enrichment analysis revealed overrepresentation of terms related to cell localization, motility, and adhesion, but also related to response to stimuli and anatomical development. Myogenesis and immune response seem to be among the affected phenotypes: for instance, BBX is found to help the binding of double stranded sequence-specific DNA regions and could be implied in bone development, or PRKRA gene product is a protein kinase that is activated by double stranded RNA and is involved during viral infections. Possible factors responsible for these results include different climatic conditions and food availability that sustain differential mass development, and the distribution of the African swine fever, which is among the most important pathogens affecting both wild boar and domestic pig, and is endemic on the island since the 1970s.

Our results suggest that the environment has played a role in shaping the genetic differentiation of the Sardinian wild boar in an evolutionary limited timescale. Further comparative genomic studies could contribute to clarify meaningful adaptive differences between the insular and mainland populations.

**Who's your mother? The first parentage reconstruction in the Apennine brown bear**Buono V.<sup>1</sup>, Macrì N.<sup>1</sup>, Mattucci F.<sup>1</sup>, Benazzo A.<sup>2</sup>, Antonucci A.<sup>3</sup>, Latini R.<sup>4</sup>, Bertorelle G.<sup>2</sup>, Mucci N.<sup>1</sup>, Davoli F.<sup>1</sup><sup>1</sup>Unit for Conservation Genetics (BIO-CGE), Department for the Monitoring and Protection of the Environment and for Biodiversity Conservation, Italian Institute for Environmental Protection and Research (ISPRA), Ozzano dell'Emilia, Bologna, Italy.

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GOOD

**Introduction** – The Apennine brown bear is a critically endangered endemic taxon (*Ursus arctos marsicanus*) living in complete isolation at a very small population size. The long-term isolation has turned such a population into a unique evolutionary unit, highly depleted of original genetic variability, thus requiring constant monitoring. To date, non-invasive genetics, by using a reliable set of 13 microsatellite markers (STR), enabled the identification of individual genotypes, representing the first step for kinship reconstruction and evaluation of reproductive success and individual fitness. However, the low genetic variability of this population and the low discrimination power of the STRs panel currently used made the execution of parentage analysis problematic. A new set of highly variable markers is therefore required. Our aims were to i) select a panel of high-quality single nucleotide polymorphisms (SNPs); ii) test its efficiency in individual identification on non-invasive biological samples; iii) perform, for the first time, parentage analyses.

**Methods** – Highly stringent filtering criteria were applied on consensus reads of five genomes recently sequenced in the Apennine bear population to find highly informative SNPs. Specific primers were designed in the SNP flanking regions using Primer 3 software and SNPs were validated by Sanger sequencing. Then, internal primers were designed to bind adjacent to each SNP and a SNaPshot Multiplex System was performed to score allelic variability. Different-length tails (poly-A) were added to the 5' end of the primers, allowing multiplex SNaPshot reactions. The panel of SNPs was then tested on invasive and non-invasive samples from putative family groups identified through field data. The power of different sets of markers (STRs, SNPs, STRs+SNPs) to discriminate individual multilocus genotypes was evaluated calculating the probability of identity (PID) for random pairs of individuals at increasing number of loci, the equivalent probability for pairs of full siblings (PID SIB), and the mismatch distributions (MM-pairs). Parentage analy-

ses were performed with two different approaches implemented in the packages COLONY 2.0.5.0 and FRANZ 2.0. Parentage exclusion probabilities were calculated as a measure of the informativeness of our marker sets for parentage inference.

**Results** – Ninety-two hypervariable SNPs were identified and for 72 of them the internal primers were designed. A final subset of 67 SNPs proved to be more reliable to distinguish individuals. The selected SNPs were finally combined in thirteen multiplex reactions. This panel provided better resolution power when compared to the 13 STRs currently used in the Apennine population monitoring program, with lower  $P_{ID}$  and  $P_{IDSIB}$  values (SNP  $P_{ID} = 10^{-17}$ , STR  $P_{ID} = 10^{-5}$ ; SNP  $P_{IDSIB} = 10^{-9}$ , STR  $P_{IDSIB} = 10^{-3}$ ). In addition, combining both marker sets, probabilities of identity reached much lower values (STR+SNP  $P_{ID} = 10^{-22}$ , STR+SNP  $P_{IDSIB} = 10^{-11}$ ). Likewise, all observed mismatches in the data set were greater than 3MM-pairs, both with the SNPs and with the combined panels. When tested on parentage analyses, all marker sets confirmed field data and obtained correct family assignments. SNPs provided higher probabilities than STRs, and the combined set reached a 100% assignment probability. Moreover, the very high exclusion probability value (SNP  $P_E = 0.97 - 1$ , STR+SNP  $P_E = 1$ ) suggests that parentage analysis using these markers is very accurate.

**Discussion** – The selected SNPs proved to be more informative and reliable than STRs currently used, showing an improvement of the discrimination capacity, increasing the chance of individual identification, and reducing the probability of identity and shadow effect. By allowing the possibility to even reconstruct the family relationships in about 200 individuals sampled in the last 20 years, the highly informative SNPs identified will be promising to better monitor and protect this threatened population in the future.

## Sessione tematica del Gruppo Mesocarnivori (GRiMeC)

Moderatrice

Romina FUSILLO

XII Congresso Italiano di Teriologia

### Bridging the gap: the importance of connecting scientific research with applied conservation to protect Italian biodiversity

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GRiMeC01

Global biodiversity is undergoing a serious crisis caused by environmental changes induced by human activities. Although the causes are well known and of general interest, the lack of communication between science, politics and the general public has led to the failure of almost all the objectives for the protection of biodiversity set for 2020, and risks compromising the achievement of those set for 2030. In this historical moment, in which Italy plays a key role in Europe to try to limit the consequences that anthropogenic activities have and will have on biodiversity

and the environment, it is important that scientists connect with all actors involved in the conservation of biodiversity to provide solid foundation for planning concrete and sensible actions. Scientific research should be translated into practical actions where objectives, ecological and economic feasibility, societal impact and possibility of the action effects to last over time are all part of the same project. These interlinkages are necessary to guarantee the protection of biodiversity in the coming decades and ensure that national and global biodiversity goals are met.

XII Congresso Italiano di Teriologia

### A bridge between research and management: the invasive raccoon in Italy

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GRiMeC02

Science-based management involves integrating scientific information to help achieve the wildlife management goals and objectives. While sometimes these might seem like alternative processes, science is instead integral to wildlife management since management without application of the scientific approach could lead to mismanagement. This becomes particularly true when a species is introduced outside of its natural range, becomes invasive and needs to be controlled or eradicated.

Here we report the steps taken in the eradication campaign of a population of the invasive raccoon in Lombardy (Italy). We used an integrated approach of camera traps and live traps developed in 4 steps. The first one consisted of visual surveys and interviews with local stakeholders along the river Adda to identify the area for the first trapping campaign that covered 30 km<sup>2</sup>. During the second step, to better address the trapping effort after the first 8 months of captures, we performed a camera trap survey. This covered 120 km<sup>2</sup> with 88 camera trap sites each surveyed for 16 consecutive days. The results revealed that the detectability of raccoons increased in proximity to the river and their occupancy was higher in urban areas. This knowledge allowed us to increase the trapping success whilst reducing the effort. The third step saw a second trapping season in 95 sites to remove the remaining individuals. During the final step, we used baits in front of the camera traps and doubled the number of cameras compared to

step 2 to cope with the reduced density of the population after the captures. Stakeholders were interviewed again, and visual surveys were carried out so that where raccoons were detected by cameras or stakeholders, we activated traps opportunistically to remove the last individuals. During the captures, systematic collection of catch and effort data allowed the estimation of population size and thus to have a continuous update on how far the campaign was from the complete eradication of the species, allowing to adjust the trapping effort accordingly. Moreover, camera trap data also allowed us to make a Rapid Eradication Assessment that estimated an eradication probability of 99% after 6 months without detections. We captured a total of 73 raccoons during 7799 cage trap nights between 2016 and 2019; raccoons were euthanized by CO<sub>2</sub> inhalation following the EC and AVMA guidelines. Their carcasses were analysed to verify the presence of the zoonotic nematode *Baylisascaris procyonis*. This successful campaign is an example of how wildlife management requires a scientific approach, and conversely the science of wildlife ecology requires management to carry out experiments. We believe that a similar approach could be used for other terrestrial mesocarnivores that need to be managed, controlled or eradicated with the idea that wildlife management operations can be used as good experiments, provided that they are monitored scientifically.

### City to regional scale bat acoustic monitoring: different approaches for anthropogenic impact assessment

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Although human changes to natural environments always occurred over centuries, speed and intensity of modifications have dramatically increased in recent decades, with clear signs of further intensification in the future. Cities are the most evident and radical example of land use change, their massive growth resulting in habitat loss and fragmentation, barrier effects and road mortality, chemical and physical pollution. However, human pressures can extend far beyond city borders, involving processes such as land conversion for agricultural and livestock use, creation of spaces for extraction and energy production plants, waterway artificialisation, road construction, and forest management. With a view to sustainable and resilient human-modified habitats, robust ecological information is essential to guide proper development and management. Bats (Chiroptera) are promising candidates to track the effects of human pressures on biota, as their response is highly species-specific, and their presence can be accounted through acoustic surveys.

To date, a few studies investigated bat occurrence and activity along urbanisation gradients. However, no studies used a human footprint gradient to summarise and consider together the main human pressures occurring in a certain area. Moreover, little is known on habitat exploitation by bats in large urban centres. Here we present a regional-level and a city-level study, carried out in northern Italy, where bats were used as bioindicators of human pressures. The former was aimed at studying bat occurrence and activity along a human footprint gradient defined for Piedmont region, while the latter was aimed at studying the different urban habitat use by bats in the city of Turin. Both studies were conducted through passive acoustic monitoring (PAM). For the regional-level study, a global human footprint raster dataset was used to random distribute 96 sampling sites along an increasing human footprint gradient for Piedmont. Differentiation at habitat level (urban areas, woodland, agricultural areas, and water bodies) was also performed. At each sampling site, an automatic bat detector was left recording for a full night every two months during 2021 active season, for a total of three temporal replicates for each site. Acoustic identification at species or genus level was performed at first step using an automatic classifier, and at second step through manual checks to validate the presence of each species. Activity data were then derived and weighted based on occurrence dataset and probability of correct identification provided by the classifier. Bat distribution and activity were analysed both in relation to human footprint level and habitat variables. Preliminary results showed some degrees of tolerance for areas with medium-low human footprint levels for *Plecotus* and *Myotis* species, probability of occurrence and activity

decreasing dramatically from medium to high human footprint levels. *Nyctalus* species also showed low tolerance to high levels of human footprint. Opposite trends were found for two highly urban-linked species, *Pipistrellus kuhlii* and *Tadarida teniotis*. However, human footprint level seemed to have a weaker effect if compared with habitat, suggesting the importance of preserving key natural habitats even in areas with moderate levels of human footprint. In this regard, forest and water habitats were linked to the presence of more sensitive species, such as those belonging to *Barbastella*, *Myotis*, *Nyctalus* and *Plecotus* genera. For the city-level study, Turin was considered as an example of large urban centre. Neighbouring municipalities were also included in the study area, as they are the actual city outskirts, as well as connections with surrounding rural and natural areas. Starting from high-resolution land cover data, a reclassification was made to identify 8 habitats which may have ecological relevance for bats: high-, medium- and low-density urban areas, industrial areas, urban green areas, woodland, agricultural areas, and water bodies. Potential sampling zones were randomly selected for each habitat and uploaded to a website ([www.batmap.it](http://www.batmap.it)) as circular buffers. Volunteers could navigate the web map, select the zone where their house fell and book a bat sampling night. In return, each volunteer received a report with the list of species recorded in that site, some curiosities about their ecology and previous data on their occurrence in the city. Citizen science approach allowed safe bat detector installation in urban centre, while for other habitats sampling sites were selected on public land. Given the small extension of study area, spatial replicates were preferred on temporal replicates and single, full recording nights were carried out at a total of 250 sites during 2020 active season. Species acoustic identification was performed as for the regional-level study. Preliminary results showed *Hypsugo savii*, *P. kuhlii* and *T. teniotis* as the most common species in disturbed habitats such as high and medium density urban areas, whereas woodland and large urban parks can host more sensitive species like *Barbastella*, *Myotis* and *Plecotus* genera. Presence of *Rhinolophus ferrumequinum* in Turin was confirmed after 80 years. In summary, even if conducted at different scales, both studies highlighted the importance of preserving natural spaces in large urban centres and in areas characterised by moderate human footprint levels. In particular, woodland patches, large urban parks, and undisturbed water spots can help more sensitive species to exploit highly human-modified habitats. Both highly sensitive and highly urban-linked bat species can be considered valuable bioindicators of the level of human pressure.

Poster

## Feeding behavior of the wolf in Aspromonte National Park

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PO23

The Italian wolf (*Canis lupus italicus*) is probably one of the most studied species in Italy. To date, despite the large number of projects that have been addressed to it, few studies have actually been carried out in the southern Calabrian Apennines. This is the first in-depth study of the wolf's diet in Aspromonte National Park. This study aimed to evaluate the feeding behavior of the wolf in the protected area.

The collection of signs of presence was achieved between May and October 2019 by performing standard and opportunistic transects about 207 km. In total, from 100 excrements collected, 97 were selected and analyzed to assess the wolf diet. In order to avoid the sampling of scat belonging to species sympatric with the one under analysis (for the study area fox and dog) and to minimize possible attribution errors, some criteria were adopted (size and diameter, typical smell, content, discovery at marking sites). Sample preparation was performed in the laboratory by sterilization, soaking, washing, and drying. Then the macroscopic components of the sample (hair, bones, vegetation) were separated and identified. The following methods were used to quantify the relative importance of the various prey species in the diet, with samples collected from the entire Park area: absolute occurrence frequency, relative occurrence frequency, average percentage volume. The Levins Index was applied to investigate the width of the trophic niche.

The indigestible remains contained in the analysed scat belong to 6 macrocategories: "Hair", "Bones", "Vegetation", "Fruit", "No food item", "Other". A total of 6 specific food categories were

found in the diet: "Suidae", "Roe deer", "Other mammals" (mustelids), "Goat", "Sheep", "Cattle". The categories found with volumetric percentages <3% ("Hare" and "Dog") were excluded from the analyses.

The analysis revealed a restricted trophic niche with a diet represented almost equally by wild ungulates (Absolute Frequency, FA=54.5%, Relative Frequency, FR=55.7%, Median Volume, Vm=46.1%) and domestic ungulates (FA=49.5%, FR=47%, Vm=40.1%). In particular, suidae (wild boar, wild boar × pig hybrids) represented the main preyed species (FA=51%, FR=48.6%, Vm=43.1%), followed by goat (FA=30.1%, FR=29%, Vm=25.2%). The Levins Index ( $\beta$ ) and the Levins standardized index ( $\beta_{sta}$ ) revealed an overall narrow trophic niche with a diet based mainly on the food categories "Suidae" and "Goat": for frequencies it was  $\beta=2.97$  and  $\beta_{sta}=0.33$ ; for volumes  $\beta=3.84$  and  $\beta_{sta}=0.47$ .

The diet of wolves in the Aspromonte National Park is almost equally represented by wild and domesticated ungulates and these considerations differ from previous studies in Italy, where the consumption of the former is prevalent compared to the latter. The trophic niche was narrow overall, with a diet based mainly on suide and goat. The study confirmed the importance of wild boar, more or less hybridized, in the wolf's diet but also found the entry of the other wild ungulate present, the Italic roe deer (*Capreolus capreolus italicus*), recently reintroduced in the National Park (2008–2011).

## Evidence of spatial genetic structure in a snow leopard population from Gansu, China

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PO28

Understanding the spatial structure of genetic diversity provides insights into a populations' genetic status and enables assessment of its capacity to counteract the effects of genetic drift. Such knowledge is particularly scarce for the snow leopard, a conservation flagship species of Central Asia mountains. Focusing on a snow leopard population in the Qilian mountains of Gansu Province, China, we characterised the spatial genetic patterns by incorporating spatially explicit indices of diversity and multivariate analyses, based on different inertia levels of Principal Component Analysis (PCA). We compared two datasets differing in the number of loci and individuals. We found that genetic patterns were significantly spatially structured and were characterised by a broad geographical division coupled with a fine-scale cline of differentiation. Genetic admixture was detected

in two adjoining core areas characterised by higher effective population size and allelic diversity, compared to peripheral localities. The power to detect significant spatial relationships depended primarily on the number of loci, and secondarily on the number of PCA axes. Spatial patterns and indices of diversity highlighted the cryptic structure of snow leopard genetic diversity, likely driven by its ability to disperse over large distances. In combination, the species' low allelic richness and large dispersal ability result in weak genetic differentiation related to major geographical features and isolation by distance. This study illustrates how cryptic genetic patterns can be investigated and analysed at a fine spatial scale, providing insights into the spatially variable isolation effects of both geographic distance and landscape resistance.



## Short blankets in snow leopard conservation: the Case of Qilianshan National Park (China) and surrounding areas

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POO1

The assessment of landscape-level connectivity patterns is centrally important to the conservation management of wildlife species. This is especially true for highly vagile carnivore species, for which conservation efforts should extend beyond protected areas and link core populations. We investigated the effectiveness of the Qilianshan National Park (China), across the provinces of Gansu and Qinghai, in providing adequate conservation to snow leopard habitat and major dispersal routes. We coupled resistant kernel and factorial least-cost path analyses to identify core home-range areas and major corridors connecting them. We compared two resistance surfaces derived from habitat and genetic models in their ability to describe connectivity routes. We ranked core areas and corridors based on their intensity of snow leopard movement flow. We found that much of the extent

of core habitat patches, and a vast proportion of corridors length and area, were located outside the National Park. The kernel analyses identified a critical area to range-wide connectivity connected to the park but not formally protected. We also identified important patches representing the backbone of snow leopard habitat and stepping-stone patches ensuring landscape structural and functional connectivity. The Qilianshan National Park effectively protects some core snow leopard habitats. However, it alone appears insufficient to cover several important core areas and a number of critical connectivity linkages. In the context of ensuring meta-population persistence on the Tibetan Plateau and facilitate gene flow, conservation efforts should expand institute new protected areas strategically located to conserve core habitat areas and provide connectivity linkages among them.

## Anomalous colouration in European pine marten: the case of Elba island

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POO3

Evidence of abnormal colourations in wild animals provides useful information to better understand their adaptive function and their impact on survival. For this reason, it is useful to know the frequency and distribution of these abnormal phenotypes in wild populations. Here, we report two records of hypopigmentation in European pine marten *Martes martes*, obtained during a camera-trapping survey on Elba Island, central Italy. On 10 March 2020 and on 23 May 2020, camera traps recorded two videos of pine marten with light colouration in two different parts of the island. Both videos show adult pine martens with a lack of pigmentation throughout the whole body including the nose and with unidentifiable eye colour. Although the hypopigmentation of the nose might suggest albinism, the fur appears

to not be totally depigmented and could thus correspond to a case of leucism rather than albinism. The cause of the observed anomalous phenotype is unknown, although the possible inbreeding in this isolated population could have contributed to its occurrence. While light colouration certainly increases visibility of pine martens, it is possible that the low predator pressure and the absence of other wild carnivore populations on Elba Island could mitigate the mortality risk due to the light phenotype. The increased use of camera traps across the world can potentially facilitates the discovery of cases of anomalous colourations in wild populations, providing a valuable insight on the occurrence of this phenomenon in wild mammal species.

## Three islands, three histories. Sharply divergent mitochondrial DNA lineages in the hedgehog populations of Sardinia, Sicily and Malta

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PO13

Genetic monitoring and identification of evolutionarily significant units or management units through different molecular markers is one of the best estimator of natural populations sustainability, since their genetic variation underpins long-term potential for survival and adaptation. The main target of this study was to investigate the evolutionary and phylogeographic patterns of hedgehog populations living in Sardinia, Sicily and Malta, using mitochondrial DNA analysis. Hedgehogs are widespread globally, but island populations can be locally declining and vulnerable.

Between 2019 and 2021, 30 hedgehogs were collected from northern Sardinia, south-eastern Sicily and Malta, as road kills or from wildlife rescue centres. After DNA extraction from tissue or hair samples using a commercial kit, a 465-bp fragment of the mitochondrial DNA D-loop region was amplified by PCR, using primers developed in *Erinaceus europaeus*. PCR products were purified and sent to BMR Sequencing Service for sequencing. We obtained 26 sequences corresponding to 9 different D-loop haplotypes from Sicily (4), Sardinia (3) and Malta (2). A total of 183 homologous D-loop sequences were retrieved from GenBank to be used for phylogenetic analysis. They corresponded to *Erinaceus europaeus* from all its European range and *Atelerix algirus* from North Africa; other hedgehog species were used as outgroups. Evolutionary analyses were performed using the software MEGA X, and a minimum spanning evolution network was created in PopArt.

The minimum spanning network shows three clusters of haplotypes, corresponding to the three islands. Sicilian and Sardinian

haplogroups were closer and separated by a minimum of 14 fixed mutations. The Maltese group was apart, diverging from the Sicilian one by a minimum of 37 mutations. D-loop homologous sequences retrieved from GenBank corresponded to 96 different haplotypes: these were aligned with our 9 novel haplotypes to explore their phylogenetic relationships. They were inferred by using the Maximum Likelihood method and the selected Hasegawa-Kishino-Yano model with gamma distribution in MEGA. The haplotypes from samples collected in Malta and Sicily appeared clearly distinct in the ML tree. The Sardinian haplotypes fell with *E. europaeus* sequences from hedgehogs originating in mainland European populations including Central and Northern Italy. Instead the Sicilian and Maltese populations showed a high phylogenetic distance from any reference population. Their haplotypes represented two distinct lineages respectively of *E. europaeus* and *A. algirus*.

Based on our results, the Sicilian hedgehog population might represent a different Evolutionary Significant Unit (ESU). Sardinian hedgehogs might have originated from multiple introductions occurred at a certain time between the Neolithic and the Roman Age, when many mammal translocations to the island have occurred. Maltese sequences represented an independent monophyletic lineage belonging to the African clade. Further studies, including more samples and combining molecular data (autosomal markers) with morphometrical and ecological data are needed to test these hypotheses and clarify the evolutionary history of these hedgehog populations.

## A first resident group of the greater noctule bat *Nyctalus lasiopterus* in the Italian Eastern Alps discovered through bat detectors

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P005

The greater noctule bat *Nyctalus lasiopterus* (Schreber, 1780) is one of the most enigmatic and rare bat species in Europe. The species is protected by the EU Habitats Directive (Annex IV) and is classified as Critically Endangered in the Italian Red List. While its distribution in the Mediterranean region is quite well known, the knowledge on its occurrence in the central and western parts of Europe is still scarce. The most recent data for the Italian Alps include few records coming from the province of Trentino and the region of Friuli Venezia Giulia. However, these records are occasional sightings along migration routes and not individuals of resident populations. The lack of data can be related in part to the fact, that direct observations of *N. lasiopterus* are particularly difficult, as the individuals usually seek shelter in tree holes and are fast and agile fliers, hunting and flying at high altitudes. However, in the last ten years, the use of bat detectors has been widely established making it easier to detect this elusive species. So, here we report the first evidence of the greater noctule bat for South Tyrol and the presence of at least one resident group of the species on the southern side of the Alps, achieved by intensive use of bat detectors.

Between May and October of the years 2016 to 2021, Elekon Batloggers A+ were installed at 254 locations for at least three consecutive nights per location, covering all habitat types occurring in South Tyrol. All sequences were manually scanned with the software BatExplorer 2.0. The presumed calls of *N. lasiopterus* were reanalysed with Batscope 4.1.1 and measured with the robust measurement methods implemented in Raven Pro 1.6.1. Statistical analyses permitted to exclude the confusion with similar sequences emitted by the sympatric species

*Tadarida teniotis*.

A total of 42 sequences of *N. lasiopterus* were identified at five different localities in the southernmost part of South Tyrol in several years (Lana 2016, Terlano 2019 and 2021, Laives 2018, Montagna 2019, Egna 2018). The calls were recorded on 14 different nights in the period from late June to mid-August, whereas in June at one site two individuals of *N. lasiopterus* were recorded twice simultaneously.

Notably, despite intensive surveys in the entire province, the species could only be detected in the Adige Valley. This is an area of low elevation and mild climatic conditions and is considered an important corridor for sub-Mediterranean species. Based on the current state of the knowledge, it cannot be assumed if the limited distribution indicates the lack of suitable habitats in other parts of the province or a recent expansion from the South. However, the repeated records of *N. lasiopterus* at different localities during the summer months of several years suggest that this species occurs regularly in the southernmost part of South Tyrol, at least in the summer season. This newly discovered presence of resident individuals of the greater noctule bat is important for its conservation in a regional context, as its occurrence was detected exclusively in the most anthropized part of the province. However, our results are also important at the European level, as there is so far little data on the occurrence of resident populations in Europe outside the Mediterranean region. For these reasons, any new information on the distribution and ecology of the greater noctule bat is crucial and further research on this species is required.

## The marmot in the area of Corno alle Scale, Bologna Apennine: distribution and ecology

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P098

The Marmot *Marmota marmota* is one of charismatic animal in the Alpine environments and for this reason it was also introduced in the northern Apennines, at the top of Modena area. The species has slowly expanded and today also occupies the area of Corno alle Scale, the highest peak in the Bolognese Apennines. The current study is aimed to investigate the adaptations to these environments located outside the optimal home range and the expansive capacity of the species. The marmots and especially their burrows have been sought on the ridge and in the adjoining grasslands that refer to the Corno alle Scale and nearby peaks. From May to October 2021, surveys were carried out to recover the geographical information of the burrows, categorize them in terms of use and evaluate the presence of the Marmot in the different environments. 17 are the main burrows identified and 51 secondary excavations or temporary marmot shelters. Compared to the surveys of 2015 and 2019, 4 areas of new settlement

were found showing a limited positive trend towards expansion. The dens are mostly distributed between 1650 and 1750 meters as already found in the Modena area in the past. The majority of the dens, as far as the slope is concerned, falls between a slope of 20° and 30° and with greater exposures in the octants W, N/W and N/E. Most of the excavations are not far from the paths, despite the numerous tourists always present who induce even a few alarm whistles. The analysis of preferences on a 100 m buffer with Jaccard index showed how the marmots prefers habitats characterized by moorlands and grassy formations such as those categorized as 6150 and 4060 while the categories 8100 and 8200, scree and rock faces have been negatively selected. Research continues to identify potential axes of displacement and expansion of colonization and to evaluate the role that this rodent appears to play in these mountain ecosystems.

**Activity rhythms of the dormouse: a case study in the Alta Murgia**Bergamino C.<sup>1</sup>, La morgia V.<sup>2</sup><sup>1</sup>Università degli Studi di Torino, Dipartimento di Medicina Veterinaria, Largo Paolo Braccini, 2, 10095 Grugliasco (TO)<sup>2</sup>Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA), via Ca' Fornacetta 9, 40064, Ozzano Emilia (BO)

PO07

**Introduction** – The dormouse (*Glis glis* Linnaeus, 1766) is a rodent of the *Gliridae* family. Because of its diversified diet, it often causes damages to crops, which are used as food sources. Hazelnuts are among its most appreciated fruits, and for this reason, the species could generate considerable impacts on hazel grows.

To deepen the knowledge on this phenomenon and to experiment preventive methods, a study began in 2016 in Alta Langa (Piedmont, Italy), with the aim of testing physical barriers on aerial cables, which are often used by the dormouse as a way for accessing hazel plantations. Monitoring the use of aerial cables with camera traps allowed to develop a complementary study on the activity rhythms of the species.

**Methods** – The camera trap survey was carried out from July to mid-October in four study areas. Camera traps were set to be active only at night, covering a time span of 12 hours. The time impressed on the videos allowed to calculate the mean time of the observations, the range and evaluate the uniformity of the observations over 24 hours (Rayleigh test) and their concentration in specific time intervals, thanks to the length of the vector *rho* (at higher values of *rho* corresponds a higher concentration of the observations in narrow time intervals). Moreover, we assessed the presence of differences in the activity rhythms of the dormouse between months and study areas (Anova for circular data and Watson-Wheeler test).

**Results** – Camera traps were active for 117 days, with an operating efficiency of 45%. Overall, 4134 videos were recorded in the selected time frame, but only 769 (18.6%) were related to the dormouse. The activity rhythm analysis demonstrate that the

dormouse has a daily maximum activity range of 10 hours and 11 minutes, with an average activity time around 00:52. The overall value of *rho* corresponds to 0.76, suggesting a low concentration of the observations. We also highlighted significant differences in the mean activity time among months ( $F_{(3,765)}=8.73$ ;  $p<0.01$ ) and study areas ( $F_{(3,765)}=6.21$ ;  $p<0.01$ ), as well as differences in the amplitude of the activity range among months ( $W_6=144$ ;  $p<0.01$ ) and study areas ( $W_6=105$ ;  $p<0.01$ ).

**Discussion** – These results indicate that the species increases its activity range from July to October, from about 7 to 10 hours. In October, there are gaps in the activity range, while in the previous months the activity pattern is monophasic. In October, there is also a higher frequency between 08:00-09:00 pm and a lower frequency after midnight, while in the previous months the frequencies are relatively homogeneous throughout the activity range, with the exception of a peak in September around 09:00 pm. The average activity peak tends to anticipate as the summer season progresses, going from around 01:00 am in July to 10:26 pm in September, with a parallel decrease in the *rho* value (from 0.89 in July to 0.72 in September). This indicates a lower concentration of the observations linked to an increase in the activity range. Despite being preliminary, these results provide interesting information on the behaviour of the dormouse and confirm previous results obtained from another area of Italy. Alongside other data collected as part of the study in the Alta Langa, information on activity rates could be useful for evaluating management activities or species monitoring strategies in hazelnut grows.

**Historical presence of Eurasian otter (*Lutra lutra*) In Aosta Valley**Bertolin F.<sup>1</sup>, Navillod F.<sup>2</sup>, Bertolino S.<sup>1</sup>, Ferrari C.<sup>1,3</sup><sup>1</sup>Department of Life Sciences and Systems Biology, University of Turin, Torino, Italy<sup>2</sup>Museo regionale di Scienze Naturali Efsio Noussan, Aosta, Italy<sup>3</sup>Alpine Wildlife Research Centre, Gran Paradiso National Park, Italy

P008

Eurasian otter (*Lutra lutra*) is a carnivorous mammal belonging to the Mustelidae family and adapted to aquatic life. Since the second half of the twentieth century, the species has undergone a drastic decrease throughout Europe due to direct persecution and environmental alterations caused by anthropogenic actions. The species is classified as "Near Threatened" in the IUCN Red List. In Italy, the species became extinct in the north and centre and survived in the south of the country. Although currently absent, the otter was present in the Aosta Valley in the past.

The main objective of this project is the historical reconstruction of the presence of this species within the Valle d'Aosta territory. Previous presence data have never been systematically organized for this territory, and the latest national survey did not find the species in the region. Historical data, when available, are dispersed in many documents or are present only in the historical memory of some people and therefore can be lost. Our work aimed to collect available data on the presence and distribution of otters in Aosta Valley. For this purpose, historical data, such as old documents or publications reporting the presence of the species, have been consulted. A questionnaire was also produced and sent to libraries and schools to involve their parents and reach as many people as possible. The questionnaire was available in print and online. Finally, some people were contacted directly by telephone.

We consulted 12 written sources (books and other publications), and four reported records of the species in the region. With the questionnaire, we collected seven responses regarding the past distribution of the species; 15 people were subsequently

contacted, and it was possible to recover one further point of presence. Overall, we collected 32 points reporting the historical distribution of the otter in the Aosta Valley. These records were distributed between 1938 and 1970 and reported the species in an altitudinal range between 340 m a.s.l. and 1700 m a.s.l.

Collected data was used to create a georeferenced map of the past distribution of the otter within the Aosta Valley. We then run Maxent to produce a historical suitability model for the region. Land use contributed more to the model (53.7%), followed by altitude (45.3%), while exposition was not influential. The probability of finding the otter in the past decreased with altitude and was higher peri-urban areas. This unexpected result may suggest that elusive mammals, such as otters, may probably be observed in areas where people spend most of the time. We also have to acknowledge that we used Corine Land Cover form 2012 while records refer to 1938–1970. Therefore, it is likely that areas now urbanized were more natural in the past.

This work made it possible to reconstruct, at least partly, the distribution of the otter in the Aosta valley. The project is still open and will continue in the future. The questionnaire will remain active so that people may continue to provide new points of presence. Finally, this research is the first step toward a better knowledge and awareness of public opinion towards the otter, which was considered a threat to fish fauna in the past. Considering the distribution of the species in France, its entry into the western Alps soon is likely. We hope that this project will contribute to the greater acceptance of the species.

## Do wildlife-friendly cities exist? Analysis of wildlife perception of the natural-urban gradient

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PO10

During the past decades global landscape changed due to urban expansion, with consequences on wildlife populations. Urban areas, indeed, host a mosaic of different habitats with a variety of species who have adapted in many ways to live in this environment. However, it is not always easy to define what is and what is not “urban”. Different species of different size and, consequently, ability to move may perceive the same urban environment differently and consider it as a suitable habitat or an hostile barrier. In this work we investigated how three selected species (*Sciurus vulgaris*, *Meles meles* and *Sus scrofa*) may perceive the urban environment of two different sample cities: a small city like Varese and a large one like Milan.

We used the NDVI (Normalized Difference Vegetation Index) as a measure to define what is “urban” and what is “green”. We calculated NDVI on a selection of Sentinel 2 mission (10 m spatial resolution) imagery. In order to have an all-season coverage image we calculated an averaged NDVI map based on four different months of the years 2020/2021 (April, June, October and January). We reclassified the averaged NDVI into 3 land cover classes: “urban” (-1 to 0.2), low vegetation (0.2 to 0.5, i.e., meadows and shrubs), high vegetation (0.5 to 1, trees). We then calculated the proportion of each class within radii of different size, depending on the mean home range of the selected species

(respectively 200, 750 and 1500 m).

The small town of Varese host significantly higher levels of vegetation compared to the large city of Milan. This pattern was also confirmed for single species home ranges: for all the home-range sizes, vegetation proportion is significantly higher in Varese. Hence, Varese urban vegetation could be perceived similarly by the three model species. In Milan, the proportion of green areas per simulated home range is much lower (<30%) and similar for all the home-range sizes. What was slightly different from Varese was the proportion of perceivable urban area, that increases for badger and wild boar perspective, potentially becoming a barrier.

This work suggests that green structures in urban areas could affect species presence, indicating that in defining the “urban environment” researcher and city planners should pay attention to species needs. Different cities with different sizes and with different green structures could be considered as tough urban environment for some species but not for others. With this work we present a preliminary analysis on the potential perception of an urban landscape by wildlife, aiming to better understand the interaction between human infrastructures and wildlife, ultimately addressing planning for a “green” city.

## Relationship on the edge: mountain hares distribution at the southernmost limit in Europe in relation to brown hare presence

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PO81

Human impact on nature is evident, indeed global changes are affecting several ecosystems. Global warming is one of the most pronounced impact and is driving changes in species distribution and their relationships, often reformulating species communities. Changes can be even more evident in arctic and alpine species, indeed higher temperature could reduce alpine biodiversity by driving cold-adapted species out of their current distribution range and generate local extinction in species with narrow ecological niches. Moreover species on the edge of their distribution are under strong ecological and genetic pressure. In this project, funded by CClimaTT Interreg ALCOTRA, we examined the distribution of two lagomorphs living in the Alps: mountain hare (*Lepus timidus*) at its southernmost distribution part in Europe (Marittime Alps) and brown hare (*Lepus europaeus*) present all over the Italian peninsula (except for the main islands).

We worked in two Italian Regional Parks: Parco Naturale Alpi Marittime e Parco Naturale del Marguareis (Piedmont). Line transect survey were applied over an area of approximately 400 km<sup>2</sup>. Hares signs have been recorded along 6 different transects across a wide altitudinal gradient (1200–2200 m a.s.l.). Every sign have been georeferenced and dung have been collected and

stored for DNA analysis. Dung have been analysed to identify hare’s species.

Hare signs have been found along all six transects and along all altitudinal gradient. Thanks to the DNA identification mountain hare have been detected in all areas unlike brown hare. Mountain hare is present even at very low altitudes (1200 m a.s.l.) and brown hare is present also at very high altitude (2200 m a.s.l.). Low hybrid percentage has been registered. During the project has been developed a monitor protocol for these species.

Understanding species distribution and interaction is fundamental for nature conservation. We applied a monitoring protocol to asses mountain hares distribution at its southernmost edge in Europe, not so far from the Mediterranean sea. Mountain hare is still present all over the study area at different latitudes. Surprisingly it is present also at very low altitudes, contrary to the hypothesis that this species should find refuge at higher altitudes. On the other side brown hare is present also during winter season over 2000 m a.s.l., that should not be the ideal environmental condition. This pattern show as it is important to keep monitoring species distribution and interaction to point out useful conservation actions.

**Assessing threats for Pallas's cat in the Central Mongolia: shepherd and feral dogs**Bombieri G.<sup>1,2</sup>, Cicero M.<sup>1,3</sup>, Dartora F.<sup>1</sup>, Monti I.E.<sup>1</sup>, Augugliaro C.<sup>1,4</sup><sup>1</sup> Department of Research and Conservation, Wildlife Initiative Italia, via Rovigo, 12, 31040 Pederobba (TV), Italy<sup>2</sup> World Biodiversity Association c/o Museo Civico di Storia Naturale Lungadige Porta Vittoria, 9 37129 Verona (VR), Italy<sup>3</sup> Department of Biological, Geological and Environmental Science, via Selmi, 3, 40126, Bologna, Italy<sup>4</sup> Wildlife Initiative, Bayangol District, 6th Khoroo, Micro District 10, Ulaanbaatar 210349, Mongolia

PO12

Mongolia hosts a large territory characterized by mountain steppe, which is identified as the prime habitat of the Pallas' cat. The low mountains surrounded by steppe, ensures both, den/shelters and a large number of preys. The mortality of Pallas's cat (*Otocolobus manul*) due to predation by domestic dogs, recently drew the attention of conservationists. Shepherd and guardian dogs are very spread across central Asia overlapping their territory with wildlife. Differently from the past, the increasing number of livestock could bring unsustainable pressure on elusive species such as the Pallas's cat. Furthermore, the Pallas's cat has to face other threats, such as hunting, and the decreasing number of Siberian marmot (*Marmota sibirica*), which presence ensures den to mesocarnivores, where habitat does not offer many opportunities. This study conducted in Bayan Onjuul district, in the Central Mongolian steppe, aimed to explore the threats affecting the Pallas's cat focusing mainly on depredation by dogs. We assumed the dogs kill the Pallas's cat in the project area and local herders could give precious information to establish effective mi-

gitation measures to reduce this and other threats. Thirty-seven interviews with local herders were conducted between October and November 2021. The questionnaire includes questions to explore: the socio-ecological context; the presence of Pallas's cat, shepherd dogs, and free-ranging dogs; the potential threats to Pallas's cat and other wildlife, due to direct and indirect human action; the possible measures to improve the shepherd dogs caring by herders. The answers were analyzed under a descriptive statistic, resuming the most relevant results. Over 50% of the respondents perceived the attacks by dogs as the main threat for the Pallas's cat, approximately 40% perceived snaring, and only 6.8% the diseases as the main threats. Based on this study we developed possible solutions to mitigate the impact on Pallas's cat of domestic and feral dogs in central Mongolia. Among these, supplementary food for dogs, collaring dogs with a little bell applied to the collar and reducing pastureland pressure on the mountainous system, could be feasible and resolute in this socio-ecological context.

**Spatial behaviour of yellow-necked wood mouse *Apodemus flavicollis* in two coppice stands of Central Italy**Bonacchi A.<sup>1</sup>, Devineau O.<sup>2</sup>, Bartolommei P.<sup>1</sup>, Gasperini S.<sup>1</sup>, Manzo E.<sup>1</sup>, Cozzolino R.<sup>1</sup><sup>1</sup> Fondazione Ethoikos, Convento dell'Osservanza, 53030 Radicondoli, Siena, Italy<sup>2</sup> Department of Forestry and Wildlife Management, Faculty of Applied Ecology, Agricultural Sciences and Biotechnology, Inland Norway University of Applied Sciences, Campus Evenstad, N-2480, Koppang, Norway

P113

Rodents and ecosystems share strong reciprocal relationships. Human activities changing the structure and functioning of ecosystems can thus influence rodent behaviour and ecology. The yellow-necked mouse *Apodemus flavicollis* is widely distributed in Europe and its spatial ecology has been studied in various habitats, but research is lacking for Mediterranean forests which often undergo alterations by forest management practices. Our investigation on the spatial behaviour of *A. flavicollis* was carried out in a sub-Mediterranean deciduous oak forest subject to forest management in central Italy. We radio-tracked 27 individuals in two different coppice stands, i.e. a recently cut area and a high forest which differed in terms of species-specific habitat quality

and rodent population density. We analysed home range size in relation to habitat type and sex. Results indicated that home range and core area sizes did not differ between habitat types or sexes. The spatial behaviour of *A. flavicollis* therefore did not seem to be influenced by population density and habitat quality. The absence of sex-related differences is consistent with current knowledge on the spatial ecology of the species. Our findings provide the first useful information on the spatial behaviour of *A. flavicollis* in sub-Mediterranean deciduous oak forests, the ecological processes of which can be considerably influenced over different trophic levels by this key rodent species.

## Woodland suitability for wood mice (*Apodemus* sp.) at landscape scale in an intensively cultivated area

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PO19

**Introduction** – Small rodents play important roles within the typical forest habitat community. First, they promote forest regeneration through the storage of large food reserves in their underground tunnels; the seeds stored and not consumed will be in an ideal position for germination. In this way, these mammals contribute significantly to seeds dispersal and the renewal of many forests. These species also play a key role in the food chain, as they are among the species most consumed by many secondary consumers. Furthermore, small mammals are considered good model species for a global evaluation of the effects of habitat loss and fragmentation in agricultural landscapes. The aim of this research was to improve the knowledge concerning wood mice (*Apodemus* sp.) and their selection in terms of habitat at landscape scale in an intensively cultivated area. In fact, understanding the dynamics that woodland rodents carry out in fragmented landscapes and how they respond to the changes imposed by human activities is vitally important, not only for the conservation of these species themselves but also to ensure and maintain unaltered the dynamics that involve the entire community.

**Methods** – This study was carried out in Lomellina (province of Pavia, northern Italy), a portion of Po Plain intensively cultivated, especially with rice fields. Fifty residual woodlands were randomly chosen and sampled in two seasons (winter and spring), in according to Capture-Mark-Recapture method and by using Sherman live-traps. The influence of environmental variables (land use and habitat configuration) on the presence and abundance of *Apodemus* sp. was evaluated using a multi-grain approach, analysing 500 m, 1000 m, 1500 m and 2000 m radius buffers generated around the sampling transect, and with the help of generalized linear models (GLM) with binomial and Poissonian error distribution. In addition, the seasonal habitat use was investigated by Manly's  $\alpha$  index.

**Results** – In total, we captured 87 individuals of *Apodemus*

sp. in the winter season and 44 in the spring season, with a clear prevalence of males. Males appear larger in size (weight and foot length) than females. The multi-grain analysis showed that the presence of *Apodemus* sp. was affected by a landscape scale greater than or equal to 1000 m. The environmental variables that positively influenced the presence of mice were related to shrub cover. On the other hand, herbaceous cover (e.g. meadows, areas with sparse vegetation) and urbanized areas negatively affected the presence of *Apodemus* sp.. Manly's  $\alpha$  index highlighted a negative selection of areas with sparse vegetation in spring. In contrast, the variables that influenced the abundance had a predominant effect on a 500m scale. The species was positively affected by the density of the hedgerows and the density of the edges of natural forests. Likewise, also rice paddies favoured the abundance. Contrarily, the abundance was negatively affected by variables related to low coverage (e.g. meadows, which negatively influence abundance in both winter and spring seasons), as well as by arable crops.

**Discussion** – In an intensively cultivated area, the presence of wood mice are positively related to shrubs, which offer a dense cover useful for the construction of the nest and which guarantee greater protection from predators, as shown by other studies. Moreover, it is evident the link between small rodents and marginal elements, as well as hedgerows, which is supported by numerous studies. In contrast, herbaceous cover is under-selected by small rodents both for the lesser protection against predators and for the scarce quantity of food it offers. In addition, urban areas and arable crops negatively affected the species, probably due to the use of herbicides that eliminate weeds and insects, which *Apodemus* sp. tends to feed from. However, it is interesting the positive influence exerted by the presence of rice paddies on the abundance of *Apodemus* sp. in the spring season, since in literature there are few studies regarding *Apodemus* sp. and rice fields, further research could better explain this association.



## Are wild boar sensitive to the human disturbance?

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PO15

Considering the behavioral state as a further dimension in spatial behavior modelling may ensure a more detailed comprehension of the relationships between animal movements and landscape attributes, especially those linked with the human disturbance. While this approach was profitably applied on conservation, it remains unexploited for large mammal management.

We modelled the behavior-specific resource selection of wild boar (*Sus scrofa*), focusing on the broad behaviors which are most relevant for its management: resting and overall activity. We chose as study area the North-Western Sardinia, one of the most important Italian touristic resort characterized by a high seasonal variability of human presence. We used activity sensor data to distinguish resting from activity phases within wild boar spatial behavior. We then investigated the seasonal variability of wild boar selection/avoidance of human infrastructures, roads, beaches, and agricultural crops, separately for resting and active phases. Moreover, we tested whether the resource selection of active wild boar was constrained by the distance from the previous resting site and described the temporal patterns of resting sites use.

Wild boar resource selection was not influenced by beaches and roads distribution, during resting nor during activity. Unexpectedly, the negligible effect of beaches and roads was observed throughout the year, including the touristic season (i.e., summer). Wild boar even preferred the proximity with human infrastructures across all seasons, both when resting and when being active, while agricultural crops were selected for activities but avoided for resting. When active, wild boar selected locations as close as possible to their previous resting site. On average, wild boar changed their resting site every 1.94 days, but each wild boar used a limited set of different resting sites during the monitoring (1.59 resting sites/month used on average by each individual). Our behavior-specific analyses showed that wild boar spatial preferences were basically unconcerned by human disturbance and by its high seasonal variability in the study area, widening our knowledge of wild boar adaptations for living in human-dominated landscapes. Nonetheless, the patterns of resting sites use opened interesting perspectives for more efficient and science-oriented management strategies of the species.

## Denaturing Gradient Gel Electrophoresis (DGGE) from stool-DNA as a tool to assess the dietary habits of the apennine wolf (*Canis lupus italicus*), preliminary results

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The Apennine wolf (*Canis lupus italicus*) is an apex predator that actively preys on medium to large size mammals and often scavenges on both carcasses and human leftovers. The analysis of the dietary habits of a large predator such as the wolf has not just ecological implications, but can also be useful to better understand and then mitigate the conflict of the predator with human activities. Advancements in molecular biology allow the extraction and analysis of DNA from several samples, one of them being feces. The analysis of fecal DNA has been widely used for non-invasive sampling of elusive species or just to avoid disturbance of wild populations. Wolf feeding ecology has been investigated by means of direct observations, by analyzing the morphology of undigested remains retrieved from scats or by selectively amplifying DNA of presumed preys. Each of these methods has positive and negative aspects, the main drawbacks stem from the elusiveness of wolves, from the differences in training of the operator who does the morphological analysis and from the costs of molecular analyses. Therefore, an objective and cost-effective method could be a valuable asset for the routine application of a protocol to identify the prey species in a scat sample.

This work aims to test the applicability of Denaturing Gradient Gel Electrophoresis (DGGE) as a fingerprinting tool for the analysis of the prey content in wolf scats. DGGE is a molecular biology protocol that bases on the sequence-dependent denaturation of amplified fragments in a polyacrylamide gel which contains a gradient of denaturing substances. The fragments with higher contents in G-C will resist the denaturants migrating more into the gel comparing to fragments poor in G-C that will require less concentrations of denaturants to unwind and stop their migration in the gel. To avoid the complete denaturation of DNA fragments one of the primers used must be provided with a tail of repeated Gs and Cs to create a region of the fragment that will not be easily denaturated.

In brief, wolf scats were collected throughout Umbria and in the Sibillini Mountains National Park, and at least two samples each scat were prepared for extraction, along with the muscular tissue of wolf, wild boar, roe deer, hare and sheep to be used as reference samples. The sample for DNA extraction was taken from the inner part of the scat to avoid sampling the cells that desquamates from the intestinal epithelium of the predator, that are abundant in the outer mucous layer of the scat, as the DNA contained in them is of better quality and quantity. A 308 bp fragment of the mitochondrial gene *cytb* was successfully am-

plified with a standard set of primers directed toward conserved regions. Amplicons were loaded in the DGGE apparatus, that gives a pattern of bands for each sample; each band represents a fragment with a unique sequence and fragments with the same sequences loaded on different lanes should stratify in bands at the same level in the gel. To obtain a taxonomic identification of each fragment, a series of known samples from putative preys were loaded in the run to allow for a comparison and a visual identification. Furthermore, after the DGGE, selected bands were excised from the polyacrylamide gel and the DNA was recovered and purified to be sequenced, along with the DNA extracted from bone fragments found in scats. At the same time, all scats were also morphologically inspected analyzing the epicuticular pattern of undigested prey hair following a classical protocol which aims to stamp the hair in a thin film of transparent nail polish on a microscope slide.

The data collected from both the molecular and morphological analyses were then compared through a correlation analysis. The sequenced samples confirmed the visual attribution made using the reference samples and was also able to provide a taxonomic identification of two unmatched band groups, detecting DNA from the stone marten and the crested porcupine. Molecular data formed positive correlations with other molecular data whereas morphological data were, mostly, in negative correlation with other morphological data.

The evidences gathered suggest that the DGGE can be a valuable and cost-effective way to do massive screenings of fecal-DNAs to be inspected for prey composition. As for the other methods, it comes with both positive and negative sides. Like every other genetic application, it requires instrumentations and reagents that might be not readily affordable especially if sequencing is needed, plus some samples from the same scat showed variable patterns. The main advantages of a PCR-DGGE protocol are to be found in the objectivity, that allows operators with little to no knowledge to successfully perform the analysis, and in the greater revealing power compared to the morphological analysis. DNA can be extracted from a fragment of a scat while still being representative of the whole excrement, and the undigested remains of smaller preys can be hidden to the eye by remains of much bigger preys. The PCR-DGGE also allows to search for prey DNA without establishing a list of potential prey that might be subject to an underestimation bias. Further studies are then necessary to fully assess the validity of a PCR-DGGE protocol to describe the dietary habits of wild wolves.

## Noninvasive genetic characterization of the Alpine brown bear population (*Ursus arctos arctos*) using microsatellite molecular markers

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PO02

**Introduction** – The population of brown bears in the Italian Alps descends entirely from a few individuals reintroduced from Slovenia in the Adamello Brenta Natural Park in the late 1990s (Project LIFE – *Ursus* LIFE96NAT/IT/3152). Non-invasive genetic monitoring of the population has been carried out since 2002 by genotyping fecal, saliva, and hair samples using a panel of 15 microsatellite loci (STR), validated and shared with transboundary teams involved in collaborative research programs. Tracing individual genotypes has been crucial for the management and conservation of this species in the Alps. For example, individual genotyping has provided data about the outcome of the project (e.g. whether the reintroduced bears remained on the territory to reproduce), enabled demographic parameters to be estimated (e.g. population dynamics, individual fitness, immigration), and allowed the identification of problematic and confident bears. The decrease in genetic variability due to the small number of reproducing founders has made the biomolecular reconstruction of family relationships more difficult in more recent generations using the standard 15 STR panel. In this study, we selected additional markers previously developed for high-throughput sequencing (HTS) to: i) test their efficiency using traditional Sanger sequencing on non-invasive genetic samples, and ii) evaluate their power in kinship identification, maintaining the continuity of the research efforts on transboundary conservation of this species.

**Methods** – In this study, we screened 13 STR loci previously developed for HTS by the Centre National de la Recherche Scientifique, Université Grenoble-Alpes, Laboratoire d'Ecologie Alpine (LECA) and currently in use for the Pyrenean and Slovenian brown bear populations. A total of 169 DNA samples belonging to 102 genotypes were selected from the twenty-year Italian reference biobank. STRs were amplified by PCR and typed on an ABI3130XL Genetic Analyzer. The discriminatory power of the panel was computed by estimating the probability of identity for an increasing number of loci (PID), the probability of identity among siblings (PIDSib), and the mismatch distributions (MM-pairs). Variability indices computed with this data set were compared with those obtained by both the previous 15 STR panel and an additional combined set (15+13 STR).

Analyses were conducted with the software Reliotype, Micro-Checker 2.2.3, and GIMLET v. 1.3.3. Parental analyses were performed by comparing the results of two different approaches (COLONY 2.0.5.0 and FRANz 2.0) for the three sets of markers. Parentage exclusion probabilities were calculated as a measure of the informativeness of our marker sets for parentage inference. **Results** – All the 13 LECA markers were polymorphic. Expected heterozygosity values ( $H_o$  and  $H_e$ ) estimated from the different STR markers sets were not significantly different; however, the values of PID and PIDSib decreased substantially with the increasing number of loci. The combined panel of 28 STR provided better resolution power when compared to the new 13 STR and the 15 STRs currently used for the Italian Alps population, with a lower number of mismatching pairs. The results of the analysis showed that the set of 13 STR markers was also reliable ( $R > 95\%$ ,  $ADO < 3.9\%$ ,  $FA < 0.09\%$ , absence of null alleles, and large dropout). The new panel of 13 STR alone as well as 15 STRs panel didn't provide satisfactory results about the identification of individuals and kinship relationships. The 28 STR combined marker set confirmed maternities and paternities provided by previous field and genetic data, with very high exclusion probability values (FRANz 96%, COLONY 100%), and, in addition, improved information about uncertain parentage hypotheses underlining the elevated accuracy of parentage identification of this marker set.

**Discussion** – We demonstrated that the new panel of 13 bear STRs provided reliable results using traditional electrophoresis on a Sanger sequencer, improving information about genetic diversity in the Italian bear population and are useful and exportable to other monitoring projects. The combined panel of 28 STR provided better resolution power when compared to the 15 STRs currently used in the Italian Alps population, with a lower number of mismatching pairs. It also resolved all but one doubtful parentage hypothesis in the third generation. This panel will allow: (i) a major increase in discriminating power, improving the identification of individuals and kinship relationships; (ii) data harmonization among transboundary research groups, allowing tracking of bears movements across frontiers (iii) cost reduction compared to the use of HTS.

## The reintroduction of the Nubian Ibex (*Capra nubiana*) in the mountains of Lebanon, a challenge

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PO11

After more than a century of absence and decades of speculations, the Nubian Ibex (*Capra nubiana*) is making its comeback in Lebanon through a reintroduction project promoted by the Shouf Biosphere Reserve (SBR). The initiative is coherent with the country's commitments and goals under the UN Convention on Biological Diversity as it represents an important step to restore the past biodiversity of the Shouf Mountains and to reconstruct the natural vertebrate community of Lebanon. Specific inquiries allowed to clearly state that Nubian Ibex is an indigenous species of Lebanon that became extinct in the country in the middle of the 19th century mainly due to large scale habitat destruction and overhunting. The comeback of this iconic native species must therefore be considered a major environmental added value to the richness of the SBR ecosystem, but also a unique opportunity to educate local people to the importance and value of biodiversity.

Following the directions of the IUCN a captive breeding plan, preparatory for a subsequent re-introduction program, was developed in 2016 through preliminary studies by experts and the transfer of a first herd of Ibex from Jordan to a fenced area located on the eastern side of the Shouf mountain range. A five-year management and monitoring plan for the Nubian Ibex was realized, including the feasibility study, guidelines for silvo-pastoral activities and an executive project, that are essential preliminary steps towards the reintroduction of the animals into the wild. The ultimate goal of the initiative is the reconstruction, on the time horizon of several decades, of a wild minimum viable population (MVP) of Nubian Ibex in the SBR and surroundings, which can coexist in equilibrium with the ecosystem and with resident human populations. A reliable MVP estimate is currently not possible but, based on the information available on the mean home range of the species, the reintroduction study area appears large enough to meet the objective.

The surveys conducted in the last 5 years and the habitat suitability model evidence that large patches of the study area are suitable for the species, in particular higher elevation and western orientated areas, for an overall surface of 170 km<sup>2</sup>. The studies also led to the identification of priority areas for the release of the founder herd — namely zones with “escape terrains”, difficult accessibility to humans, low livestock impact, and availability of

water sources. Based on these considerations, the analyses identified the region of Ain Zhalta, in the north of SBR, as most suitable for the release and first settlement of the founders. Taking into account the biological features of the species, the minimum number of founders to set free into the wild is considered to be 45 individuals. Such stock should be obtained transferring 36 to 42 Nubian Ibex into acquaintance fences in Lebanon and letting them breed freely in captivity until the minimum consistency of 45 individuals is reached. Based on the stock already living in the existing Lebanese enclosure and the ongoing negotiations for the transfer of more animals from other Middle Eastern countries to Lebanon, the process of release into the wild could start in 2022 and be concluded within 36 months. In order to monitor the sensitive reintroduction process, all released animals must be individually marked with 2 different ear tags and a PIT-tag, and most of them equipped with a radiocollar for monitoring. Direct observations must be realized on a regular basis. The monitoring work will be critical to acquire scientific knowledge and help address any problem that may arise during the process. The research work conducted evidence that the causes that led to the local extinction of the Nubian Ibex in the past are no longer an insurmountable threat and / or can be properly addressed through a rigorous management and the long-term commitment of all stakeholders.

The reintroduction has therefore a high probability of success if all the potential risks for the survival of Nubian Ibex in the new area are properly managed and measures are taken to prevent any conflict between the Ibex and existing human activities. Special attention is to be paid to the interaction between Nubian Ibex and goats to avoid as much as possible territorial overlap. Another critical measure is the reduction or eradication of stray dogs in the reintroduction sites, which is nowadays being managed. Altogether, a key factor for the success is the involvement of the local populations, seeking the acceptance of the initiative by the local community on one side and preventing any “excessive” interest on the other: such task is being addressed through an adequate plan of involvement and communication. Lastly, the engagement of all the SBR staff and a fruitful cooperation of all institutions and organizations involved is the essential element for a long lasting presence of Nubian Ibex in Lebanon.

**Internal and external factors influencing wild boar speed**

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P018

Average speed is one of the parameters that are studied to understand how an animal moves in space, to reach the resources necessary for survival. The spatio-temporal variation of the average speed is important to understand the ecology, behavior, and physiology of wild animals. Moreover, a better understanding of animal speed and the ecological drivers, that determine its spatio-temporal variation, can help to define targeted and effective management measures regarding the impact that wildlife has on human activities and ecosystems. Remotely recorded location data, such as those provided by satellite telemetry, represent a useful tool for measuring the distance travelled by animals. Technological advances in the field of animal tracking have resulted in more accurate and autocorrelated data. Nevertheless, analytical methods for analyzing tracking data are also evolving to provide accurate and unbiased estimates of speed. It is the case of Continuous-time movement methods (CTMM) that are more accurate and unbiased than most commonly used discrete-time methods because they take into account autocorrelation and tortuosity of location data. By means of the continuous-time movement modelling (ctmm) package of R, we estimated the average monthly speed of 28 wild boar (*Sus scrofa*) and modelled

its variability in respect to internal (sex, age, body measures) and external (month of the year, weather, availability of different habitat types, home range size) drivers related to wild boar ecology, using generalized additive models (GAMs). On average, males (5.86 km/day) were faster than females (5.13 km/day), but the two sexes showed different speed variation patterns along the year, accountable to their different reproductive cycle. The average speed was found to be positively influenced by average precipitation, perhaps because wild boar take advantage of humidity against overheating and rain favoring the olfactory ability. Also the average speed was negatively influenced by the availability of human-dominated areas, perhaps due to a greater availability of constant food resources. Finally, we observed that the average speed increased with home range up to a certain threshold, and then remained stable, probably due to the fact that wild boar in this study did not move daily along the whole monthly home range. Our results can support the definition of more effective management measures of a pest species like wild boar, especially with regard to the prevention of crop damages and the spread of diseases.

**Activity of wild boar in Lago di Vico Natural Reserve: a preliminary approach**Ciampricotti A.<sup>1</sup>, Luzi G.<sup>2</sup>, Puddu G.<sup>3</sup>, La Morgia V.<sup>4</sup><sup>1</sup>Via Corchiano 12, 01034 Fabrica di Roma (VT).

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P020

Aim of this work is the study of the relationship between wild boar and forest habitats, using camera-trapping techniques, in "Lago di Vico" Natural Reserve (Lazio, VT). Through a sampling design constituted by 1 square grid, 57 monitoring points were identified, located in the respective centroids. All the points fall in the wooded areas of the municipalities of Canepina, Caprarola, Ronciglione, Vallerano, Vetralla and Viterbo, which are the cities included in the perimeter of the protected area or bordering on it. The grid covers the whole forest communities of the Vico district, with greater attention to forest entities dominated by European beech (*Fagus sylvatica*), Chestnut (*Castanea sativa*) and Turkey oak (*Quercus cerris*), managed as high forest or coppice. The monitoring was conducted starting on 07/31/2018 for a total period of 249 sampling days, divided into three different surveys with around 20 sites each, and an average of 66 sampling days (min=57; max=81), using two camera-trap type: LTL Acorn 6310 (28 sites) and Cuddeback Flash E3 (29 sites).

The data collected from the camera trapping monitoring, were used to estimate activity level. We fitted flexible circular di-

tribution to time of detection data to describe the underlying activity schedule, considering the differences between seasons. Moreover, Vico's woods were analyzed to collect descriptive dendroauxometric measurements that were used as covariates in generalized regression models, relating the number of camera trap detections to ecological and management features. The analyses were conducted using R packages *activity*, *overlap*, *CircStats* and *lme4*.

As expected, the main activity peak seems to occur after dusk, from 7:00 PM to 10:00 PM, with a shift towards 11:00 PM in the summer. In a completely unexpected way, during the summer we observe a bimodal distribution, with a secondary activity peak around 6:00 AM, probably related to the disturbance caused by intensive agricultural activities.

Some information emerging from the data analysis suggest the possibility of investigating other aspects of wild boar biology to better understand the spatial distribution of individuals and to define adequate management strategies of both the animal and the environments where it lives, considering and integrating information related to its behavior as well.

## Considerations about application of the R.E.M. method to correctly evaluate the density of roe deer *Capreolus capreolus* (Linnaeus, 1758): the determining role of the $v$ factor

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P022

The selective hunting of roe deer has been widely practised for a number of years thanks to the abundance of these animals throughout Italy. Overall, however, the number of active hunters has gradually decreased, mainly due to the advanced average age of the hunters. Year-on-year, this has made it increasingly difficult to carry out drive counts aimed at quantifying the consistency of roe deer as well as the consequent shooting plan. Therefore, it is necessary to experiment new techniques to assess densities that employ fewer people; one of these is represented by the Random Encounter Model, undertaken in 2019 by the “Genova 2 Levante” Hunting Territorial Zone under the supervision of ISPRA and discussed here in terms of the importance of the  $v$  factor.

The experiment (still in progress) has been carried out in the Aveto Valley (Municipality of Rezzoaglio), on the Po Valley side of the Genoese Apennines at altitudes between 700 and 1300 m above sea level; the data for 2019 and 2021 is shown (in 2020 no activity was carried out due to the COVID-19 lockdown). Ten square cells of 0.50 km per side were positioned, featuring maximum diversification in terms of types of land use (except for anthropogenic aspects). Two equidistant points were identified on each side of the cells; of these 8, during the monitoring, camera traps were installed in 6 points per cell: in practice 2 camera traps worked simultaneously in each cell in as many points for 10 days, for a total survey period of 30 days. The instrumentation was moved twice after the first ten days of operation. Furthermore, on 18/05/2021 an M2 roe deer was temporarily captured: an Impala GPS Ecotone Telemetry radio collar was applied to the captured roe deer to obtain on-site data useful to better quantify the daily distance travelled, represented in the model by factor  $v$ . The R.E.M. was calculated using 5 different values of  $v$  obtained from the bibliography, and using the  $v$  obtained from the data transmitted by the animal wearing

the collar.

The model was applied by using 6 different values relating to the  $v$  factor (km/24 h): 1.00; 1.25; 1.99; 4.22; 4.80; 11.90. For both years, the data processed provided very different density calculations, which fell between the following extremely wide ranges: in 2019 between 3.52 and 41.93 ind./km<sup>2</sup>; in 2021 between 3.01 and 35.84 ind./km<sup>2</sup>.

Our research has shown that, among the various elements used to calculate the model, the  $v$  factor represents a particularly critical aspect because it is not easy to determine and it is currently used in a somewhat diversified manner in the scientific bibliography, to the extent that it can potentially lead to macroscopic differences in the local assessment of roe deer density. Our preliminary test seems to suggest that the telemetry data probably represents the daily micro-movements accomplished by an adult male roe deer in the Apennine area. Despite the great geomorphological and ecological differences of the locations, our opinion appears to be confirmed by telemetry data very similar to ours obtained in Sweden in 2017 as part of the sole application of the R.E.M. among those we consulted which involved the use of telemetry on 4 different roe deer to obtain the average daily distance travelled. The frequent use of somewhat low  $v$  values deduced from the bibliography, far removed from the values recorded by roe deer equipped with radio collar, could explain the apparent tendency of R.E.M. to overestimate densities like recorded by some authors compared to other counting methods, such as direct observation, snow track counts or dung counts. In conclusion, our contribution aims to be a stimulus and an invitation to technicians experimenting with R.E.M. on roe deer to carefully carry out a detailed and shared evaluation of the  $v$  factor, to avoid any possible risk of incorrectly quantifying the density of the species in areas where selective hunting is employed.

## Two houses are better than one: spatio-temporal inhabitation of settlements by crested porcupine (*Hystrix cristata*)

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PO49

The spatio-temporal inhabitation of burrow systems by semi-fossorial mammals has been a neglected topic even though it is a key aspect for the assessment of rodent ecology and population dynamics and their conservation and management in human-modified ecosystems. Settlements inhabited by crested porcupine are usually shared, at different times, by badger (*Meles meles*) and red fox (*Vulpes vulpes*) and cohabitation (i.e., simultaneous inhabitation of the same settlement) was reported between porcupines and badgers. Porcupine reproductive pair shows high den-site fidelity. The use of more than one settlement by a porcupine pair, driven by a seasonal preference for different burrow orientations, was previously hypothesised. No evidence supporting this hypothesis is available as well as if this behavioural pattern may be affected by reproduction or co-habitation with other semi-fossorial mammals. In this study, for the first time we investigated the spatio-temporal inhabitation of settlements by crested porcupines by using camera-trapping and we analysed the influence of ethological factors (i.e., porcupettes presence and co-habitation with badgers) on their selection.

Data collection was performed in a hilly area of 2583 ha in the municipality of Crespina-Lorenzana in the province of Pisa (Tuscany, Central Italy) where 68 settlements were known, for a density of 2 settlements/km<sup>2</sup>. In the study area porcupine capture sessions were performed to make each captured animal recognisable in the videos recorded by camera-traps. In addition, other specimens were individually recognisable by the presence of phenotypic peculiarities (e.g., mainly blindness and presence of injuries). The presence of marked or individually recognisable animals allowed us to identify the porcupine families. The camera-trapping monitoring was performed on 12 settlements among the 68 presents in the study area, previously monitored to assess the effective inhabitation by a porcupine family. The total number of inhabitation days by a family in each settlement was measured. Inhabitation of the settlements by a family was analysed by using Generalized Additive Model (GAM) with binomial distribution implemented within the mgcv package in R. Julian date, reproduction and cohabitation were included as explanatory variables in the model. In order to

estimate the effects of the explanatory variables on the length of inhabitation period in a settlement by a family, a new variable (period length, PL), which described the number of consecutive days of inhabitation by a family in a settlement, was defined and modelled by using a GAM with Poisson distribution.

The crested porcupine resulted to be the main inhabitant of the surveyed settlements. Each monitored settlement was inhabited by a single and recognizable porcupine family and no cohabitation with other porcupine families was detected. Most of the monitored porcupine families did not inhabit a single settlement, but rather alternatively and complementarily inhabited two different settlements, which were no more than 250 m from each other. The inhabitation of two settlements by another family of porcupines other than the "owner" was never observed even when the "resident" family was not present. The exclusive inhabitation of both settlements by a single porcupine family suggests that porcupine settlements inhabitation may be distributed in a spatio-temporal binary system. Each porcupine family showed a different inhabitation pattern of the two inhabited settlements during the whole period of monitoring. Our results showed that the selection of the main vs the secondary settlement was affected by the Julian date and, surprisingly, increased when badgers were present, whereas it was not affected by the presence of porcupettes. The period length of settlement inhabitation were positively affected both by the presence of porcupette and cohabitation with badger.

These results provide new ethological knowledge on porcupine spatio-temporal inhabitation of settlements that can be a base for further investigation on ecological factors driving settlements selection and a useful tool for the sustainable management of the impact of this rodent on human infrastructures such as riverbanks. The results obtained could also be involved in the evaluation of the ecological epidemiology of infectious diseases between porcupine and badger within a one health approach. Further investigation on trend in settlements inhabitation in relation to their availability, environmental conditions, and density of porcupine and badger population are desirable.

## Assessing the impact of human activities on medium-large mammals in Myanmar tropical forests using camera trapping

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PO25

The increase of human activities in tropical areas is causing forest fragmentation and habitat loss with drastic consequences on biodiversity. Myanmar forests represent a strongly altered habitat: indeed, in the last decades a very high deforestation rate has been reported as well as illegal hunting activities. It is known that human presence can influence wildlife and species richness, in particular for mammal communities, driving also animals to change their behaviour to avoid — or at least reduce — direct contact with human by minimizing spatio/temporal overlap and increasing niche segregation.

We used data from camera traps placed in two different regions of Myanmar: Rakhine (West), near the Rakhine Yoma Elephant Range Wildlife Reserve, and Sagaing (North), within the Htamanthi Wildlife Sanctuary. The first area is characterized by a high level of human disturbance, while the second presented a low level of anthropic pressure. Within the two study areas, 8 survey sites were selected (4 per area) and a camera trapping scheme was set up with 30 camera traps for each site, activated for about 45 days during the dry season from 2016 to 2019.

At the end of the survey a total of 6324 videos of wild medium-large mammals and 3947 videos of human and domestic dogs (with a great difference between the two study areas) have been recorded. The total camera days exceeded 30000 and we identi-

fied 34 different species. Activity patterns of some vulnerable species as Sun bear, Asiatic golden cat, Asian elephant, and Northern pig-tailed macaque, differed between high and low human disturbance areas, and this would indicate the existence of mechanisms aimed at reducing competition with humans in areas with high disturbance level. In addition, species richness and community composition were different between the two areas, indicating that the two mammal communities could have been shaped by human pressure. Finally, we found that threatened species were spatially related to environmental variables as evergreen forest presence, while other commonly hunted species were negatively affected by the human presence.

This study suggests that human disturbance has some influence on medium-large mammals community in our study areas; some species indeed adapted their behaviour to avoid, at least partially, human presence in highly disturbed habitats.

In addition, the great amount of data collected on multiple species allowed us to extend inferences to higher hierarchical levels of ecological organization, as well as to assess biological diversity effectively comparing species richness and community composition between two different areas with different levels of human pressure.

## Mammals in the City: what they do?

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PO66

World human population and consequently urban areas are rapidly increasing affecting wildlife distribution and behaviour. Due to this trend, in the last decades, urban ecology has been recognized as an important interdisciplinary field. Cities and their urban ecosystems can indeed play an important role to favour the presence of several species. Moreover, one of the most important functions of urban wildlife is to connect urban citizens with their environment, raising awareness on the importance of biodiversity conservation. Therefore understanding distribution patterns and behaviour of wildlife communities in cities can help not only in protecting their presence but also in planning a proper “green management” to avoid conflicts with humans and reduce the risk to spread diseases. Thanks to the project “SelvatiCittà – la fauna in ambiente urbano”, we analysed the mammal community present in public parks and gardens of a small Italian city (Varese, 80000 inhabitants) in northern Italy using camera trapping.

Six urban parks have been chosen, accounting for a study area of about 43 ha. Camera trap monitoring has been carried out in 2021. In each study site camera traps (Boly SG520-24mHD) have been used to maximize medium-large mammals and arboreal fauna capture rate, and set to record 20 s videos all day. All videos recorded have been archived and examined to identify captured species. All the data have been used to create a chec-

klist, to analyse naïve occupancy, species richness and mammal activity patterns.

During the project 14 different mammal species have been identified, including humans and domestic animals. On average 8 (SD 1.7) mammal species per site have been documented. Naïve occupancy of the species ranged between 0.05 to 1 with humans showing the highest values in all the parks. Due to the low number of recorded events, it has been possible to calculate activity patterns for 11 out of 14 recorded species.

All the species identified are considered as Least Concern (LC) by the IUCN Red List. Unfortunately, two Invasive Alien Species (IAS) have been documented in these urban parks. Indeed, *Sciurus carolinensis* and *Callosciurus erythraeus* are included in the Annex of the EU Regulation 1143/2014. The highest species richness has been found at the parks in the northern part of the city at the border with Campo dei Fiori Regional Park (a Natura 2000 site). In this area three different ungulates have been captured (roe deer, red deer and wild boar). This underlines that urban parks can be important areas acting as corridors for mammal species, preserving connections between natural areas. Human high occupancy values were expected as the parks are dedicated mainly to citizens, but it becomes evident that even when human presence is widespread and constant some mammal species can adapt their behaviour to exploit the same site.



## Dormouse *Muscardinus avellanarius* in the Sila biosphere reserve (Calabria)

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P026

*Introduction* – As part of the actions engaged in the Prioritized Action Framework (PAF) and in the Management Plans of the Natura 2000 Network, a preliminary research was conducted on the dormouse presence within 38 SAC (Special Area of Conservation) included in the area of the Sila Biosphere Reserve.

*Methods* – To investigate the presence of dormice we use the classical nest tube placed on tree branches or hedges at a height of 1–1.5 meters above the ground. In September 2018, 126 nest tubes were mounted in 42 sites located in different environmental types, representative of the entire study area. The nest tubes were checked in two different periods of the year: autumn 2018 and spring 2019.

*Results* – The research found the presence of the species in 17 SAC on the 38 investigated (44.7%). The 23 nest found represent the 18.25% positivity on the whole number of tubes. Positive tubes were found between 120 and 1744 m above sea level. Nest

tubes occupancy frequency was of 33.33% in the mixed forest, follows 23.33% in the deciduous forest, 16.66% in permanent crops, 12.5% in open shrub lands, 11.11% in the Mediterranean maquis, 6.66% in the pine forest.

*Discussion* – Although knowledge of the distribution of Dormouse in Calabria is fragmentary, the spread of the species throughout the regional territory seems to be rather continuous. The research, although preliminary, show a good percentage of dormice in the different environmental types present in the Reserve, especially in deciduous and shrub woods, in particular if well diversified by dominant species and by vertical structure. The frequency of use of the nest tubes is low, however, in the pine forests, mostly artificial and with absence of undergrowth. It is noteworthy to note that in many cases the occupation of nest tubes occurred in a short time, as evidence of the effectiveness of the investigation method and, perhaps, also of the good state of the populations.

**A hair-tube survey of small mammals from Serra di Ivrea (NW Italy)**Cullati C.<sup>1</sup>, Fonda F.<sup>2</sup>, Balestrieri A.<sup>3</sup>, Chiatante G.<sup>4</sup><sup>1</sup>Department of Earth and Environmental Sciences, University of Pavia, via Ferrata 1, 27100 Pavia, Italy.  
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PO27

Natura 2000 is the largest coordinated network of protected areas in the world and the main tool for biodiversity conservation within the European Union. Monitoring the protected habitats and species in all network sites by efficient survey methods is essential to plan effective conservation strategies. Small mammals, although including species of conservation interest and being major components of the food web, are often understudied. Through an intensive survey, we investigated the small mammal community of the Special Area of Conservation IT1110057 Serra di Ivrea (Piedmont, NW Italy).

We overimposed a 1×1 km grid to the study area and selected a random linear transect in each cell. From mid-May to mid-June 2016 we collected small mammal presence data along 55 transects, where we set 955 hair-tubes of 60 mm (n=369) and 30 mm (n=586) in diameter, in a number proportional to each transect length. The largest hair-tubes were positioned on trunks or horizontal branches of trees (ca. 160 cm above ground level) about 100 m from each other, whereas the smallest tubes were tied to shrubs (ca. 80 cm a.g.l.) with 30 m spacing. A bait (hazelnut cream) was used to attract animals and an adhesive strip was attached at each end of the tube to collect the hairs. We checked the hair-tubes twice, with an interval of 15 days. We examined the hairs using a microscope (20× and 40× magnifications) and species were identified by comparing the characteristics of the cuticle scale pattern, medulla and cross-section of the hairs.

To collect information on ground-dwelling species, in September 2019 we carried out a four-nights capture session using Sherman traps (7.5×9×23 cm). We placed 10 traps at a distance of 10 m from each other along each of three selected transects. Hazelnut cream was spread at the entrance of each trap, while seeds, a slice of apple and cotton were put at the bottom. Traps were checked daily and trapped individuals were sexed and

weighted before being released at the site of capture.

In 28650 trap-days we found 185 positive hair-tubes. We detected a total of five to six species: *Sciurus vulgaris*, *Eliomys quercinus*, *Moscardinus avellanarius*, *Glis glis* and *Apodemus sylvaticus/flavicollis*, mice's hairs being indistinguishable by hair morphology. Most occurrences were in the second check (n=156) when we found 126 *Apodemus* sp., 15 *Sciurus vulgaris*, 7 *Eliomys quercinus*, 6 *Moscardinus avellanarius* and 2 *Glis glis*. In the first check (n=29) only 19 *Apodemus* sp., 3 *Sciurus vulgaris*, 4 *Eliomys quercinus* and 3 *Moscardinus avellanarius* were detected. Overall, 168 presence data were collected: 132 *Apodemus* sp. (13.82%), 17 *Sciurus vulgaris* (1.78%), 10 *Eliomys quercinus* (1.05%), 7 *Moscardinus avellanarius* (0.73%) and 2 *Glis glis* (0.21%).

Sherman trapping allowed detection of 41 small rodents belonging to two species: *Apodemus sylvaticus* (92.7%) and *Myodes glareolus* (7.3%).

Hair-trapping allowed to record a species not included in the SAC Standard Data Form, namely *Moscardinus avellanarius*, included in Annex 4 of the Habitats Directive, and also an elusive and understudied species such as *Eliomys quercinus*. Hair-tubes are a non-invasive and cost-effective method to get information on small mammal distribution. Anyway, considering the number of hair-tubes deployed, capture success was low, also for a potentially common species such as *Glis glis*, suggesting that a large trapping effort is needed for assessing spatial niche overlap between ecologically similar species and their habitat preferences. The simultaneous use of multiple survey methods may provide a more complete assessment of the small mammal community and allow to collect more reliable data about the genus *Apodemus* and others ground-dwelling species such as *Myodes glareolus*.

## Do bears like honey? Analysis of predation risk and damage to the bee heritage in Sondrio province

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PO29

Sharing territory between humans and large carnivores often generates conflicts which, if not managed, cause discontent in the human population, the rejection of wild carnivores, ultimately imperiling their survival. A fair wildlife management is essential to find compromises between preserving biodiversity and protecting human activities. This work proposes an analysis of this conflict in Valtellina (Sondrio Province, northern Italy), where in the last fourteen years, several male bears expanding from Trentino population have been spotted. The current management of livestock, often lacking in appropriate protection measures, goes against the presence of the bear. Beekeeping is one of the most widespread activities in this area: there are hundreds of beehives and consequently the damage to the sector is increasing. This work analyses the brown bear presence, relating it to, damages to the livestock and to the beekeeping sector to create a risk assessment map to help stakeholders to improve management strategies. The final goal is to achieve a degree of acceptable coexistence between humans and bear.

Thanks to the Sondrio Province Game Office and the local beekeeping Association (APAS), between 2019 and 2021 three types of data relating to the last 14 years have been collected: 1. presence of brown bears, 2. damage to livestock and to beehives 3. positions of the apiaries. We applied MaxEnt models to the dataset, including also several ecogeographic variables to create 3 different models, respectively for brown bear potential distribution, potential distribution of damage to livestock and potential distribution of damage to apiaries. Successively the three models have been merged in a final risk map which divides Valtellina into four risk classes: incidental, low, medium, and high.

Analysis shows that 42% of brown bear signs recorded are predation events: 36% of these concern apiaries, affected between March and September. The most damaged areas are between the municipalities of Aprica and Bianzone and between Sernio and Mazzo di Valtellina. In 2020 were registered 1429 beekeeping stations with 12569 beehives. The brown bear potential distribution model shows that Valtellina area is highly favourable to the specie presence. Less suitable areas are the valley floor, the more densely populated centres, and the higher peaks with inaccessible slopes. The potential distribution model of predation events

shows that areas near the bottom of the valley, in pastures and in mountain pastures where there is a greater presence of farmed animals are most subject to bear predation. Potential distribution of damages to apiaries identifies as risk-prone areas those where permanent hives are concentrated, or areas of floristic interest for nomadic hives. A higher suitability to damage can be noted for the mid-upper Valtellina belts, near the corridor used by male bears expanding from Trentino. Overlay analyses considering the most recent beehive distribution showed that 42% of the beehives were in the high-risk area, 14% in the medium risk, 18% in the low risk and 26% in the incidental area. A further analysis shows that, despite most of the stations are located in the West district of Valtellina, only 27% of these are at high risk of damage, against 52% of those in the Valtellina East district.

The prediction of suitability for brown bear in Valtellina and the analysis of areas at higher conflict risk are important tools for future wildlife management. Furthermore, these tools will be fundamental to raise awareness among beekeepers on the proper use of dissuasion instruments as electrified nets. In Valtellina beekeeping is widespread and the areas of placement of the hives, as this study shows, are often the same chosen by the bear. Almost all beekeepers, however, underestimate, or do not know, the problem: often, electrified nets are used only after a damage instead of for preventive purposes. Damages could be partially limited with a correct use of prevention instruments: in territories where they have been adopted, predatory events were significantly reduced. In the next few years, given the growth of the Trentino bear population, it can be assumed that bear presence in Valtellina will increase, amplifying the conflict. The models, indeed, show that a large part of Valtellina is suitable for brown bears and that any unattended apiary placed in this area can be subject to high risk of damage. Awareness of beekeepers located in the areas at higher risk, as the sparsely populated ones, near woods and almost all of the sites in East Valtellina should increase, encouraging the use of electrified nets. However, these risk maps only give indications on potential risk, that has to be assessed considering also other information. In the future, it would be important to analyse whether, with the increase of use of protective nets, the risk rate will decrease in the areas classified as "more dangerous" so far.

**Wolf predation on fallow deer in San Rossore estate**Del Frate M.<sup>1</sup>, Bongi P.<sup>1</sup>, Sieni S.<sup>2</sup>, Apollonio M.<sup>1</sup><sup>1</sup>Università degli Studi di Sassari, Dipartimento di Medicina Veterinaria, via Vienna 2, 07100 Sassari<sup>2</sup>Università degli Studi di Firenze, Dipartimento di Scienze e Tecnologie Agrarie, Alimentari, Ambientali e Forestali, P.le delle Cascine 18, 50144 Firenze

P014

**Introduction** – Wolf (*Canis lupus*) is considered an opportunistic predator (Becker et al. 2008), which tends to select the most abundant prey. Furthermore, like other predators, it should choose the most profitable prey, according to optimal diet theory. Predatory success can also be considered in relation to age classes and body size, so young and medium-sized individuals are the most vulnerable.

Wolf predation was considered also in relationship to environmental characteristics, and some authors showed as wolf prey deer species in open areas.

In our study, we investigated the predatory preferences of the wolf, towards two communities of ungulates, highlighting the differences in the sex and age classes of ungulates predated and considering the environmental characteristics of the predation sites.

**Methods** – In the San Rossore Estate, Pisa (43°14'30" N; 10°11'90" E), there are two communities of ungulate species, represented by fallow deer (*Dama dama*) and wild boar (*Sus scrofa*), and one wolf is present since 2016. Fallow deer populations showed a mean density, in the last 15 years, of 42 head/100 hectares, while wild boar in the same period, showed a mean density of 3.2 head/100 hectares. We performed 12 standardize transects (mean length=8738.69 m), covering the whole study area, with the aim of searching ungulates' carcasses. Following Di Nicola et al. (2010), the cause of death was attributed to wolf predation, and we collected data on the sex and age classes of the carcasses examined.

We evaluated a selection on the prey sex and age classes, in relation to the availability present in the area at the time of the study, with a  $\chi^2$  test processed with SPSS 19.2 software. We also generated a heat map, which allow easy identification of

predation hotspots using QGIS 3.24.0 software.

**Results** – We looked at predatory occurrences that have occurred since the wolf first came in the study region. We discovered 93 fallow deer predations and only 4 wild boar predations. The sex of predated fallow deer could be determined in 89 cases, and there were significant differences (df=2;  $\chi^2=5.20$ ;  $p<0.05$ ) between males (N=52) and females (N=30) in respect to the sex classes provided. We aged fallow deer predated when it was possible, and we found a significant difference in age class (df=3;  $\chi^2=13.83$ ;  $p<0.01$ ) both in males (fawn=4; pricket=22; sore=10; buck=16) and in females (1–2 years=6; >2 years=23) sex classes. Therefore, we considered predations in relationship to habitat where carcasses have been find, and 90.4% of fallow deer were find in open areas, while 9.6% were find in wooded areas. 3 wild boar were find in open areas, and just one in wooded areas.

**Discussion** – According to our findings, the wolf has focused its predatory behaviour on the most abundant species, fallow deer, while mostly ignoring wild boar. Fallow deer predation did not respect the current population's sex class ratio, since more males were predated. This predatory choice could be conditioned by the choice of the predation site. As matter of fact, the wolf tends to prey on deer in open areas, which, in our study area, are also those with the greatest availability of trophic resources. From previous studies conducted in the same study area, it emerged that males, following the theory of sexual segregation, mainly use the richest areas, from a trophic point of view. Within the sex classes, a significant difference emerged in the choice of age classes. In particular, young males were preyed on in male sex class because they have less developed antlers and therefore defend themselves with more difficulty; while in the female sex class, adult individuals were mostly preyed.

## Cost benefit analysis to identify the best type and location for a wildlife crossing structure for the brown bear

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PO86

Wildlife-vehicle collisions cause damages and loss for people and animals alike and are a reason of human wildlife conflict. Collisions are considered a consequence of the landscape fragmentation which is also a major cause of biodiversity loss worldwide. In Europe the most of the recorded accidents involves ungulates, and in Trentino (N Italy) a similar trend is observed. Since 2010, an average of 700 collisions per year have been reported between wildlife and vehicles (99% ungulates of which 77% roe deer) and a total of 6 collisions involved the brown bear (*Ursus arctos arctos*). Even if the number of accidents with bears is small, the size of the species poses a risk for the drivers and the loss of a bear individual can have a big impact on the small and isolated population of the South Eastern Alps. Wildlife crossing structures increase habitat connectivity and reduce up to 86% the number of accidents when appropriately designed and strategically placed. This work aims to identify the best type of structure and its location to reduce bear-vehicle collisions in the Province of Trento (PAT).

The data used to perform the analysis includes: habitat suitability models and connectivity models for the brown bear available from literature, the wildlife vehicle collision geo database from the PAT, GIS layers about topography, land use, road network and human settlements. The analysis included a GIS assessment to overlap the main movement corridors, the hotspots of wildlife-vehicle collisions and the terrain features that allow the building of a crossing structure. After a field survey of three possible locations, Environmental Impact Assessment (EIA) and Cost-Benefit Analysis (CBA) were used to identify the best type of structure and its final location. The cost-benefit analysis was performed using prices and other economic values available

from in literature for other countries.

The GIS assessment identified the road SS45bis in “Valle dei Laghi” as an hotspot with some tract with more than 10 collisions per km in 9 years. This road has a high volume of traffic and cuts two large areas with high habitat suitability for the bear. The potential sites have been selected in function of their proximity to the wildlife corridors, the permeability for the species and concordant slope on both road sides. The latter is important from building perspective. The most appropriate crossing structures in this study case was an overpass: brown bear and ungulates are known to prefer overpasses to underpasses and the site geomorphological conformation is more suited for an overpass, thus facilitates the construction phase. The location identified as the best to build an overpass would connect two forest patches and is within 400 m of two potential corridors. The final mitigation system consists in the two-lanes overpass, two km of fences and eight Jump-outs (2 per km, per roadside). The total cost is estimated in 4730750 euro and it would require 50 years to amortize the costs (life span of the structure is 75 years) and would avoid more than 700 accidents.

This work identified the most effective engineering solutions and spatial locations to build wildlife crossings in Valle dei laghi, Trentino and complies the local Mobility Plan. The final estimation of the cost and its depreciation are the most critical part, because the costs of collisions and structures are based on prices derived from other countries and are probably under estimate. The availability of several type of data, especially the locations of collisions highlights the importance of continuous monitoring for suggesting detailed options for conservation and accident reductions.

**Relationship between wolf, wild boar and collective hunting: beyond popular belief**

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PO30

The presence of wolf in highly anthropized areas, lead to an increase of conflict with humans since impact on anthropic activities such as livestock breeding as well as on wildlife of hunting interest (i.e., wild boar and roe deer). While wolf-livestock conflict was strongly debated and several strategies were adopted to face this conflict, lack of knowledge are available on wolf impact on species of hunting interest, fueling the popular belief of wolf as a competitor of hunters for wild boar. The aim of this study was to assess the impact of wild boar collective hunting on wolf persistency on the territory as well as of wolf presence on wild boar population in a highly atrophic area of lower Pisan hills of 1295 ha (Casciana Terme-Lari and Crespina-Lorenzana, Tuscany, Italy).

Between 2018 and 2021, twenty camera-traps were permanently placed in the study area where a wolf pack ranging from 5 to 10 individuals is present. Impact of wild boar collective hunting on wolf pack was assessed by compare the frequency of video-capture events of wolves recorded in the wild boar hunting period (November to January) with those of non-hunting period (February to October) in the hunting seasons 2018/2019, 2019/2020 and 2020/2021. For each hunting season, both the number of weekly collective wild boar hunting events and the total number of culls carried out were recorded.

In 2018/2019 and 2019/2020 the frequency of wolf video-

capture events did not show statistical differences between the hunting and non-hunting period, while in 2020/2021 resulted significantly higher in the non-hunting period than in the hunting one ( $\chi^2=48.6665$ ;  $p<0.001$ ). In the hunting seasons 2018/2019, 2019/2020 and 2020/2021 a total of 108, 90 and 60 wild boars were killed during collective hunting, respectively. In the third hunting season, wild boar collective hunt events were performed 3 times/week but only for two months instead of three as in other two seasons due to COVID19 pandemic. Moreover, three young wolf-wild boar interactions were recorded during the monitoring period and in all cases young wolves quickly escaped from the wild boar adult male.

The absence of significant variation in the frequency of wolf video-capture events between hunting and non-hunting seasons in 2018/2019 and 2019/2020 suggests that wild boar collective hunting does not affect wolf pack persistency on the territory. In June 2021 the pack has chosen a rendezvous area in a place monitored by a camera-trap that have determined the higher frequency of wolf video-capture events recorded in the non-hunting season 2020/2021 than in the hunting one. Number of killed wild boar recorded suggests a low impact of wolf presence on wild boar population in this study area and the lower number of wild boars killed in the third hunting season is attributable to the shorter period of hunting

**Never stop looking: multi-year pack dynamic, genetic variability and introgression estimates in a small still-growing wolf population of the Northern Italian Apennines**Dissegna A.<sup>1,2</sup>, Dalpiaz N.<sup>1</sup>, Mencucci M.<sup>3</sup>, Fusco G.<sup>1</sup>, Cappai N.<sup>2</sup>, Fabbri E.<sup>4</sup>, Mucci N.<sup>4</sup>, Velli E.<sup>4</sup>, Caniglia R.<sup>4</sup><sup>1</sup> Department of Biology, University of Padova, Via Ugo Bassi 58b, 35121 Padova, Italy.

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PO32

Human persecution and habitat decline are global threats for the wildlife, especially for large animals. Despite this trend, in Europe several large carnivore populations are growing, due to species conservation laws and changes in human activity in rural areas. In Italy, the wolf has had a recent transition from threatened to locally abundant, after naturally recolonizing the country. Different studies have investigated the first years of this expansion and those focused on identifying family groups with non-invasive genetic sampling were particularly useful in understanding packs dynamics.

However updated information are lacking in the Apennines, despite their importance in checking if the population is still growing and healthy. We focused on a National Park in the

Northern Apennines, where noninvasive genetic sampling was carried out from 2002 to 2020. We assessed the status of this small population, checking if the number of packs has changed across the years, if families were stable and the status of genetic diversity. We found a numerically healthy still-growing population, with long-lasting families showing a significant female-biased philopatry. On the contrary, genetic diversity decreased in the last years and road kill resulted as the majority cause of death in wolves found dead in the study area. These results highlight the importance for protected areas to keep checking their populations' status, in order to detect possible threats and guarantee genetic flow among different populations of the same species.

## How to choose? A multidisciplinary approach to assess best-performing methods to count wolf packs in the Apennines

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PO31

In the last decades, several European carnivores such as the wolf have experienced a general numerical increase and geographical re-expansion, mainly due to favourable ecological conditions and protective legislation. However, human-wolf coexistence issues and threats to long-term wolf presence are still present. Conservation and management strategies should be carefully designed on updated population data and planned on a wide scale, tailored to the target population. Unfortunately, ecological data are difficult and expensive to obtain and their comparison across time or among different areas is often impossible, because of disparity in sampling design and detection methods. In order to assess most common methods to estimate the Apennine wolf abundance and distribution in Italy, we simultaneously applied three techniques: wolf-howling, camera-trapping and non-invasive genetic sampling in a protected area of the northern Apennines, evaluating the results both separately and in an inte-

grated way. We aimed at counting the minimum number of wolf packs during a single wolf biological year and evaluating pros and cons for each technique, testing if sampling effort can affect results. We showed that packs' identifications could be hardly comparable if methods were used individually with a low effort: wolf howling identified nine packs, camera-trapping 12 and non-invasive genetic sampling eight. Integration of techniques yielded to the highest number of packs detected, 13, but it was the most expensive option. However, this issue tends to disappear with a higher sampling effort, yielding to consistent and comparable results among all used methods. We showed how results from different sampling design should be compared carefully. The development of a common sampling strategies should be a priority to compare key population parameters, for a shared effective management and conservation of a large carnivore such as the wolf.

## Never stop looking: multi-year pack dynamic, genetic variability and introgression estimates in a small still-growing wolf population of the Northern Italian Apennines

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PO33

The long-term social and economic development of a country is strictly connected to its environmental condition. Mongolia, with its unique ecosystems, has been experiencing a rapid social and economic development since the 1990s that are threatening the persistence of biological resources. The Koprowski Conservation Research Lab (KCRL), in conjunction with the Mongolian Academy of Sciences (MAS), are studying the mammalian community in Bogd Khan Mountain Strictly Protected Area (BMSPA) south of the capital city of Mongolia, Ulaanbaatar, which is facing a high degree of urbanization expansion.

Although wolves (*Canis lupus*) are the most extant canine species throughout Northern America and Eurasia, they can face local extinctions, mainly because of high conflicts with humans due to their large body size, foraging behavior, and valuable body parts for clothing and medication purposes. With a growing human population in Ulaanbaatar, an increasing number of feral dogs is becoming a big issue in wildlife conservation in the region because these sympatric species impact the mammalian community, as well as crossbreed with wolves. The IUCN regional status of Mongolian wolves is "Near Threatened", but the observed declines in population size suggest that further surveys may reveal that it should be listed as "Vulnerable" or even "Endangered".

In this ongoing project we will study and obtain the data to

characterize the wolf populations in and around the BMSPA boundaries. The project aims to (1) assess wolf and feral dog occupancy as well as prey availability using camera traps and develop related species distribution maps in BMSPA; (2) determine if crossbreeding with feral dogs is occurring by collecting wolf scat to perform genetic analysis; (3) determine the local human perception of wolves and the effect of wolves on livestock through a questionnaire. Pending genetic analysis, in 2023 (4) I will document predator movement and identify patterns of predation and depredation on livestock using GPS collar technology on wolves and hybrids.

With a firm understanding of wolf natural history and status in BMSPA we hope to help reduce human-wolf conflicts and provide more scientific knowledge to help locals understand the value of conserving wolves and their ecosystems. This project will help understand the current status and the limiting factors to gray wolves in Mongolia due to overhunting, natural prey items, and hybridization issue with feral dogs. Moreover, we hope to establish future work with MAS and potentially clarify the connectivity of wolf populations in Mongolia. The techniques and discoveries made during this project will hopefully set the stage to perform research and apply wolf management techniques to other regions of Mongolia.

## Movement behaviour of a wolf along a residual lowland woodland in northern Italy: a functional ecological corridor or an anthropogenic trap?

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PO34

The wolf is an adaptable species able to tolerate human-induced pressures. Nevertheless, widespread urban networks and dense transport infrastructures may represent ecological barriers for species long-range movements. The aim of the study was to investigate the movement ecology of a radio-collared wolf released within the Ticino Natural Park, a wide forest corridor connecting northern Apennines and Central Alps and crossing one of the most anthropized landscapes in Europe. To investigate the movement behaviour of the released wolf we: (i) tested for differences between stationary/exploratory and diurnal/nocturnal movements through Mann-Whitney tests with permutation; (ii) identified the home range and core areas by a Brownian Bridge Movement Model (BBMM) considering the 95% and the 50% BBMM, respectively; and (iii) investigated how landscape composition affected the wolf movements by a Step Selection Function (SSF) on active steps only.

During the monitoring period of 208 days, we obtained 771 GPS locations. Overall, the wolf covered a cumulative line distance of 1184 km. It alternated exploratory and stationary periods; during the exploratory periods the wolf travelled three times northwards along the Ticino River (about 20, 35 and 50 km, from the release site, respectively) and then southwards to the Apennines (about 95 km from the release site). Mann-Whitney tests with permutation revealed that the mean ( $\pm$ SD) distance between consecutive GPS locations covered during exploratory periods ( $2.9\pm 0.4$  km) was significantly higher than the

mean distance covered during stationary periods ( $1.2\pm 0.08$  km) ( $U=0.641$ ;  $p<0.0001$ ); similarly, mean distance between consecutive GPS locations covered during the night ( $2.1\pm 0.1$  km) was significantly higher than the mean distance covered during the day ( $0.5\pm 0.04$  km) ( $U=0.785$ ;  $p<0.0001$ ). The home range ( $65.6$  km<sup>2</sup>) and the core areas ( $9.1$  km<sup>2</sup> and  $3.6$  km<sup>2</sup>) identified through the BBMM were located around the release site, where the wolf spent all the stationary periods. The SSF showed that during active movements, the wolf significantly avoided urban and cultivated areas and water courses.

The monitored wolf spent all the stationary periods in the most undisturbed and prey-rich area within the Ticino Natural Park. It probably used this area as biding area, showing the interesting behaviour of temporarily using a small area with home range-like characteristics to increment chances of successfully dispersing. When moving, the wolf avoided potential encounters with humans by travelling mainly during the night keeping away from urban and cultivated areas. The movement behaviour showed by the radio-collared wolf suggests that it attempted to disperse northwards multiple times, but the dense network of urban areas and traffic roads acted as an ecological barrier to long-range movements. Albeit preliminary, as based on data from one individual only, these results provide important insights about the wolf movement behaviour in highly urbanized landscapes and about possible issues concerning the functionality of the Ticino Natural Park as an effective ecological corridor.

## Landscape genetics analysis and the role of barriers in structuring the wild boar (*Sus scrofa meridionalis*) population in Sardinia (Italy)

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PO35

Land-use changes can affect the degree of landscape permeability to wild animal movements and impact genetic differentiation between and within populations. Landscape genetic studies integrate population genetics, spatial analyses and landscape ecology to test hypotheses about how environmental features influence population genetic structure and gene flow. Assessing how environmental connectivity affects gene flow is useful to guide wild species management, especially in fragmented landscapes. In this study we analysed population genetic structure and landscape genetics of the native wild boar (*Sus scrofa meridionalis*) population inhabiting the island of Sardinia (Italy), and test for the existence of Isolation-by-Distance (IBD), Isolation-by-Barrier (IBB), and Isolation-by-Resistance (IBR). A total of 393 Sardinian wild boar samples were analyzed using a set of 16 microsatellite loci. Signals of genetic introgression from introduced non-native wild boars or from domestic pigs were revealed by a Bayesian cluster analysis including 250 reference individuals belonging to European wild populations and domestic breeds. After removal of introgressed individuals, genetic structure in the population was investigated by STRUCTURE and Adegenet (in R), supporting a partition into five discrete

subpopulations, corresponding to the following geographic areas on the island: north-west (NW), central west (CW), south-west (SW), north-central east (NCE) and south-east (SE). To test for IBD, IBB and IBR, we optimized resistance surfaces using genetic algorithms and linear mixed-effects models with a maximum likelihood population effects parameterization in Circuitscape.

Landscape genetics analyses revealed that genetic discontinuities between subpopulations can be explained by landscape elements, suggesting that main roads (especially the SS131, crossing the island from south to north), urban areas and arable lands (intensively cultivated areas) are hindering gene flow within the Sardinian wild boar population. Our results reveal how human-transformed landscapes can affect genetic connectivity even in a large-sized and highly mobile mammal such as the wild boar and provide crucial information to manage the spread of pathogens, including the African Swine Fever virus, endemic in Sardinia. Long-term effects (small population size, inbreeding, genetic drift) of habitat fragmentation should also be carefully evaluated in the Sardinian wild boar, in order to promote a sustainable management of its endemic genetic diversity.



## Antipredator responses of fallow deer to the wolf in a mediterranean area

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P038

Prey are expected to adopt behavioural tactics to minimise the risk of an encounter with predators. Among these tactics (e.g., increased vigilance, increased group size, spatial and temporal avoidance), spatial avoidance has been reported especially in large and relatively undisturbed protected areas. However, actual antipredator responses may not be consistent across studies. Moreover, prey responses to predators are object of increasing interest, especially considering the recent recovery of large carnivores in Europe, and the alleged potential for behavioural antipredator responses to trigger consequences at the ecosystem level.

In this study, we used camera trapping to investigate wolf-fallow deer relationships in a Mediterranean protected area recently recolonised by this apex predator. Previous work showed an antipredator response of fallow deer based on temporal avoidance. Here we concentrate on (i) spatial relationships and (ii) vigilance behaviour of female fallow deer, including also forest habitats, where focal observations are usually impossible.

Our results show that the spatial patterns of locomotory acti-

vity of wolves were positively associated to local fallow deer detection rates. No evidence was found for fallow deer avoiding sites with higher predator detection rates. As for the vigilance, both the rate and the duration of vigilance of female fallow deer increased with the local frequency of wolf activity. Vigilance decreased with increasing group size and was the lowest in ecotone/open habitats, while it increased in autumn-winter in respect to spring-summer.

We suggest that, besides an antipredator response based on temporal avoidance, female fallow deer adjusted their vigilance according to the perceived spatial variation of risk of encounters with predators, finely tuning their vigilance to the environmental cues (i.e., vegetation, visibility) and season. We emphasise that antipredator responses should be evaluated on a case-by-case basis. An antipredator response based on temporal — rather than spatial — avoidance, as well as increased vigilance, would undermine the potential for the predator to trigger behaviourally mediated trophic cascades.

**EUROSMALLMAMMALS: a network for collaborative science in small mammal ecology**Ferrari G.<sup>1,2</sup>, Delucchi L.<sup>2</sup>, Tagliapietra V.<sup>2</sup>, Urbano F.<sup>3</sup>, Devineau O.<sup>1</sup>, Cagnacci F.<sup>1</sup><sup>1</sup>Fondazione Edmund Mach, Research and Innovation Centre, Via Edmund Mach 1, 38010 San Michele all'Adige (Trento), Italy<sup>2</sup>Faculty of Applied Ecology, and Agricultural Science and Biotechnology, Campus Evenstad, Inland Norway University of Applied Sciences, 2480 Koppang, Norway<sup>3</sup>Joint Research Centre, European Commission, Ispra, Italy

PO37

Environmental, climatic and anthropogenic modifications constantly impact worldwide ecosystems resulting in global scale biological responses across all ecological levels (individual, population, species and community). As a consequence living organisms can adapt their niche breadth either via genetic evolution and phenotypic plasticity or through distributional shifts, which may alter the communities, lead to novel host–vector species pairings and to the emergence of infectious disease. To detect and investigate these responses on wildlife, animals often require long-term monitoring studies or (possibly) retrospective spatio-temporal longitudinal studies across environmental gradients. Small mammals are an elusive group of animals particularly important for their ecological and epidemiological role, and for their capability to track environmental and climatic changes through functional and numerical responses. In this context, data sharing and reuse can play a crucial role to address unforeseen questions on global changes across a broad range of habitats and species. In 2019 within the collaborative network “EUROMAMMALS” (<https://euromammals.org>), we have initiated a new branch specifically dedicated to small mammals named EUROSMALLMAMMALS. Our aim is to promote collaborative open science and networking among scientists involved in small mammal ecology across Europe, for connecting different species-specific bottom-up projects.

From 2019, we contacted 20 European researchers involved in small mammal projects and 4 had requested to join the network later. In order to promote data sharing of reliable, standardized and harmonized data, partners were encouraged to fill a specific questionnaire in which they can provide the metadata of their projects. These metadata served as reference to translate small mammal data collection protocols into a relational database built under open-software platforms (PostgreSQL, PostGIS, Django, OpenLayers, Bootstrap, jQuery). Data included all the aspects

covered during a small mammal study: study area characteristics, type of experimental designs, local environmental and climatic data, descriptors of capture events, data derived from laboratory and epidemiological analyses. Further, the partners shared their raw data which passed through quality check and harmonization process and then included in the database.

At December 2021, 15 partners belonging to 9 countries across Europe (Spain and Andorra, France, Germany, Italy, Norway, Poland, Czech Republic, Albania) joined the network. The data, spanning from 1990 to 2019, included 48 small mammal species (e.g. voles, mice, glirids, lemmings and shrews), 70562 captures, 113 study areas and 7 pathogens (e.g. hantavirus, *Leptospira* spp., *Borrelia* spp., *Babesia* spp., TBEv, *Anaplasma phagocytophilum* and *Hepatozoon* spp.). Generally, the animals were captured applying live or snap-trapping methods. Moreover, some small mammal data derived from owl pellets analyses are included. We created a EUROSMALLMAMMALS website (<https://eurosmallmammals.org>) which includes project aim, scientific purposes and outputs, and a mailing list dedicated to the partners ([eurosmallmammals@googlegroups.com](mailto:eurosmallmammals@googlegroups.com)) to improve communication.

EUROSMALLMAMMALS collaborative network is constantly expanding throughout European countries, involving partners that cover different fields of interest, e.g. population demography and dynamics, epidemiology, conservation genetics, community composition, prey-predator dynamics and landscape ecology. By scaling up the knowledge from the individual to the ecosystem and by sharing data and expertise on small mammals' populations, this initiative could give the opportunity to fill some important knowledge gaps and provide novel perspectives to evaluate the effect of global changes on species distribution, ecosystems functioning and epidemiological aspects.

## Activity budget and feeding ecology of the eastern gray squirrel in an urban park in Turin

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PO39

The Eastern gray squirrel (*Sciurus carolinensis*) is one of the most invasive animals in Europe. In Italy, Great Britain and Ireland this alien species is outcompeting the native Eurasian red squirrel (*Sciurus vulgaris*). Piedmont is the Italian region that hosts the largest population in Italy. The species adapted to human dominated landscapes and colonized many urban green areas. In this research, we studied the activity budget and feeding ecology of the eastern gray squirrel in Turin. The aim of the study was to determinate the ability of this species to exploit local food resources and the importance of supplemental food provided by citizens.

The research was conducted in the Parco del Valentino, the largest and most popular park in the city center. Field observations were conducted from November 2020 to November 2021, twice a week. We found squirrels by patrolling the park on foot and conducted focal animal sampling with a continuous recording of behaviour. When squirrels were observed feeding, the food source was recorded. Observations were dictated on tape a tape recorder and later transcribed on spreadsheets for data analysis. In total, we observed squirrels for 179.3 hours. Squirrels were active most of the time during the field observations and the majority (58.7%) of the active time was spent foraging. Interactions between squirrels occurred regularly throughout the year, with many antagonistic behaviors observed for the competition for food and territory. Nest construction was observed throughout the year, especially during spring when most of the reproductive

behaviors took place. Squirrels interacted with other species, including common pigeons, hooded crows, and dogs. Human interactions were observed almost every day, with park visitors supplying peanuts and walnuts to the squirrels, which represented the bulk of their diet in all seasons. Squirrels used a wide range of tree species to collect food resources, which varied by season. Beech and oak acorns were consumed regularly, followed by fruits and seeds. During winter bark consumption was common, as well as flowers and grass during spring and summer.

Gray squirrels spent most of their time on the ground, using trees and branches mainly for resting, eating food, and escaping possible predators such as dogs. Supplementary feeding by visitors provided enough food resources for squirrels to survive periods of natural food shortage and helped to support what appear to be a high population density in the park. We conclude that the use of a wide range of foods and changing of food habits throughout the year are key factors enabling squirrels to adapt to urban areas. Bark-stripping behavior and fruit consumption could lead to significant damage to local plants, especially in areas with high population density such as Parco del Valentino. It's important to continue monitoring and to limit artificial foraging because it contributes to maintaining high population densities, encouraging the dispersal in the surrounding areas but also promoting the iconicity of gray squirrel to the people, which makes difficult the management of the species.

**The density of badger setts in a natural river corridor (NE Italy)**Fonda F.<sup>1,2</sup>, De Luca M.<sup>3</sup>, Mori E.<sup>4</sup>, Pecorella S.<sup>2</sup><sup>1</sup>Department of Life Science, University of Trieste, via L. Giorgieri 10, 34127 Trieste, Italy<sup>2</sup>THERION Research Group, loc. Castel San Mauro 1, 34170, Gorizia, Italy<sup>3</sup>For-Nature S.r.l., via T. Ciconi 26, 33100 Udine, Italy<sup>4</sup>Consiglio Nazionale delle Ricerche, Istituto di Ricerca sugli Ecosistemi Terrestri, Via Madonna del Piano 10, 50019, Sesto Fiorentino (FI), Italy

PO61

The European badger *Meles meles* (Linnaeus, 1758) is a common semifossorial mustelid species widely distributed throughout Europe. It also shows a high degree of plasticity, adapting its spatial and temporal behaviour to live in highly disturbed environments. Badgers live in social groups occupying underground systems called setts, which could be classified as “main” (i.e., the complex systems with a great number of entrances), and as “outliers”, “annexes” and “subsidiary” (i.e., the other burrows with a low number of entrances). An extensive scientific literature occurs on the ecology and biology of this species, and some information is available also for setts density in Europe and in Italy, too. However, since badgers may inhabit a wide variety of habitats, the setts density varies significantly both locally and on a large scale. We aimed to provide setts density in a river basin in the North-East of Italy.

From January to March 2022, a sett survey was conducted in the eastern plain of Friuli Venezia Giulia Region (NE Italy), along the floodplains of the lowest reaches of Isonzo/Soča river basin, from Pavia di Udine (Torre river) to the Isonzo river mouth, a natural corridor surrounded by a highly human-modified matrix. Transects to collect setts information were made in the entire area of 27.82 km<sup>2</sup> by two or three operators. For each sett, we recorded the geo-referenced location, the type (main, subsidiary and outliers), the habitat, and the number of entrances. To esti-

mate the density, we only considered active main setts, dividing their number by the area.

A total of 22 main setts were identified within the floodplains, corresponding to a density of 0.79 setts/km<sup>2</sup>. The mean number of entrances was 13.67 (min: 5, max: 28) and they were mainly recorded in forested patches (riverine forests and transitional woodlands-shrublands). We founded other 14 subsidiaries and 13 outliers setts. The density estimated in our study area is remarkably high compared to those estimated in similar environmental conditions (e.g., Po plain area, NW Italy), but considerably lower than those reported for natural habitats (e.g., Alpine area). Even if we did not specifically analyse habitat selection of the badger for the location of setts, our results confirm the importance of the forested area and specifically riverine forests for the badgers in agricultural matrices.

Furthermore, it is known that several mammals use the complex burrow system of the European badger as shelter or as a reproductive site. In a highly fragmented and disturbed area, the high density of badger setts could favour the expansion and the survival of other species, some of which are of conservation interest (e.g., European wildcat *Felis silvestris* and golden jackal *Canis aureus*) and some other invasive species (e.g., the raccoon dog *Nyctereutes procyonoides*).

**Investigating Ecotourism impacts on mammal activity in a Costa Rican protected area**Fonda F.<sup>1</sup>, Vezzani L.<sup>2</sup>, Mena Aguilar L.A.<sup>3</sup>, Romeo G.<sup>4</sup>, Sonetti D.<sup>4</sup>, Dal Zotto M.<sup>2,4</sup><sup>1</sup>Department of Life Science, University of Trieste, via L. Giorgieri 10, 34127 Trieste, Italy.  
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PO40

Costa Rica belongs to one of the 36 world biodiversity hotspots, representing one of the most important ecotourism destinations in the world and providing huge socio-economic and environmental benefits. However, tourism may have an impact on biodiversity which should be investigated thoroughly, giving priority to poorly studied areas. The Karen Mogensen Wildlife Refuge (KMWR) is part of the Biological Corridor of the Nicoya peninsula (NW Costa Rica), among the least studied regions of the country in terms of mammalian fauna. In the past, this area underwent significant human-alterations, but most habitats were restored thanks to the establishment in 1996 of a private protected area, owned by ASEPALECO association. Inside the KMWR, ecotourism and the establishment of an eco-lodge represent a fundamental income for the economic sustainability of the protected area. Through a camera trapping survey, we investigated the mammal community of the KMWR and we assessed the influence of tourists on their diel activity patterns. The survey was carried out from mid-January to mid-April 2019 using six camera traps placed close to the paths and sources of water, with the aim to improve animal detectability. A species accumulation curve was built to assess if our survey effort was sufficient to describe the community. To assess if mammal community was disturbed by human presence, we tested if the presence of tourists changed the diel activity patterns of i) the most common species (>50 detections), ii) the entire community, iii) nocturnal vs. diurnal species, and iv) strictly terrestrial vs. predominantly or semi-arboreal species. We described the diel patterns with a probability density function (Kernel Density Estimate), and we calculated the coefficient of overlap  $\Delta_i$  to compare the activity variation in relation to tourists' presen-

ce/absence; we tested the statistical significance of the difference through the Watson's two-sample test. Tourist presence/absence data were provided by ASEPALECO, which records all the entrances in the protected area.

In 537 trap-days we recorded 467 independent detections of 12 mammals: *Odocoileus virginianus*, *Dicotyles tajacu*, *Puma concolor*, *Leopardus pardalis*, *Conepatus semistriatus*, *Eira barbara*, *Nasua narica*, *Didelphis marsupialis*, *Tamandua mexicana*, *Cebus imitator*, *Cuniculus paca*, *Dasyprocta punctata*. The accumulation curve indicated that we reached a plateau after 219 trap-days, i.e., no new mammals recorded after this period. During the sampling, tourists were present for 52 days, and absent for 50 days, with little difference in the number of camera-trap detections (239 and 228, respectively). The presence/absence of tourists did not produce any significant change (e.g.,  $\Delta_i > 0.77$ ) in the temporal activity patterns all species and groups considered. Our results showed that the number of large mammals in the KMWR is comparable to that recorded in other protected area of Costa Rica, including some rare and elusive species; this suggests that habitat restoration was effective for mammal conservation. Interestingly, during our survey, we documented the first reproductive event of the top-predator *Puma concolor* in the area, an encouraging indication of the recovery of the food-web, after years of protection. There is a large literature documenting the impact of tourism on wildlife activity patterns, showing an increase of nocturnality. However, our results showed little effects of tourists on the activity patterns of species and groups. This suggests that present tourism management in the KMWR is compatible with mammal conservation and provides a nice example of sustainable touristic exploitation.

## Assessing the impact of bears, wolves and jackals on extensive livestock practices in north-eastern Italy

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PO41

Human-carnivore conflict is one of the main causes which have led to the decline of several carnivore species worldwide, and to the abandonment of livestock practices in those areas in which conflicts were more intense. In Friuli Venezia Giulia (hereafter, FVG) the main carnivores which may come into conflict with human activities are the brown bear (*Ursus arctos*) and the grey wolf (*Canis lupus*). As for the brown bear, the re-colonization of the Region occurred due to the natural dispersion of individuals coming from both the central Italian and Dinaric Alps. Within the Region, from one to seven individuals are monitored each year. For what concerns the grey wolf, the re-colonization of the territory occurred because of the natural dispersion of individuals coming from both western and Dinaric Alps. The species re-established in FVG in 2016/2017 and now seven packs are estimated to be present, at the very least. The recent natural arrival of the golden jackal (*Canis aureus*) from both the Dalmatian and Slavonian populations opens new ecological scenarios. To date, the population in FVG is estimated to be composed of about 25–35 packs, at the very least. However, this new presence claims the need for an adequate monitoring program to assess the eventual impact on human activities. Based on these considerations, the main purpose of the present work was thus to quantify the impact of brown bears, grey wolves and golden jackals on livestock activities within the FVG Region. Specifically, we aimed to address the main following research questions: (i) Is there a difference in terms of predatory pressure among predators? (ii) Is there a difference in terms of the overall number of predated individuals, also taking into consideration the affected livestock species and responsible predator? (iii) Is there a difference in terms of number of predatory events among seasons? (iv) Is there a variation in terms of compensations (€) recorded per year and considering each predator? (v) Is there a difference in terms of number of predatory events between farms that use and don't use mitigation measures?

Data on carnivore predations (from 2009 to 2021) were collected by the regional wildlife technicians in collaboration with the researchers of the University of Udine and the members of the Forestry Service. Seasons were classified as follows: autumn (October, November, December), winter (January, February, March), spring (April, May, June), and summer (July, August, September). To answer questions (i), (ii), (iii) and (v), both the chi-square and Fisher's exact test (in the case of contingency tables showing values <5) were used. The eventual difference among more than two categories was subsequently explored through the *pairwise nominal independent function* (*pnif*). To answer the question (iv) we used linear regression models. Statistical analyses were run using the Software R (v. 4.1) and setting the level of significance at 0.05.

Our findings revealed a significant difference ( $\chi^2=61.12$ ,  $p<0.001$ ) in terms of number of predatory events among predators: bears (n=81, 53.29%), wolves (n=54, 35.53%), jackals (n=17, 11.18%) and in terms of number of predated individuals per predator ( $\chi^2=225.08$ ,  $p<0.001$ ). However, in the latter case the only significant differences (*pnif*,  $p<0.001$ ) were recorded comparing bears (n=206, 46.08%) and jackals (n=27, 6.04%), as well as wolves (n=214, 47.88%) and jackals. For what concerns bears, sheep (n=163, 78.74%) were significantly (*pnif*,  $p<0.001$ ) more predated than both goats (n=32; 15.46%) and cattle (n=12, 5.80%); and the same significance was observed for wolves: sheep (n=191, 89.25%), goats (n=22, 10.28%), cattle (n=1, 0.47%). Regarding jackals, only predations at the detriment of sheep were observed (n=27, 100%). A significant difference ( $\chi^2=57.75$ ,  $p<0.001$ ) in terms of number of predations was recorded among seasons: autumn (n=25, 16.45%), winter (n=12, 7.89%), spring (n=53, 34.87%), summer (n=62, 40.79%), with the only exception of spring vs summer (*pnif*,  $p=0.34$ ). A significantly higher ( $\chi^2=16.12$ ,  $p<0.001$ ) number of predations was observed in farms which did not use mitigation measures (n=94, 61.84%) compared to those that used them (n=58, 38.16%). For what concerns bears, no significant variations (LM,  $R^2=0.008$ ,  $p=0.77$ ) in terms of compensations was observed among years. Conversely, a significant high variation (LM,  $R^2=0.45$ ,  $p=0.13$ ) was observed for wolves.

The higher number of individuals predated by wolves underlies the impact that wolves may have on livestock practices, especially in the light of its recent re-appearance in the Region. Sheep confirmed to be easier to predate because of their smaller size and poor anti-predatory strategies. The higher number of predations recorded during the warm seasons match the transhumance period, during which animals are moved at higher elevations to feed in open pastures and, therefore, are more likely subjected to carnivore attacks. The high number of predations recorded in farms that did not use mitigation measures, suggests that the latter may effectively deter predators. Regarding bears, we did not observe significant variations in terms of compensations per year. However, data variability reported by the  $R^2$  did not allow us to elaborate strong inferences. Conversely, for wolves, higher compensations were registered especially in the latest years. As for jackals, compensations were given starting from 2018 when the species was included in the list of 'potentially damaging carnivores' for human activities. To conclude, our findings revealed an existing degree of negative interactions between carnivores and human activities in north-eastern Italy. Therefore, monitoring the carnivore population and adopting adequate mitigation measures assume remarkable importance to enhance the coexistence in the long-term.

## I'm in charge here! Effect of the golden jackal presence on the behaviour of other smaller-sized competitors in a neo-colonization area of north-eastern Italy

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According to the mesopredator suppression theory the biggest carnivore living in the territory behaves as the apex predator through killing small-sized competitors to reduce competition and, occasionally, to feed on them. The interspecific competition among sympatric carnivores is one of the main causes which may lead smaller competitors to modify their activity rhythms to reduce the likelihood of encounters with larger predators. In Friuli Venezia Giulia (hereafter, FVG) the medium-sized carnivore population includes the golden jackal (*Canis aureus*), the red fox (*Vulpes vulpes*) and the wildcat (*Felis silvestris*). The golden jackal is mainly distributed in the karstic areas of Gorizia, Trieste, and the Julian and Carnic Pre-Alps. However, in recent times, the species has started to colonize even the regional lowland areas where it shares its habitat with both foxes and wildcats. Because these species present a similar trophic niche (at least for what concerns the carnivorous component) the competition for resources is very likely, especially during the wintering period when the diet of both jackals and foxes is mostly composed of animal component. Using data obtained from camera-trapping the main purpose of the present research was to assess the activity pattern and temporal overlap among golden jackals, red foxes and wildcats to explore how the presence of jackals may alter the behaviour of the other medium-sized competitors. We would expect to observe that both foxes and wildcats may adjust their activity pattern to reduce the odds of encounters with jackals as the latter, being bigger in size, could behave as the apex predator in the area thus exerting direct negative effects.

Overall, 12 camera traps were placed along trails and in two different areas: six in the Carnic Pre-Alps and six in the riparian lowland area. Before placing the cameras, both study areas were divided into squares of 3.3×3.3 km and in each square one or two cameras were placed, depending on site accessibility. For what concerns the Carnic Pre-Alps, the first camera was placed from 29/09/2021 to 23/03/2022; while in the riparian lowland area the first camera was placed from 22/09/2021 to 12/04/2022. Cameras were activated 24 h per day, set to record both photos and videos and checked every 15 days to download data and change batteries (if needed). The significance in terms of activity pattern among species was assessed through the Hermans-Rasson's test. The degree of activity overlap between species was evaluated considering the coefficients of overlap  $\Delta 4$  and/or  $\Delta 1$ , in the case of a small number of detections (<50).  $\Delta < 0.50$  indicates low temporal overlap,  $0.50 < \Delta < 0.75$  indicates moderate temporal overlap, while  $\Delta > 0.75$  indicates high temporal overlap. Statistical analyses were run using the R Software (v. 4.1) and setting the level of significance at 0.05.

In the Carnic Pre-Alps, during a sampling effort of 1050 trap-days, we recorded 71 positive detections for the red fox and 23 for the wildcat. No positive detections for the golden jackal were obtained. As for the riparian lowland area, during a sampling effort of 1212 trap-days, we recorded 335 positive detections for the red fox, 172 for the wildcat and 52 for the golden jackal. Our findings revealed that in the Carnic Pre-Alps the wildcat was significantly more active during the sunset (around 18:00) ( $T=19.87$ ,  $p<0.001$ ), while the red fox showed no significant peaks of activity ( $T=6.62$ ,  $p=0.06$ ). In the riparian lowland area, all three species showed significant peaks of activity. Specifically, it turned out that the wildcat was mostly active during the night (around 24:00) ( $T=54.73$ ,  $p<0.001$ ), the red fox showed a bimodal activity pattern being most active during the night (from 23:00 to 06:00) and late in the morning (around 10:00) ( $T=36.45$ ,  $p<0.001$ ), while the golden jackal was mostly active late in the morning (around 10:00) ( $T=39.22$ ,  $p<0.001$ ). In the Carnic Pre-Alps, low temporal overlap ( $\Delta 1=0.44$ ) was observed comparing both wildcat and red fox patterns of activity. Conversely, in the riparian lowland area, high levels of temporal overlap ( $\Delta 4=0.82$ ) were observed between these species. Lastly, in the riparian lowland area, both the wildcat and red fox showed a moderate temporal overlap with the golden jackal, i.e., wildcat vs golden jackal ( $\Delta 4=0.54$ ) and red fox vs golden jackal ( $\Delta 4=0.59$ ).

The low level of temporal overlap between wildcat and red fox observed in the Carnic Pre-Alps suggests temporal avoidance between species, most likely to reduce the degree of resource competition. This result is even more interesting if we consider the high level of temporal overlap between these species observed in the riparian lowland area, where the golden jackal was detected. Here, both the wildcat and the red fox showed moderate temporal overlap with the golden jackal. Therefore, we speculate that wildcats and red foxes modulate their temporal behaviour (hence resulting in overlapping between them) most likely to reduce the odds of direct encounters with golden jackals. These results are consistent with studies realized in FVG and Romania, respectively, in which it was shown that the presence of the golden jackal may lead to increasing allostatic load in wildcats, as well as reducing the body weights of juvenile red foxes. To conclude our research revealed that the presence of the golden jackal may represent a disturbing factor for both wildcats and foxes forcing them to modulate their activity pattern to reduce the risk of direct encounters. Nevertheless, further research also taking into consideration the diet analyses of these species are needed to provide detailed insights.

## Predicting sarcoptic mange prevalence within the Italian red fox population using citizen-science platforms



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PO63

The red fox (*Vulpes vulpes*) is a mesocarnivore widely distributed in Italy and capable of reaching high densities even in human-altered environments. Red foxes are notoriously major hosts of several diseases (including zoonoses) at a global level and, among these, the sarcoptic mange (hereafter, mange) is well documented in fox populations. Mange has been shown to have detrimental effects on biodiversity globally, including disease-induced mortality of endangered species. These effects can be potentially exacerbated by the plasticity of the mite *Sarcoptes scabiei* (i.e., the etiological agent of mange) that allows the ectoparasite to be transmitted across a wide variety of host species. Since Italy is known for the high prevalence of endemic species, assessing the occurrence of mange in one of its main hosts, assumes remarkable importance to delineate adequate actions to counteract potential spill-over events across wild mammals. Moreover, the spread of the disease has always been ascribed to human expansion, and the ubiquity of the species in Italy makes it a suitable model to test for the effect of anthropization on the epizootic dynamics.

Owing to the accessibility of data and the suitability of the selected species, we used information obtained from citizen-science biodiversity platforms (i.e., iNaturalist and Ornitho) to explore the main factors that can shape mange prevalence among foxes in Italy. We checked 2107 pictures collected between 1990 and

2021 to determine the presence/absence of clear signs of mange in foxes individuals. Subsequently, we modelled the variability of mange occurrence in the red fox investigating the effects of individual and environmental covariates, such as age class, status of each individual (alive, road-killed, dead for other causes), and elevation.

The prevalence of mange in Italy was 6.17%. Our preliminary results revealed that (i) the occurrence of mange in juveniles was higher than in adults, (ii) the occurrence of mange in alive foxes was higher than in road-killed foxes, but lower than in foxes dead for other causes, and (iii) the occurrence of mange was higher at lower elevations.

The fact that clear signs of mange were associated with a lower risk of being road-killed might be linked to the behavioural effect of mange, e.g., leading to a lower dispersal tendency. The inverse relationship between mange occurrence and elevation may find an explanation in the higher levels of urbanisation typical of lower elevations, which in turn may promote higher fox densities. This last result is in accordance with other studies reporting foxes closer to human settlements to be more infested by the ectoparasite, and hence, to increase the risk of mange spreading, thus generating potential impacts at the community level.



**Preliminary results of a low-cost method for roe deer monitoring in north-western Italy**

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PO42

Wild ungulates have fundamental role within the terrestrial ecosystems: they represent primary prey for large carnivores, which exert both direct (density mediated) and indirect (risk mediated) effects on them, and, at the same time, act as ecosystem engineers through wallowing, rooting, bark-stripping, grazing and trampling they affect plant cover and soil properties. They have a profound effect on the environment, moreover, they represent important species for hunting. For these reasons, robust and precise techniques are mandatory for their monitoring, in particular when the management aim requires reliable information on population parameters. The roe deer (*Capreolus capreolus*) is the smallest ungulate indigenous to Europe; found throughout the continent, from Mediterranean to boreal areas, in human-dominated and wilderness areas, during the last decades its population greatly increased in number and geographic distribution. The aim of our study is to evaluate a low-cost method to obtain useful parameters, i.e. minimum population size and density estimates, of the roe deer in study areas differing from the presence of the wolf (*Canis lupus*), the landscape, and the management of the species.

The collection of data was carried out in seven different study areas located in north-western Italy (extent of the study areas: from 18 to 27 km<sup>2</sup>), which are very different from the environmental perspective. These areas are: A) "Triangolo Lariano" (CO-LC); B) "Boschi Negri e Moriano" (Natural Park of the Ticino Valley, PV); C) "Basso Monferrato" (Natural Park of the Po River, AL) D) "Riserva Naturale Torrente Orba" (AL); E) "Colline dell'Oltrepò Pavese" (PV-PC); F) "Val Tidone" (PV-PC); G) "Alta Valle Staffora" (PV-PC). For two consecutive years (2020–2021 and 2021–2022) during the winter (from November to March), when broad-leaved vegetation is scarce and roe deer live in groups, we carried out our surveys. We used camera trapping, superimposing a 1.5×1.5 km grid to deploy one camera trap within each sample unit at a random location, to estimate the minimum population size in each area. Moreover, we carried out direct observations, between dusk and dawn hours, travelling along paved and dirt roads recording the number of roe deer groups, the number of deer in each group

and the distance between the observer and the group. Therefore, using distance sampling we also estimated population densities. Collected data were modelled using (1) the uniform function with cosine adjustment, (2) the half-normal function with cosine adjustment, (3) the half-normal function with Hermite polynomial adjustment, (4) the hazard-rate function with cosine adjustment. The model that best fitted the data was selected according to Akaike's Information Criterion (AIC).

During 1653.5 trapping days (2020–2021: n=808; 2021–2022: n=845.5), we collected 579 videos recording roe deer presence (2020–2021: n=278; 2021–2022: n=301). Counting the number of captured individuals in each event and classifying them by sex and age, we obtained the minimum number of distinct individuals at each camera-trap site; subsequently, taking into consideration the locations of and the distances among camera traps, we obtained the minimum number of distinct individuals in each study area. We reckoned the presence of 135 distinct roe deer in 2020–2021 and 173 distinct roe deer in 2021–2022; the minimum number of individuals was estimated for G ("Alta Valle Staffora") in 2020–2021 (n=7), while the maximum number of individuals was estimated for B ("Boschi Negri e Moriano") in 2021–2022 (n=39). We carried out 84 road surveys (2020–2021: n=23; 2021–2022: n=61) during which we observed 1200 roe deer in 368 groups (2020–2021: n=85; 2021–2022: n=283). The average group size greatly differed among study areas ranging from 1.6 (mean) ±0.7 (SD) in A ("Triangolo Lariano") to 5.6±4.5 in D ("Riserva Naturale Torrente Orba"). Even estimated roe deer densities differed among study areas, with study area B ("Boschi Negri e Moriano") showing the highest: 24.9±3.9 (SE) ind./km<sup>2</sup>.

Management practices often have to compromise between the quality of their results and the effort required to obtain them. The methods we used were low-cost considering the effort they required in terms of both time and workforce. Moreover, both sampling designs and the subsequent analyses can be easily performed. Thus, our approach proved to be effective to obtain the considered population parameters.

## Preliminary analysis of community structure and distribution of medium-to-large mammals of the “Massiccio del Taburno” and “Camposauro” Special Areas of Conservation

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PO43

The “Massiccio del Taburno” and “Camposauro” special areas of conservation (SACs) are two forested Natura 2000 sites in the Benevento province (Campania region, Italy), included in the Regional Park of Taburno-Camposauro. During 2019 a partnership involving environmental protection and scientific organizations started a project (“Sve(g)liamo la Dormeinte”) aimed at increasing the knowledge of, and improving the, biodiversity in the Park and SACs. The project received the financial support of the foundation “Fondazione con il Sud”, and is ongoing.

As part of the project actions, we collected camera-trap data to characterize the medium-to-large mammal community, to identify carnivores of conservation interest, namely the wildcat *Felis silvestris*, pine marten *Martes martes* and wolf *Canis lupus*, and to investigate the impact of livestock and forest management on carnivores. No systematic sampling of meso-large mammals has been conducted previously in the area. During 2019–2020, we deployed 37 white-flash camera-traps in a study area of 108 km<sup>2</sup>. At each location the camera-traps run for 71 days on average ( $\pm 15$  SD), for a total of 2635 camera-trapping days. The naïve occupancy and the capture rate (n° of detections/100 camera-trapping days) were quantified for all wild mammals and for humans, dogs and cattle. At each camera-trapping site we also visually assessed the percentage of shrub and tree canopy cover and the most prevalent diameter class for trees.

We obtained 1113 detection events of 8 species of meso-large mammals. Camera-traps revealed the presence of the wildcat in 8 locations; potential hybrids and domestic cats were detected in 4 sites. Among large mammals, beside the wild boar *Sus scrofa*,

the roe deer *Capreolus capreolus* sspp. was camera-trapped in both SACs. Moreover, the camera-traps captured images of two adult wolves with two pups, providing a first proof of a breeding pack in the area. The roe deer and the wildcat represented new records for the area. No detections of the pine marten were obtained during the study.

Among carnivores, the red fox was ubiquitous and was captured by the cam-traps at a rate (21.63) about 3 to 7 times higher than the stone marten *Martes foina* (6.73) and the badger *Meles meles* (3.95), respectively. The wildcat, the wolf and the roe deer had a capture rate less than one on average. The second most frequent mammal was the wild boar (capture rate 8.80) detected in 33 sites (naïve occupancy 0.89). Naïve occupancy was also high for the stone marten (0.76) and the badger (0.65), and between 0.22 to 0.05 for the wildcat, the wolf and the European hare (*Lepus europaeus*).

We did not find clear evidence of a negative influence of livestock, humans and dogs on single mammal species, possibly because of the small sample size. However, preliminary analyses evidenced a higher cattle capture rate (5.36 on average) at sites where the stone marten was not detected than where this species was present (2.85). Moreover, the capture rate of the stone marten was positively correlated with the percentage of shrub cover at camera-trapping sites. We also found evidence of potential avoidance between wildcats and red foxes.

We discuss the possible origin of roe deer in the study area, local threats to wildcats and wolves, and the possible causes of pine marten absence in the SACs.

## Adaptive management of problematic bears: the role of personality and cognitive abilities in operational protocols

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PO44

Ursidae are primarily large animals, and when they come into contact with humans or their activities, the interaction behaviour could be problematic. To inhibit this type of behaviour, operational protocols have been developed worldwide reporting how to react to a challenging situation when it occurs. The role of animals' personalities in response to management actions is reported as fundamental in determining the success of such activities. The standardised application of protocols, without considering the characteristics of single animals, rarely leads to complete success. In most cases, the results of deterrence actions vary depending on the attribute of the animal. Many authors highlighted the importance of the individuality of a single bear in evaluating the most effective procedures. Different cognitive abilities have been demonstrated in bears, such as distinguishing different numerical quantities, use of tools, memory capacity, and self-recognition in front of a mirror. Studies on the personality of individual bears are to date scanty. However, understanding the interactions between personality, other animals' characteristics and how bears react when they are the object of deterrence could improve management and conservation strategies.

This work aims to evaluate whether the adaptation of deterrence protocols to the characteristics of single individuals improves their effectiveness. For this purpose, we reviewed the literature searching for articles considering three macro-topics: protocols and their applications, animals' cognitive abilities, and bear personality. Additionally, we developed a survey on these issues administered to researchers, managers, and other experts involved in problematic bears management. Finally, the case study of F1.99, a problematic Apennine brown bear (*Ursus arctos marsicanus*) present in the Maiella National Park, was evaluated in detail through the analysis of videos and its movements recorded through a GPS radiocollar. The questionnaire results show that not in all cases, the standardised approach leads to a decrease in problematic behaviour in the long term. The difference in

reaction to deterrence or prevention is primarily due to factors such as gender and age of the bears and the interaction with environmental characteristics. According to others, these differences depend more on other factors, such as how the animals modify their spatial behaviour in response to prevention and deterrence actions and the development of tolerance. Still, a significant percentage of respondents believe that the causes are to be sought in other more subjective factors. The case study presented showed a high ability of F1.99 to evade the protocol. It was able to modify its chicken coop predation strategy, bypassing the preventive safety measures implemented.

In science literature Ursidae are described as species with high cognitive abilities, comparable to primates. On the other hand, unlike the latter, these abilities are not due to their sociality, as they are considered non-social species, but to the enormous environmental and food variability present in their habitat. Therefore, it is essential to know these skills and understand their development to comprehend how they encode the environment and, consequently, how to avoid the onset of problematic behaviours or intervene once individuals show them. Routinely, protocols are standardised for every individual regardless of their characteristics and ability to react to these stimuli. In this study, we focused on how individual bears react to operational protocols to inhibit problematic behaviours. Each animal has its history, ontogenesis and experiences that lead it to develop a specific personality that influences its decisions. A better understanding of these aspects, still little considered today, could help solve complex coexistence problems. In conclusion, adapting the protocols to the characteristics of single individuals, taking into account their personality and cognitive abilities, can increase the success rate in the re-education of the problematic bear avoiding extreme events such as their captivity. This is essential for conserving populations, often present at very low densities, such as in central Italy, where every individual is necessary.

## Historical presence and current distribution of the crested porcupine *Hystrix cristata* in Calabria (southern Italy)

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PO45

**Introduction** – The historical distribution of the Crested porcupine *H. cristata* L., 1758 in Calabria is not well documented. However its presence was not homogeneous, with some areas of absence. Historical sources document that the species suffered a considerable decline and range contraction after the second half of the nineteenth century, disappearing from most of the region. In contrast, there has been a process of expansion in recent years; this has involved the entire range of the species and has led to reoccupation of part of its old range in Calabria and colonization of areas of historical absence.

**Methods** – Information on the presence and distribution of *H. cristata* in Calabria derives from a critical review of the available bibliographic data and from unpublished data. The bibliographic sources include: i) historical literature (up to 1970); ii) modern scientific literature (after 1970); iii) “grey literature”. The unpublished data come from studies conducted by the present authors both as targeted investigations carried out in an opportunistic manner and as occasional surveys during field research. Moreover, documented reports from reliable observers have been taken into account.

**Results** – Up to the second half of the nineteenth century, the crested porcupine was abundant and common in Calabria, espe-

cially in the eastern part, but was absent or very rare in the main mountain groups (Sila, Calabrian Serre, coastal chain) and in the central-northern Tyrrhenian coast. At the beginning of the twentieth century, the species was believed to be extinct throughout the southern part of the region and had become rarer in the remaining area of its presence; this was probably due to environmental changes that occurred in those years (extensive deforestation, an increase in cultivated land and, to a lesser extent, greater hunting pressure). During the period of greatest range contraction, the presence of the species was limited to the central-northern Ionian coast and the Crati River valley. The recent expansion of the populations has led to colonization of areas of historical absence such as Sila, even at high altitudes (1700 m a.s.l.), and the Tyrrhenian coast, where sightings are increasingly frequent.

**Discussion** – On the whole, the distribution of the species in Calabria is relatively homogeneous from the Pollino massif (in the north) to Angitola Lake where the southernmost sightings have occurred. In view of the significant expansion of the species throughout Italy in the last few decades, the absence of recolonization of Calabria south of the Isthmus of Marcellinara, where the ecological conditions seem to be favourable, is surprising.

## Animove: a free and open source framework for the analysis of animal movements with QGIS

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PO46

In 2022 the QGIS software will be 20 years old. This program has the characteristics of being free and open-source and this allows to have access to the code and be able to improve it, but above all it allows to implement plugins that, exploiting the core-software, perform specific algorithms.

Here, we presented the AniMove plugin, adapted to version 3.xx of the QGIS program. This plugin allows to perform the main calculation operations about the Home Range evaluation (MCP, Random HR, Random HR path), and some tools to estimation of the Kernel Density. For all the algorithms used, there is the possibility of varying different calculation parameters. The plugin, already fully functional, maintains, however, a framework logic, that is to be expandable and integrable with new routines

and calculation algorithms that can be interesting in the world of applied zoology analysis and radio tagging. The tool is fully integrated with the hundreds of features and algorithms in QGIS; it is therefore easy to create models that extend its capabilities, e.g.: analysis of habitat selection and land use, social indices (distances, overlaps), etc. Further development will automate some of these features to create an animal movement analysis suite. Further customizations and contributions are easy, cheap, and most welcome.

The source code of the plugin is available at the address <https://gitlab.com/faunalia/animove>, and the plugin can be installed automatically through the usual plugin installation menu, directly from within QGIS.

**Diet of the otter *Lutra lutra* in the Abruzzo Lazio and Molise National Park**

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PO47

The Eurasian otter *Lutra lutra* is listed as Endangered in Italy. The species returned to the Abruzzo Lazio and Molise National Park (ALMNP) in 2018, and it is one of the last territories colonized permanently by otters along the peninsula at its most northern range boundary. The National Park hydrographic network is well connected with the surrounding water basins, thus representing a strategic area for the future expansion of the species in Central Italy. Understanding the key factors for the survival of a viable population of otters in this area is therefore essential to enhance the expansion process and adopt cost effective conservation measures. Among these, availability of feeding resources is a basic ecological requirement affecting species fitness. We aimed to explore the diet composition of the otters along a river to lake gradient in the ALMNP, and to evaluate any spatial pattern or a seasonal variation in prey composition.

We collected 103 spraints at 9 sampling stations along 29 km, from the source of the river Sangro to the Barrea reservoir during two sampling sessions (autumn 2020 and summer 2021). Data from the 9 sampling sites were pooled in upper, middle, and lower river sections. Prey remains and diagnostic bones were analysed through morphological analysis, using a microscope and a reference bone collection. Prey categories were sorted in five prey categories (fish, amphibians, crustaceans, reptiles, birds, and mammals). Fish remains were further identified up to class level and, when possible, family. Data were reported as Relative Frequency of Occurrence (RFO), i.e. the number of prey occurrences out of total occurrences  $\times 100$ . We used ANOVA and MANOVA to test for the variation of prey categories among sections and seasons, and PCA and biplot to explore differences among sampling sites in terms of prey frequency.

As expected, results showed a significant prevalence of fish (72.6%), followed by amphibians (13.1%) and crustaceans (9.2%), whereas reptiles, birds and mammals occurred just occasionally. Among fish, Salmonidae recurred significantly more frequently (60.8%) than Cyprinidae (21.7%) and Percidae (17.9%). Only amphibians and Salmonidae occurrences differed

significantly between the two seasons, both decreasing in autumn. The number of prey categories was almost homogeneous along the river sections during summer, whereas in autumn it decreased in the upper section. Fish were well represented along all the river sections, whereas amphibians were more frequent in the lower and middle stretches, and crustaceans were only found in the upper section. Focusing on fish, Salmonidae occurred in likely every stretch, whereas Cyprinidae and Percidae increased their frequency in the lower stretch, especially in autumn when Salmonidae decreased consistently all over the river. Fish and amphibians were the unique preys recorded at the reservoir, whereas a richer prey composition was detected along the river. However, fish composition was identical between lake and river. PCA results and biplot confirmed all these findings.

The otter resulted to be a very good bioindicator of prey spatial distribution in the study area. Indeed, the average digestion time of the otters is almost an hour, and during this time the average movements amount nearly to one kilometre, likely leading to a deposition of spraints very close to the foraging areas. As to the feeding niche of the otter in the ALMNP, fish prey decreased with altitude, being replaced with the most abundant alternative prey, i.e. crustaceans (the endemic *Austrapotamobius pallipes*). When available, Salmonidae seem to be preferred among the whole set of prey. As Salmonids are among the fastest swimmer and hard to catch fish, this preference may indicate this is the most abundant fish in the study area. Predation on Salmonidae poses some issues of human-wildlife conflicts with local recreational fishermen. Mitigation of conflicts is essential to meet the trade-off that satisfy both the counterparts and lead to enhance otter densities to foster the expansion of the otter population. Also, the selection of endangered and protected prey such as endemic fish and crayfish challenges the management of different species under conservation connected by a prey-predator relationship, claiming for a future analysis of the crayfish population dynamic and impact of the predation by the newly established top predator.

**Attitudes toward otters in a recently colonized national protected area**Giovacchini S.<sup>1</sup>, Sulli C.<sup>2</sup>, Loy A.<sup>1</sup><sup>1</sup>Dipartimento di Bioscienze e Territorio, Università degli Studi del Molise, Contrada Fonte Lappone, 86090 Pesche (IS), Italy<sup>2</sup>Servizio Scientifico, Parco Nazionale d'Abruzzo Lazio e Molise, 67032 Pescasseroli (AQ)

PO55

The Eurasian otter *Lutra lutra* is a freshwater top predator listed as Endangered in Italy. The species returned to the Abruzzo Lazio and Molise National Park (ALMNP) in 2018, 50 years after its extinction. The park is one of the last territories recolonized by otters and it is located at the most northern boundary of its current Italian range. The hydrographic network of the National Park is well connected with the surrounding water basins, thus representing a strategic area for the future expansion of the Eurasian otter in Central Italy. Understanding the key factors for its survival in this area is therefore essential to enhance the expansion process and adopt cost effective conservation measures. Among potential pressures, conflicts with stakeholders, including anglers, fish farms and farmers, may arise and result in retaliation, and in direct or indirect mortality that could compromise the fitness of local populations. Accordingly, this study was aimed to assess the attitudes toward the otters in the ALMNP by local stakeholders, and to evaluate the risk of potential human-otter conflicts.

We submitted 162 questionnaires to five categories of potential stakeholders whose activities are located near the river network of the Park, i.e. livestock farmers, farmers, nature guides, tourism companies, and anglers. Questionnaires aimed at recording i) socio-demographic data, ii) otter awareness iii) perception of freshwater ecosystems iv) perception of potential impacts on otter habitats, v) attitudes toward the otter and potential conflicts. The majority of those interviewed were male (93%), over 50 years old (60%), and included livestock farmers (19%), farmers (24%) and anglers (37%). One third of the respondents (30%) confused the otter with similar mammals (beaver, muskrat, mink, coypu or marten), and more than 59% did not believe or doubted the otter occurs in the Park. On the other hand, 19% stated the otters never disappeared from the area. The majority considered water as the fundamental resource for freshwater ecosystems (86%) and returned observations about the water

clarity of their territory and how freshwaters could be preserved. Two third of those interviewed showed a positive attitude toward riparian vegetation belts, although showing a very controversial attitude toward felling and trimming of riparian trees. Although most of interviewed agreed in some important ecosystem functions of riparian strips, like erosion prevention (69%) and provision of shelters for wildlife (28%), they mostly neglected others, such as water thermoregulation and shadow (11%), flood control (14%) and pollutants filtering (4%). Asked to choose between two pictures of sustainable vs. highly modified river management, most of the interviewed (75%) leaned towards the management of a river with more vegetation, less artificial banks and protection infrastructures more distant from the water. Most of the interviewed stated they have positive feelings toward the otters (72%), considering they deserve protection. However, more than half of them ignored that they otters are legally protected. Local communities of the Park perceived the otter as an advantage (60%) both in terms of environmental quality and touristic attraction. A small portion of responders (30%) considered the otters potential competitors for fishing activities. However, the quality of replies leaves room for a truly sustainable attitude of coexistence. Finally, answers revealed a suspicious spirit of local stakeholders toward the scientific information on wildlife dispatched by the Park.

If correctly managed, outcomes from this first investigation on the social dimension of otter conservation in the ALMNP gives hope for a peaceful coexistence of humans and otters in the National Park. Specifically, providing anglers with correct information about the feeding ecology of the otters in the Park, as well as the protection of local fish farms will promote a positive attitude toward the species. These needs also claim for an accurate survey on fish biomass and composition in the freshwater bodies of the Park, and its comparison with ongoing investigations on prey composition in otter diet.

## Alien parakeets as a potential threat to the common noctule

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PO48

The ring-necked parakeet *Psittacula krameri* (Aves: Psittaciformes) is an extensively spread species that occurs with over 40 introduced populations all over the world. The majority of these well-established populations is clearly expanding both spatially and demographically. Previous studies revealed that one of the main impacts of alien ring-necked parakeets is competition with bats species that use tree cavities as roosting sites. In Italy, the only population of *Nyctalus* bats that regularly forms nurseries occurs in an urban area in Emilia Romagna, where populations of ring-necked parakeets are currently increasing and spreading. In our work, we updated the population status of parakeets and breeding *Nyctalus noctula* in the area. We then ran a species distribution model to analyse the environmental suitability of the region for the ring-necked parakeet and a connectivity model to predict the possibility of its expansion in the area occupied by breeding noctules. We reported a high number of individual parakeets and mating colonies, as well as a significant noctule

population drop, from around 400 to roughly 120 individuals, possibly due to urban green management practices during the last 20 years. Despite the fact that some ring-necked parakeets were observed in the region, there is currently no evidence of reproduction in the noctule colony's area. However, our model revealed a high level of environmental appropriateness for the ring-necked parakeet within the area occupied by noctules. The connectivity model also revealed the possibility of a direct flow of individuals from neighboring major cities to the noctule colony. The appearance of alien parakeets in the area occupied by the bat breeding colony should be tightly monitored throughout suitable areas for this bird, as well as in recognized ecological corridors. A sustainable urban green management practice, together with an early detection of new invasions, may counteract the extinction of the southernmost breeding colony of the common noctule.

## Survival analysis of an unharvested red deer (*Cervus elaphus*) population in the northern Apennines

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PO52

**Introduction** – Wild ungulate populations have increased considerably and steadily throughout Europe in recent decades. The increase began with the end of World War II when several changes in the social structure of rural and mountain areas led to a progressive abandonment of agricultural activities and an increase in forest areas. Wild ungulates greatly enrich biodiversity, contributing to the development of complex biocenoses and supporting populations of large carnivores. Also, they include taxa with a high cultural and economic value as big game species. However, their growth has caused several problems throughout Europe (crop damage, traffic accidents, diseases). The aims of this research were (i) to predict the trend and future survival of a population of red deer in the North-western Apennines and (ii) to define a sustainable harvesting rate allowing long-term exploitation of the population.

**Methods** – The study area was located in North-western Apennines (N-Italy) on the border between the Lombardy and Emilia-Romagna regions, between the Provinces of Pavia and Piacenza. Altitude ranges between 200 and 1000 m a.s.l. and the vegetation ranges from mesophilic forests, characterized by mixed deciduous oak, to beech forests at higher altitudes. From March 2017 to October 2019, we collected data on population structure by surveys from vantage points and itineraries made by car scattered in the study area with a frequency of two surveys per week. We classified each observed deer according to age class and sex considering antler and body size characteristics. In the same period, we used camera-trapping to increase the sample for defining population structure. To estimate population size and density we carried out from 2017 to 2019 (in September) counts of roaring males from fixed listening stations distributed in the study area. We used triangulation to locate red deer males more accurately using bearings taken by different stations and to avoid double counts. We estimated the red deer population size from the roaring counts and the proportion of adult males

in the population as a result of direct observations and camera trapping using the method proposed by Mazzarone et al., 1991. We carried out a Population Viability Analysis (PVA) using VORTEX 10.00 simulating the population trend in 30 years.

**Results** – We observed 438 deers in the three years, of which 327 were determined both for age and sex (75%), 10 only for sex (2%), 76 only for age (17%), and 25 were undetermined both for age and sex (6%). The PVA has shown, in absence of harvest, the high vitality of the population, which shows a constant increase until reaching the carrying capacity in the 16<sup>th</sup> year. The probability of extinction (PE) was equal to 0. With a harvest of 10%, the population decreases, with consistency in the 30<sup>th</sup> year equal to a third of the current one. The probability of extinction is greater than 50%. Simulating higher harvest (12–15%) showed strong decreases and high PE, approximately 100%. With a mixed harvest rate of 5% for adult females and 8% for the other classes, the population reached the 30<sup>th</sup> year of the simulation with high consistency and a very low probability of extinction. The harvest was considered unsustainable with a mixed harvest at 10% in all classes with 5% in adult males, showing a rapid population decrease and a PE of 50%.

**Discussion** – The data collected during the study indicate that the red deer population is in good condition, reflecting the natural condition in terms of gender ratio and age distribution. The population viability analyses have shown an increase in population numbers in the future in scenarios without harvest and with a harvest of 5%. We suggest that a precautionary harvest of 5%, but not greater than 10%, should allow exploiting the population and also maintaining a viable population. Otherwise, to maintain a viable population by reducing consistencies, it is possible to allow a mixed harvest of 10% in all the age classes except for the adult females for which the harvest should not exceed 8%, otherwise the risk of extinction would be equal or greater than 25%.



## The forest dormouse *Dryomys nitedula* in terra raetica – an alliance for the research of a rare small mammal species

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P050

Between July 2020 and December 2021, studies on the forest dormouse *Dryomys nitedula* took place as part of an Interreg project in the Terra Raetica Region, in the border triangle between Switzerland, Austria and Italy. The aim of the surveys was, among other things, to establish a suitable monitoring method for the standardized recording of *D. nitedula*, an arboreal and nocturnal species that occurs in low densities.

In the Engadine (CH), in the Ötztal (AT) and in the Venosta Valley (IT), 2 sample plots each with 15 survey stations were established. Four survey methods were used (wooden nest boxes, woodcrete nest boxes, tracking tubes, wildlife cameras), the devices were placed at different heights of 1-6 m on trees and checked 5 times between June and October 2021.

Evidence of the forest dormouse was obtained in 3 of the 6 study sites, in each country there was one sample plot with detection of the target species. Detection success was 26.1% for wildlife cameras, and 3.3% for both nest box types and tracking tubes. The species was recorded in a variety of habitat types, from grey alder scrub forest to spruce forests to sparse larch forests. Occupied nest boxes with nests, indicating permanent use, were located in wet habitats with deciduous trees. The assembly

height of the occupied boxes was mostly above 2 m. In addition to the target species, up to 4 other small mammal species were detected depending on the location: hazel dormouse *Muscardinus avellanarius*, garden dormouse *Elomys quercinus*, edible dormouse *Glis glis*, bank vole *Myodes glareolus* and individuals of the genus *Apodemus*.

Overall, the study showed that wildlife cameras are well suited for verification of presence in areas with suspected forest dormouse occurrence, when sufficient numbers of devices are used. The main advantages are low maintenance and long-term use. Tracking tubes also have potential in arboreal species faunistic surveys with further optimization of ink, paper, and bait. Their advantages lie in their low cost and suitability for citizen science projects. Nest boxes require more effort to transport, assemble, and maintain, but are essential for deeper insights into individuals, populations, and genetics. They should therefore be an integral part of monitoring studies. In addition, a minimum 2-year study period is advisable. Since the single methods showed different advantages and limitations, a combination of methods adapted to the research question should be considered for future surveys of the forest dormouse.

## Presence and status of the wolf (*Canis lupus italicus*) in the Po Delta Regional Park, Emilia-Romagna

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PO51

The Italian wolf population is rapidly expanding, and this phenomenon also affects Emilia-Romagna and, more recently, the macroarea of the Po Delta. This phenomenon actually involves the vast territory of the Po Delta, including the plain and the coastal strip of the provinces of Ferrara and Ravenna, which represents the last frontier of the wolf population at a regional level, already permanently present in the western part of the Emilia-Romagna region. After years of occasional reports in the territory of the Po Delta, the first certain data of the presence of the species was recorded by Carabinieri Forestali of Punta Marina on March 8, 2019, in “Pineta di Ravenna” State Nature Reserve. This was followed by reports of excrement in the pine forest of Badalassona and fallow deer carcasses at the mouth of the Bevano river. In 2020, the stable presence of a couple of wolves inside the Campotto Oasis, in Argenta municipality, province of Ferrara, was documented for the first time by camera trapping.

Following these first registrations, the Emilia-Romagna Region, the Po Delta Regional Park and the Carabinieri for Biodiversity – Punta Marina Department, carried out a first survey during the first national wolf monitoring organized by ISPRA and Federparchi, using the guidelines and protocols produced by ISPRA. From October 2020 to March 2021, at the same time as the monitoring sampling period carried out on a national scale, extensive monitoring was set up through systematic sampling supported by opportunistic sampling. Previous reports have been georeferenced, n. 6 squares on the 10×10km grid were selected within the Po Delta marco-area and routes n. 23 transects. A network of specially trained operators was set up for data collection, through participation in the remote training course organized by ISPRA and through two further training meetings organized by the authors. The recording of data and effort and the relative archiving was carried out by always applying the protocols and guidelines already mentioned in order to guarantee homogeneous and comparable data with those of

national monitoring.

In the period October 2020 – March 2021 were travelled no. 89 transects, with an average of 3.78 times per transect, recording no. 59 signs of presence with an average of 0.42 for transect. The opportunistic data collected in the same period are 12, for a total of no. 71 signs of presence detected. Of these no. 24 reports were recorded as C1 data (certain evidence), no. 33 as C2 (confirmed observation) and no. 14 as C3 (unconfirmed observation). In the province of Ferrara no. 60 signs of presence of which no. 53 attributed to categories C1 and C2; in the province of Ravenna no. 11 signs of presence, of which no. 7 attributed to categories C1 or C2.

The data collected to date have confirmed the presence of the wolf in stable form in three distinct areas of the Po Delta: the pine forests of Ravenna (RA), the Argenta valleys (FE) and the Mezzano valleys (FE). It was also possible to identify the areas of greatest attendance and the breeding and possible reproduction areas. Starting from 2020 a family unit has settled permanently in the station of the Delta del Po Valli di Argenta regional park, with the birth of n. 7 puppies in 2020 and n. 8 puppies in 2021. At the moment, from the data emerged from the continuation of monitoring, it is also possible to hypothesize a reproduction in 2021 of the nucleus that settled in the Pinewoods of Ravenna and another one of nucleus in the Mezzano Valleys. It is hoped that the monitoring of the presence and distribution of the species in the Po Delta will continue, also investigating in relation to the socio-economic impacts, as well as the monitoring of any phenomena of bold wolves, which currently represents one of the main problems of management of the species in anthropized territories. Furthermore, for the conservation of the wolf, it is desirable that the monitoring scheme set up and the information continue to be shared among all the administrations involved and that the wolf monitoring network in the Po delta continues to function in the future.

**Temporal interactions among wolf, people and small carnivores in a mediterranean area**Lazzeri L.<sup>1</sup>, Oliveira R.<sup>1</sup>, Rossa M.<sup>2</sup>, Mugnai S.<sup>1</sup>, Leggiero I.<sup>1</sup>, Riggio C.<sup>1</sup>, Bazzoni F.<sup>1</sup>, Pacini G.<sup>1</sup>, Lovari S.<sup>1</sup>, Ferretti F.<sup>1</sup><sup>1</sup>Research Unit of Behavioural Ecology, Ethology and Wildlife Management, Department of Life Sciences, University of Siena, Via P.A. Mattioli 4, 53100 Siena, Italy<sup>2</sup>CESAM, Department of Biology, University of Aveiro, Campus de Santiago, 3810-193 Aveiro, Portugal

P053

There is a great and increasing interest on the role of interactions that apex predators establish with smaller carnivores.

The effects of large carnivores over smaller ones can switch from positive to negative ones often on a site-specific basis related to several ecological features such as predator density and availability of food resources. In particular, interference from larger, dominant predators has been suggested to play a major role in influencing behaviour and ecology of mesocarnivores. In turn, temporal and/or spatial partitioning would lead to interspecific coexistence.

In this work we assessed the temporal partitioning among wolf and small carnivores in the Maremma Regional Park inferred through intense camera-trapping between October 2017 and March 2021. Temporal analyses were based on a sampling effort of 20164 camera-days, and a total of 2644 wolf detections, 8018 red fox detections, 1234 badger detections, 811 *Martes* spp. detections, as well as 14302 people detections. Temporal activity patterns of each species were assessed at the seasonal level (spring: April-June; summer: July-September;

autumn: October-December; winter: January-March) using Kernel density estimation.

All the species were nocturnal or crepuscular, conversely human activity was concentrated during the daylight. Interspecific temporal overlap between the wolf and smaller carnivores was high, with  $\Delta_4$  coefficients 0.75. Overlap between the wolf and the fox was 0.87–0.96, being greater than that occurring between the wolf and the other mesocarnivores ( $\Delta_4 = 0.75–0.93$ ). Conversely, overlap with people was always lower than 0.30.

Our results did not support a temporal avoidance, suggesting that resource partitioning was locally based on other mechanisms (e.g., spatial and/or finer-scale spatio-temporal mechanisms) to explain the sympatry among apex predator and other carnivores. Further work should test the potential for human activities to affect these interactions, for instance by reducing the possibility for species to increase their diurnal activity to limit predation/interference risk.

**A tale of an african ungulate in north-western Italy: population history, abundance, and ecology**Leoncini F.<sup>1,2</sup>, Pastorino A.<sup>3</sup>, Cottalasso R.<sup>4</sup>, Cambiaso F.<sup>5</sup>, Aluigi A.<sup>6</sup>, Marsan A.<sup>2</sup>, Corlatti L.<sup>7,8</sup><sup>1</sup>Via A. Molino 7, Genova (GE), Italy<sup>2</sup>DISTAV, Dipartimento per lo studio del Territorio e delle sue Risorse, Università degli Studi di Genova, Corso Europa 26, Genova (GE), Italy<sup>3</sup>Via Piave 7/4, Pavia (PV), Italy<sup>4</sup>Strada Monterotondo 85, 15067 Novi Ligure (AL), Italy<sup>5</sup>Via valle Stura 35, 16010 Masone (GE), Italy<sup>6</sup>Ente Parco del Beigua, Piazza Beato Jacopo 1–3, Varazze (SV), Italy<sup>7</sup>ERSAF – Direzione Parco Nazionale dello Stelvio, Via de Simoni 42, Bormio (SO), Italy<sup>8</sup>Chair of Wildlife Ecology and Management, University of Freiburg, Tennenbacher Str. 4, 79106 Freiburg, Germany

P059

The loss of biodiversity is a major conservation concern of the last decades, with a key role played by invasive alien species that can cause dramatic changes to native ecosystems, altering habitats and reducing or eliminating endemic species. The aoudad or Barbary sheep (*Ammotragus lervia* Pallas, 1777) is a north-African ungulate commercialised and introduced for game hunting to Europe, South Africa, and America. As a generalist herbivore, the aoudad has a high capacity to adapt to new habitat conditions.

We studied the aoudad population inhabiting the Beigua Natural Regional Park in Liguria, north-western Italy. By combining historical data, direct observations and camera trapping, we estimated minimum abundance over the years. A Relative Abundance Index (RAI) accounting for group size was derived from camera trap data and analysed with generalized linear mixed

models to assess population trends on a subset of sites monitored over the years within the population's core area. Camera traps at a larger scale were used to assess habitat selection and activity budget. Some aoudads had most likely escaped from a game reserve in Ponzzone Municipality, Piedmont, and settled in the park at least since 2009, although sightings have always been rare. The population has increased from a minimum of 9 individuals in 2012 to 23 in 2020, a trend detected also by RAI. The population inhabits steep, rocky and woody areas in the southern and warmer part of the Beigua massif, but some observations in the northern part of the Park have recently occurred. Aoudad select the steepest parts of the study area, especially at mid-elevation, and show mostly diurnal activity, possibly for anti-predator reasons. It is fundamental to monitor this alien species and evaluate potential eradication solutions.

## Come back to stay: landscape connectivity analysis for the Eurasian otter (*Lutra lutra*) in the western Alps

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PO54

Land-use change and climate warming are some of the main threats to biodiversity conservation worldwide, as they have a strong impact on the quality and connectivity of natural habitats. This is especially true for freshwaters, that are among the most threatened ecosystems. The Eurasian otter (*Lutra lutra*) is a freshwater top predator that is slowly recovering after a strong decline in central and southern Europe in the last century. To assess the chances of a return of the otter in the western Alps, we conducted an analysis of environmental connectivity using the electrical circuit theory applied to a resistance surface with the *Circuitscape* software. The study area, comprised South-eastern France, North-western Italy, and Switzerland. We selected six environmental variables relevant for otters' movement, for which GIS data were available for the entire study area, and we rasterized layer data at 100 m resolution. To obtain the rasterized cumulative resistance surface, we assigned a value of permeability to each variable and weighted them according to their relative importance for otters' movements. We produced a maximum flow map, showing the maximum flow between any patch pair, and a cumulative current flow map, showing the sum

of all current flows between all possible patches. A gap analysis was also conducted to highlight the "conservation gap" for optimal corridors. The results revealed that the orography of the landscape was the main factor influencing the quantity and quality of the pathways in the western Alpine landscapes. As main corridors were concentrated in the valley floors, human pressure could act as a barrier to animal movement. However, multiple passages were also identified in foothill and lowland landscape, where human disturbance is lower. More specifically, the Rhone basin showed high values of almost seamless connectivity up to the coastline. In the Po Valley, connectivity was overall low, despite the presence of interesting dispersion corridors represented by the main rivers. Some important pathways did not fall within protected areas, potentially threatening otter dispersal. Recolonization of alpine territories by otters can therefore only occur if connectivity and environmental suitability combine to ensure the animals' survival over time. Our results, therefore, serve as a reference for future environmental restoration actions addressed to facilitate the return of the otter in the Western Alps.

## Habitat variables in the monitoring of the mountain hare in Belluno

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P100

The mountain hare, *Lepus timidus varronis* (Miller, 1901), one of the most iconic animals of the Alpine fauna, is perfectly adapted to the life up on the high mountains but is one of the most troubled species in the face of global change as well. Considering the scarcity of data regarding the status of the mountain hare population in the Belluno Province, a species for which hunting is allowed, it's important to investigate its presence in relation to various environmental variables in the Dolomites area. The only data available are those concerning: (i) the number of animals killed during the hunting season and (ii) the trend of the population obtainable from the ratio of young individuals and adults (the difference between the two coming from the analysis of the eye lens dry weight).

The study has been conducted within the hunting fields in the Dolomites of Belluno. Ten different linear transects have been identified according to an altitudinal gradient, each explored twice in a period ranging from 24 April 2021 to 30 June 2021, marking the presences of fecal pellets, footprints and feeding signs. Every data was georeferenced. Photo trapping has been used as an integrative investigation method in order to detect the presence of *L. europaeus* in the sampling area. As expected, results show how, during winter and the beginning of springtime, 58% of the total faecal pellets are found at lower altitudes

(between 1400 and 1800 m asl), in forests mainly composed of spruce, with a reduced presence of undergrowth and high snow cover. With summer season approaching, 63% of the faecal pellets were found at higher altitudes (between 1600 and 2000 m asl), in environments with larch and mountain pines, less amount of snow and increased grass and undergrowth coverage. Besides, more than half of the total faecal pellets detected during the monitoring were found in the proximity of feeding sites close to deciduous tree species, 82% of them being related to the presence of beech or rowans. The species tended to be more commonly found in the central part of the distribution area, with minor presences at the southernmost limits of the provincial range. Regarding photo trapping data, all of the collected pictures can be assigned to *L. timidus* with no presence of *L. europaeus* over the transects. Using linear transects, as done in this study, has therefore allowed us to collect the first objective information regarding spatial distribution of this species in relation to the altitudinal gradient and many environmental variables in the Dolomites area. To be able to better understand the size and status of the population, other parameters need to be taken into consideration, such as data on local ecology, in order to define and bring about future effective management strategies.

## Lifelong non-invasive genetic monitoring of a philopatric female wolf in the Tuscan Apennines, Italy

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P110

Wolves (*Canis lupus*), like most wild carnivores, are elusive animals which usually live at low density. This makes it challenging to monitor social, genetic or ecological characteristics of specific individuals through time. Non-invasive genetic sampling, when protracted over a long period of time and a sufficiently large geographic scale, has revealed an effective tool to follow individual ecological and spatial patterns in a population.

During a long-term project focused on the monitoring of presence and distribution of wolf packs in the Tuscan Apennines in Italy, we have followed the destiny of a single female wolf (F82) exclusively by resampling and the analysis of microsatellite multilocus genotypes obtained from non-invasive samples (n=118 including scats, hair and blood residuals) collected from 2003 to 2014.

The female wolf F82 was sampled for the first time in 2003 within the territory of a monitored pack in the province of Arezzo (Alpe di Catenaia), resulting one of the offspring of the local

pair. F82 then dispersed from the natal pack to an adjacent area where she established a new territory together with an unrelated wolf male (M97), which had never been previously detected in neighbouring zones. The pair F82–M97 persisted for 8 years, mating at least twice and occupying a territory of a minimum size of 60–80 km<sup>2</sup>. In December 2014, F82 was found dead, victim of a car accident. Her death age was estimated to be at least 11 years, as extrapolated from the time elapsed between the first and the last samplings.

Our records suggest that the female wolf F82 represents the longest-lived free-ranging wild wolf to be monitored in her pack dynamics in Europe till now. This is particularly relevant because her age and multiyear pack dynamics did not arise from a mere estimation but from the actual monitoring of a she-wolf for her entire lifetime, relying exclusively on molecular techniques applied to non-invasively collected samples.

## Wolf (*Canis lupus*) presence in Monti Cimini complex by camera-traps monitoring

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P068

The aim of this work is to describe our field activity to verify the presence of wolves in the Natural Reserve “Lago di Vico” and its neighbouring areas. Until 2017, wolf presence in the Cimini Mountains was sporadic, only established through a few random sightings. An initial sample survey, conducted in 2014 with camera-traps, had not yielded results. With a more organized and systematic approach, our fieldwork was carried out in two separate sampling seasons.

In each season, the specific monitoring sites were different, but within the same study area. The first season was divided into three consecutive surveys with an average duration of 66 days (min 57 days; max 81 days) for a combined total of 242 days from the date of 07/31/2018 until the closing date of 06/04/2018. The second season was divided into two consecutive surveys with an average duration of 46 days (min 39 days; max 54 days) for an overall total of 72 days from the date of 23/11/2020 until the closing date of 03/02/2021. The territory to be monitored was divided into a square 1×1 km grid. An area of 57 km<sup>2</sup> was monitored in the first season, while 46 km<sup>2</sup> were monitored in the second one.

The first season was mainly focused on the Natural Reserve “Lago di Vico” and the adjacent areas: in the three surveys, 26 total animals have been photographed, with 15 cells occupied (1<sup>st</sup> survey: 7 cells with 12 presences; 2<sup>nd</sup> survey: 4 cells with 6 presences; 3<sup>rd</sup> survey: 4 cells with 8 presences). The second season involved part of the Natural Reserve “Lago di Vico” and the Special Area of Conservation “Monte Cimino”: during the two surveys, in 8 cells, we have recorded 19 total appearances of wolves (1<sup>st</sup> survey: 4 cells with 5 presences; 2<sup>nd</sup> survey: 4 cells with 14 presences). Overall, there is an overlap of 38 cells between the two monitoring seasons. Three cells showed wolf presence in both seasons.

Our results suggest two outcomes. Firstly, the presence of a small group of wolves within Natural Reserve “Lago di Vico” (Minimum Number Alive = 4). This presence is further confirmed by spontaneous reports of local residents and farmers, who spotted wolves on later dates and informed the local (and general) press about the sightings. Secondly, the forest types most frequented by wolves are coppiced woods with a mixed percentage of chestnut and turkey oak coverage.

## Sampling design for elusive species: a turning point to understand the Pallas's cat (*Otocolobus manul*) ecology

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PO21

The Pallas's cat (*Otocolobus manul*) is a small cat species which lives in 11 Asian countries, but with severely fragmented populations deemed subjected to a general declining trend. The Pallas's cat has received very little attention from the scientific community, most likely because conservation studies on felids are largely skewed toward larger species and the low density and remote areas typical of this species make scientific study particularly challenging. After a preliminary camera trapping survey conducted in spring 2017 by our team, when only two times the Pallas's cat was detected, we decided to increase our effort to understand the status and ecology of this species in the Central Mongolian steppe.

From August 2019 to August 2020 we deployed 50 camera traps in 26 sites (pairing cameras in 24 sites) in the Bayan Onjuul district, with the aim of investigating the population dynamics of Pallas's cat and its activity interaction with sympatric mammals. During the 12-months survey conducted uninterruptedly at the same sites, we got 550 independent detection events of Pallas's

cat, which was the most detected carnivorous followed by the red fox (*Vulpes vulpes*) (n=445), and the beech marten (*Martes foina*) (n=74). Among the large carnivores the grey wolf (*Canis lupus*) was the only detected (n=52). The Pallas's cat main prey were also abundant with the Daurian pika (*Ochotona dauurica*) detected 3561 times and the Mongolian silver vole (*Alticola semicanus*) detected 2436 times.

Our results represent a landmark for studies on Pallas's cat using camera trapping method, since the previous ones conducted across the species distribution range recorded only a few detections units. Likely, an accurate display of cameras within selected shelters, allowed a such extraordinary result. Further analysis will enable a deep understanding of Pallas's cat ecology and population dynamics. In particular, we aim to understand how seasonal variations in large carnivores (i.e. wolves) abundance affect spatio-temporal habitat use patterns of medium and small carnivores (i.e., red fox and Pallas's cat)

## Mountain hare distribution in Valle Orco (Gran Paradiso National Park) and spatial overlap with the European hare

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PI01

Climate change is leading to an increase in average temperatures forcing some species to migrate to higher latitudes or altitudes. The mountain hare (*Lepus timidus*) is an Arctic-Alpine species that evolved in the Alps through geographic isolation from northern populations after the last glaciation. The species is generally distributed between 1300 and 2800 m and is adapted to the climatic conditions and habitats present in this context.

A research conducted in 2009 recorded the distribution of the mountain hare in the higher part of Orco Valley (Gran Paradiso National Park – Piedmont region) and highlighted the presence of the European hare (*Lepus europaeus*) at high altitudes. In 2021, we repeated the 2009 survey with the aim to: 1) investigate how the distribution of the mountain hare changed in the last 12 years; 2) assess if the European hare's expansion in altitude increased since 2009; 3) evaluate how the range of the two species overlap.

Faeces of *Lepus* spp. were collected in 47 sites, in circular plots and along transects located between 1544 m and 3010 m and also monitored in 2009. Non-invasive genetic techniques based on mtDNA were used to determine the species and sex of the animals who frequented the sites. Faeces of *Lepus* spp. were found in 17 sites (36% of the total). The mountain hare was detected in 14 sites, mainly at high altitudes; at low elevations the presence of the species was less common than in 2009. The European hare was detected in 9 sites, compared to 5 in 2009.

Sites with the presence of both species increased from 4 to 6. For 2021, genetical analyses confirmed the presence of males and females of the two species in all the 6 co-occurrence sites. In 2009, the mountain hare was dominant at all altitudes, while in 2021, the European hare was slightly more common from 1544 to 2270 m, and the two species were present in the same number of transects up to 2470 m; only at the highest altitude, up to 3010 m, the mountain hare was the only recorded species.

Our results highlight a contraction in the distribution area of the mountain hare in the last 12 years. In this period, the European hare has risen in altitude, invading the range of the alpine species. This situation of syntopy between the two species may favor hybridization, a phenomenon already described in the Alps and Scandinavia. Climate change and rising temperatures favor the European hare and relegate the mountain hare to high altitudes. However, the mountain hare will not be able to climb much above 3000 m due to the lack of suitable herbaceous habitats and the prevalence of rocks. Considering the continuous increase in temperatures, the possibilities for active conservation of the mountain hare are minimal. In some non-protected areas, the European hare may be actively controlled to reduce the risk of hybridization, but the survival of the mountain hare will still depend on its adaptability to higher temperatures and changing habitats.

## First analysis of genetic structure and phylogenetic patterns of the coypu *Myocastor coypus* in Italy

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PO04

*Myocastor coypus* is a semi-aquatic rodent native to South America, adapted to riparian ecosystems. During the last century, consequently to the uncontrolled release of farmed animals into the wild, the coypu has become an invasive species in Europe and other parts of the world and has been recently listed as a concern species in the EU Invasive Alien Species Regulation. In Italy, the species is widespread throughout the peninsula and represents a serious threat for the equilibria of river ecosystems. Previous scientific studies were mainly aimed at investigating coypu ecology and parasitology, whereas research projects analysing the genetic diffusion patterns of the species in Italy are lacking. We analysed 100 coypu invasive samples collected in five regions of Northern and Central Italy using both nuclear (20 microsatellite *loci*, STR) and mitochondrial (cytochrome b, mtDNA) genetic markers through multivariate, Bayesian assign-

ment and phylogenetic approaches. Our results showed overall low levels of genetic differentiation among samples and a mild population structure roughly reflecting the history of its recent diffusion. The populations of the central area of the Pianura Padana (Emilia Romagna and Lombardia) showed higher levels of genetic variability (both considering STR and mtDNA) than more peripheral populations (Veneto, Toscana or Piemonte) suggesting that the formers could represent the putative original group from which the species widespread started, at least in northern Italy. Phylogenetic relationships including haplotypes detected in this study and worldwide haplotypes from the online repositories suggested that the Italian populations might have originated from multiple releases of reduced pools of individuals from commercial stocks.

## Invasive Northern raccoons as a threat to the conservation of native crayfish in Central Italy

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The Northern raccoon *Procyon lotor* is a mammalian carnivore of North American origin, which has been introduced to many Eurasian countries, where several invasive populations currently occur. Regarding Italy, the species is present in Lombardy, where the population is currently managed, and in the Foreste Casentinesi National Park (Tuscany and Emilia-Romagna, Central Italy). In particular, in the second area, raccoons are present since 2013 and very little has been done to limit their range expansion. Accordingly, their distribution currently covers most of the Arezzo Province and some individuals have also been observed in the Forlì-Cesena province. In this area, the populations of the native white-clawed crayfish *Austropotamobius pallipes* complex are decreasing due to several factors, including illegal poaching, predatory fishes, and drought. Furthermore, crustaceans, where available, represent the main food items detected in Northern raccoon scats throughout the world (up to 60% of

the total diet, in the frequency of occurrence). In September 2019, we detected a total of 37 dead adult freshwater white-clawed crayfish in Central Italy, with evident signs of predation by the Northern raccoon. In 2020, crayfish were sampled by hand or by traps in 14 sites; sampled individuals were sexed and measured. Signs of raccoon presence (e.g., footprints and predated crayfish) were also recorded. Our study confirms the impact of raccoon on native crayfish. Where the raccoon is present (six sites), crayfish disappeared, or their populations have been dramatically reduced in number, with a size distribution skewed towards juveniles. In two sites, close to urban settlements, fresh footprints of *P. lotor* and predated individuals of *A. pallipes* have been recorded. Therefore, urgent actions (e.g., control of raccoons, and monitoring and, when feasible, restocking of *A. pallipes* populations) should be taken into account to guarantee the survival of this protected invertebrate species.

**Animal personality through infrared vision**Mazzamuto M.V.<sup>1,2</sup>, Morandini M.<sup>3</sup>, Lampman W.<sup>3</sup>, Wauters L.A.<sup>2</sup>, Preatoni D.G.<sup>2</sup>, Koprowski J.L.<sup>2</sup>, Martinoli Ad.<sup>2</sup><sup>1</sup>Unità di Analisi e Gestione delle Risorse Ambientali – *Guido Tosi Research Group*, Dipartimento di Scienze Teoriche e Applicate, Università degli Studi dell'Insubria, Varese, Italy<sup>2</sup>Haub School of Environment and Natural Resources, University of Wyoming, Laramie, WY, USA<sup>3</sup>School of Natural Resources and Environment, University of Arizona, Tucson, AZ, USA

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Phenotypic integration is a complex model of correlation between different functional, behavioral, developmental and/or genetic traits in a given organism. Phenotypic integration patterns can be modified by natural selection in order to improve adaptation to the environment that shapes the natural history of different species and/or populations. Individuals can react quickly to short-term changes in the environment by altering their behavior and through the action of the nervous system and the neuroendocrine response system.

Acute stress triggers two functionally related physiological systems: the Sympathetic-Adreno-Medullar (SAM) system and the Hypothalamus-Pituitary-Adrenal (HPA) axis. The activation of SAM causes the release of hormones that act peripherally causing an increase in heart rate, pressure and alertness, thus preparing the body for the immediate attack/flight response. This causes a rapid drop in peripheral skin temperature and stress-induced thermogenesis with an increase in core body temperature (stress-induced hyperthermia) proportional to the intensity of the stressor.

Behavioral responses to sudden stress can vary between individuals in a population in relation to their personality. Animal personality refers to behaviors (personality traits) that differ consistently between individuals and persist over time and across contexts.

In this project, we evaluated the link between the expression of these personality traits and the stress response in terms of body temperature variation. In mammals, bold, exploratory, and social individuals are predicted to have low levels of stress in response to an environmental challenge; therefore, we hypothesized that there are differences in the average internal body temperature and the temperature of the peripheral districts of individuals characterized by different personalities in response to a stressful event. Specifically, the temperature of the ears, nose and hind foot should be lower on average in more stressed animals and the eye temperature (as a proxy of the animal's internal body temperature) higher.

The American red squirrel *Tamiasciurus hudsonicus*, an arboreal diurnal mammal widely distributed in the North American continent, was selected as the target species for this study. In

particular, the study was carried out in the mixed coniferous forests of the White Mountains (Arizona, USA). Thirty-one individuals (20 M, 11 F) were captured using live traps. Once we captured the animal, we took several front and side photos of the animal with the infrared camera FLIR E8 with Multi-Spectral Dynamic Imaging technology. In this case, the capture event and the operator's approach to the trap represent the stressful event to which the animal was exposed. We then processed the squirrel to collect the necessary data and we tested its personality with the arena test. For each individual we selected 2 infrared photos, a frontal one where nose and ears were clearly visible, and a lateral one for the eye and hind foot. Each of these areas was processed using FLIR Thermal Studio software. We analyzed the temperatures of each body area with linear models, initially with the aim of verifying their relationship with environmental characteristics (environmental temperature and humidity that can affect both the thermal imaging camera and the animal) and the physical characteristics of the animal (sex and body mass). We then analyzed the same temperatures with linear models in relation to the significant parameters resulting from the previous analysis and to the values of the personality traits.

The arena test recorded three personality traits (repeatable), two linked to an exploratory behavior and one social. Despite this, we found no relationship between animal personality and the temperatures (minimum, average or maximum) of the different parts of the squirrel body. Body surface temperatures were mostly predicted from the local climate and not the body's core temperature, suggesting that body surface temperatures tell us more about a squirrel's environment and less about the thermal state of its core in that environment.

Despite the benefits of a non-invasive tool to detect and record wildlife body temperature, infrared thermography alone may not be sufficient for detecting small changes in surface body temperature in American red squirrels. Although the specific hypothesis of this pilot study has not been confirmed, the applications of this non-invasive technology in wildlife studies can be several. There will be many studies in the future where this tool will be used to answer new research questions.



**Analysis of the Eurasian otter trophic niche along a river gradient in southern Italy**Mirone E.<sup>1</sup>, Giovacchini S.<sup>1</sup>, De Sanctis C.<sup>1,2</sup>, De Riso L.<sup>3</sup>, Bertolino S.<sup>4</sup>, Loy A.<sup>1</sup><sup>1</sup>Dip. Bioscienze e Territorio, Contrada Fonte Lappone, Università del Molise, 86090 Pesche (IS), Italy<sup>2</sup>Sapienza Università di Roma, Piazzale Aldo Moro 5, 00185 Roma, Italy<sup>3</sup>Responsabile Ufficio Conservazione Natura, Via F. Palumbo, 18, 84078 Vallo della Lucania (SA), Italy<sup>4</sup>Dip. di Scienze della Vita e Biologia dei Sistemi, Via Accademia Albertina 13, Università degli Studi di Torino, 10125 Torino, Italy

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The Eurasian otter (*Lutra lutra*) is a semi-aquatic mustelid. Its European range suffered a sharp reduction in the last century, caused by multiple pressures, including human persecution, destruction of riverine habitats, and water pollution. In Italy, the species persisted only in the southern part of the peninsula, and it is currently listed as Endangered on the Italian Red List. As for most top predators, a sound knowledge of the feeding ecology of local populations is essential to adopting effective conservation strategies and conflict mitigation. The aims of this study were to a) compare the trophic niche of the Eurasian otter in three rivers in the Cilento, Vallo di Diano e Alburni National Park (PNCVDA) and b) evaluate the variability of prey composition along the rivers. The study was conducted through genetic and morphologic analysis of prey remains in otter scats, known as spraints. A total of 415 spraints were collected at ten days intervals from July to October 2019 at 20 sites regularly spaced along the rivers Bussento (n=12), Mingardo (n=5), and Lambro (n=3). Spraints contents were washed and analysed through a binocular microscope. The frequencies of seven prey categories (fish, crustaceans, amphibians, reptiles, birds, mammals, and insects) were compared through GLM among rivers, season, and river stretches (from the source to the mouth). The feeding niche breadth and overlap among the rivers and river sectors

(upstream, medium course, and downstream) were evaluated with Levine and Pianka indexes computed with EcoSimR.

Fish and crustaceans were the most common prey in all rivers. In the river Bussento, the endemic crayfish (*Autopotamobius pal-lipes*) was the main prey upstream and was replaced by Cyprinid fish moving downstream. The diet along the Mingardo river was mainly composed of Cyprinid fish (40% of total occurrences), whereas amphibians and insects were well represented in the Lambro River (24% and 25%, respectively). The diet in the three rivers was very similar in the mouth (Pianka Index >0.6) and the middle course (Pianka index Bussento × Lambro >0.9 and Bussento × Mingardo >0.6). On the other hand, the diet in the upper course of Bussento differed from all other river sectors (overlap index never higher than 0.36), being almost exclusively composed of crayfish. This study confirmed the otter as a generalist carnivore, relying on the most available and easily catchable prey, mainly Cyprinid fish, and secondarily crustaceans and amphibians. Results also revealed that spraints remains reflect the prey abundance at a very local scale, informing on the most cost-effective strategy to manage potential conflicts with anglers and conservation of other protected species like the endemic crayfish.

**Downtown boars: an updated snapshot from Italy**Monaco A.<sup>1</sup>, Obino F.<sup>2</sup>, Maiorano L.<sup>2</sup><sup>1</sup>Institute for Environmental Protection and Research, ISPRA, Rome, Italy<sup>2</sup>Department of Biology and Biotechnologies "Charles Darwin", Sapienza Università di Roma, Rome, Italy

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The considerable increase in numbers and distribution that the wild boar has shown in most of its range has led the species to permanently frequent peri-urban and urban areas, often attracted by the large availability of anthropogenic food and suitable context for moving and resting. The occurrence of wild boar in urban context has been reported throughout the species' range, but it is in Europe (e.g. Berlin or Barcelona) that it has assumed its greatest dimensions, requiring the definition of an ad hoc management approach and the activation of task forces to tackle the problem. In Italy too, in recent years, the presence of wild boar in the urban environment seems to be increasing, with reports and requests for action from citizens becoming more and more frequent. However, despite the widespread perception of the problem and its recurrent presence in the media, there is a lack of quantitative evidence that allows us to build a realistic picture of the presence of the species in urban areas in Italy.

The aims of the present work was (1) to draw up, on the basis of information available in online newspapers, the first comprehensive and up-to-date picture of the phenomenon on a national scale, (2) to describe its seasonality and (3) trend over the last decade and (4) to identify the Italian cities most affected by wild boar urbanisation. A further aim was (5) to assess the reliability of the approach we used by comparing it with archives built on the basis of citizen reports, made available by the competent administrations for the cities of Genoa, Rome and Trieste.

The identification of the urban centres affected by the phenomenon was carried out firstly on the basis of the reports published in online newspapers, through the consultation of the digital archives of the local editions, in order to include also the oldest reports in the data collection. Each report was evaluated and included in the archive only if it referred with certainty to a sighting of the species in an urban context or to a reporting of an injured or dead boar (e.g. due to a car-collision). All reports were geo-referenced with an associated estimate of the position

error. All those reports for which the available information did not allow a certain attribution to the urban context were discarded. In addition, reports considered to be a duplicate were discarded, either because they clearly referred to the same event, or because they were located at a distance of less than 500 metres and published in newspapers less than three days apart.

In total, more than 1500 online articles published in 187 newspapers and covering the period 2012–2021 were found. In all regions except Valle d'Aosta and Trentino-Alto Adige, the presence of wild boar in urban settings was detected. The number of reports considered reliable and georeferable was 862, referring to 105 urban centres ranging from 1004 inhabitants in Petrella Tifernina (CB) to 2759670 inhabitants in Rome. In 48.6% of urban centres the presence of the species was detected in only one year, and in 34.3% in at least three different years. The number of urban centres affected showed a steady increase during the period investigated, rising from 2 (2012) to 64 (2021). The positive peak of reports was in May (11.8% of the total), the negative one in February (5.8%).

The presence of wild boar in urban areas poses serious problems for both health and public safety, including road accidents, attacks on domestic animals and risks of aggression towards people. The situation of widespread and constant increase of the phenomenon on a national scale emerging from this work calls for the urgent adoption of a national intervention strategy. In such contexts, the management of the species constitutes a challenge from both a technical and a social point of view. In order to guarantee effective and technically consistent action, it is essential to have a clear picture of the phenomenon, both at local and at large scale. The method adopted in this study is a fast and low-cost option for monitoring the wild boar occurrence on a large scale and, at the same time, a useful method for complementing local-scale initiatives to collect more detailed occurrence data.

## Distribution and ecology of mesocarnivores in the Alta Murgia National Park – Apulia (southern Italy)



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The Alta Murgia National Park Authority (Puglia region) has promoted a research to update the knowledge on the distribution and ecology of the “meso-carnivores” group. The study was carried out between July 2019 and September 2020 within the perimeter of the protected area. Ten sampling areas were identified where as many camera traps were placed. The sites were selected from sampling units located in forest environments that are naturally separated from each other, on the basis of the peculiar landscape-ecological structure of the study area, dominated by open environments strongly characterized by arid Mediterranean grasslands. The camera traps were positioned at a distance of more than 2 linear km from each other, in order to avoid spatial autocorrelation effects. A total of 4 camera trapping sessions were carried out, each lasting 60 days, interspersed with about 30–40 days of pause. Each monitoring session concerned a specific meteorological season (summer, autumn, winter, spring). Given the time frame considered and the possible different use of the environments by the target species during the different seasons, it was decided to conduct the analysis using the “single-species, multi-season occupancy” model, which assumes for each species a change of occupancy between the different seasons. The following descriptive variables were used within a radius of 500 m from any camera trap: dominant forest type, forest cover and environmental diversity, according to the Shannon Index. The QGIS 3.4.10 Madeira software was used to calculate the areas occupied by the different environmental types and the map of the ecosystem units of the Alta Murgia National Park (1:50000 – Year 2010) was used as a cartographic basis. In addition to the camera trapping activity, road mortality was monitored by means of 2 monthly inspections along the main roads that cross the protected area.

A total of 1098 records were obtained from camera trapping activity attributable to the following species: fox (*Vulpes vulpes*), badger (*Meles meles*), European polecat (*Mustela putorius*), stone marten (*Martes foina*) and wild cat (*Felis silvestris silvestris*). The most frequent species during camera trapping was fox (82.88%), followed by stone marten (10.66%) and badger (3.92%). Of significant interest are the data of the European polecat, detected in only 3 cases (0.36%), whose presence wi-

thin the Park had not yet been confirmed. Finally, at least 3 individuals with a coat pattern compatible with *Felis silvestris silvestris* were detected. However, there have also been many observations of individuals with intermediate phenotypic characters with the domestic form, as well as several individuals attributable with absolute certainty to *Felis silvestris caesus*. It is therefore necessary to investigate further by analyzing tissue samples that allows to clarify the actual taxonomic position of the population inhabiting the Park. Fox was found to be widespread and with a generalist behavior within the investigated territory, showing high values of both occupancy (0.89) and detection probability, which vary for the second model from a maximum in winter (0.91) to a minimum in spring (0.71) and with intermediate values in summer and autumn (0.72). Stone marten shows a marked seasonality in the probability of observation with higher detection probability values in spring (0.83) and minimum values in autumn (0.25), as well as an increase in the probability of occupancy with increasing environmental heterogeneity in the 500 m radius from the camera trap. Badger was the species with the least number of contacts, due not so much to a low probability of observation but to a lower occupancy within the investigated sites. Also for this species, which shows a higher detection probability in spring and summer, occupancy increases with increasing environmental heterogeneity.

The monitoring of road mortality has provided valuable additional information, as well as in the conservation/management field, also in relation to the distribution of some rare and localized species within the Park. In this sense, the discovery of a carrion attributable to a young European otter (*Lutra lutra*) found in July 2019 along the main road that marks the southwestern border of the protected area is extremely relevant. There are no other observations of the mustelid within the park, which could therefore be visited only occasionally, especially near the dense network of drainage canals that extend close to the southern border. These first data on the ecology and distribution of meso-carnivores within the Alta Murgia National Park represent an important increase in knowledge on the biodiversity of the protected area, as well as a source of useful information for management and implementation of any conservation actions.

## On the safe side of the rock: harvest mice still occur in “Padule di Fucecchio” wetland (Tuscany, Central Italy)

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The harvest mouse *Micromys minutus* is the smallest rodent species of Europe. Its distribution covers most of Palearctic, between Northern Spain and Japan. A phylogenetic study showed a high mitochondrial DNA uniformity throughout the range, suggesting a recent evolutionary history and, possibly, the accidental translocation of individuals through trade routes.

Despite being so widely distributed, this species is suffering population decline, particularly in Mediterranean countries, mostly due to habitat loss and climatic change. Sampling harvest mice is not easy, as its low body-weight (4–13 grams) often eludes live-trapping. As to Italy, the distribution of the harvest mouse has been therefore mostly assessed through owl pellet analyses. In recent times, a remarkable population decline has been observed in some areas of the Po plain, where this small rodent was one of the main prey of barn owls *Tyto alba* and long-eared owls *Asio otus* in early 2000 and it is now a secondary prey species.

As to Central Regions, the harvest mouse is classified as Endangered. The species was reported to occur in three areas in Tuscany and Umbria, representing also the southernmost parts of its distribution range. These areas included Padule di Fucecchio wetland (Firenze and Pistoia Provinces, last literature report

dating back to 1993), the wetlands included between Chiusi and Montepulciano lakes (provinces of Siena and Perugia, last literature report dating back to 2001), as well as the area around the Trasimeno Lake (around Magione, province of Perugia, last literature report dating back to 2009). In all these cases, the detection of the harvest mice occurred at low percentages in barn owl pellets. In 2020–2021, we collected a total of 416 barn owl pellets from all these areas, searching for harvest mice mandibles.

The presence of the harvest mice was only confirmed in Padule di Fucecchio, with 4 hemimandibles (3 left and 1 right) and 1 left maxilla detected in 50 owl pellets, two nests found in the reeds and two adult individuals killed by a domestic cat in Larciano (Province of Pistoia). This suggested that the species is still present in Tuscany, but urgent effort for its conservation should be required in line with the Tuscan Regional Law 56/2000 and 30/2015. Conversely, we did not find any record in the area of Chiusi and Montepulciano lakes, nor in the area of the Trasimeno Lake, where the species was observed. Particularly, in the last area, the habitat of the harvest mouse has been completely destroyed by local environmental management programs.

**Extinct mammalian species in the last 150 years in Italy**

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The recent checklist of Italian mammals by Loy et al. (2019, Hystrix) have listed over 120 wild mammal species present within Italian borders. Amongst those, some taxa listed in previous checklists have not been confirmed in this recent work. Therefore, we summarized the mammalian taxa which has gone extinct in the last 100 years.

Amongst native species, apart from the Sicilian wolf *Canis lupus cristaldii* which went extinct in early 1900, the only one reported in previous Italian check-lists with some populations which has been excluded from the most recent update is the Blasius' horseshoe bat *Rhinolophus blasii*. Last records in Italy date back to the 1960s in the Rosandra Valley (Northeastern Italy) and more recent surveys failed in detecting the presence of this in Italy. Previous records from other regions (i.e. Piedmont, Lombardy, Sicily, Veneto, Abruzzi, Molise, Sardinia and Sicily) are not reflected by any museum specimen and should be considered as misidentifications with other horseshoe bats.

As for the pond bat *Myotis dasycneme* in Italy, only a single report occurs for Italy, i.e. a female individual collected in 1881 in Trento, currently stored at the Natural History Museum "La Specola" in Florence (sample MZUF 5231). This individual may have been an erratic juvenile in dispersal from Central Europe, i.e. the current range of this species. Similarly, only two records occur for the Northern bottlenose whale *Hyperoodon ampullatus* in the Mediterranean Sea, one dating back to the 1880 (a female with a calf, in France) and another at the end of the XX Century in Spain. We therefore may exclude its presence in Italian seas, despite it has been reported as "possible presence".

Several alien species are no more present after having established or observed for long in Italy. Amongst those, no recent record is available for the North-American muskrat *Ondatra zi-*

*bethicus*. This semiaquatic rodent has been introduced to Central Europe since 1905. First records in Italy date back to 1950s in the province of Cuneo (Piedmont, Northwestern Italy) and in Emilia Romagna, with no established populations. In the early 1990s, some individuals were observed in the Natisone river (Friuli Venezia-Giulia, Northeastern Italy), possibly due to the range expansion from the Balkans, where the species is widespread. However, no muskrat individual was observed after 1995 in Italy, thus we excluded the muskrat from this checklist. Amongst extinct alien ungulates, in 1860, four nilgai *Boselaphus tragocamelus* were released in La Mandria Regional Park in Venaria Reale (province of Torino) and they thrived so that other individuals born there were captured and released in Migliarino – San Rossore – Massaciuccoli Regional Park (province of Pisa) and in Castelporziano Royal Estate (province of Rome), where they survived up to the 1950s. Two introduction events have occurred for the Indian grey mongoose *Herpestes edwardsii* in Central Italy to control viper populations, one in Capalbio (province of Grosseto) and one in the Circeo National Park (province of Latina), both in the 1950s; last records in the latter area date back to the 1984 and the species is considered to be locally extinct. To conclude, wapitis *Cervus canadensis* released to La Mandria Regional Park (province of Torino) in the XIX Century produced fertile offspring with the local population of red deer and thus their genetic pool is intermixed with that of native deer, which prevented us to include *C. canadensis* within the Italian fauna. For two other alien species included in the most recent mammal checklist, the raccoon dog *Nyctereutes procyonoides* and the sika deer *Cervus nippon*, very few records are available and their reproduction within the Italian borders has never been confirmed.

## Integration of trigger device and warning systems for the management of traps for wildlife

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The capture of wild animals is a practice widely used in different contexts and with different purposes e.g., research, management, wildlife rescue, reintroduction, control of problematic or invasive species. Improve animal welfare, efficiency and selectivity during capture activity is the main challenge of researchers and wildlife management operators. To reduce stress and injuries to captured animals, it is necessary that the capture devices are designed specifically for the target species and that the residence time is reduced to the minimum before the intervention of the operators. The traps used in Italy, due to legislation limits, are mainly imported from countries where they are designed for capturing not target species and this often makes them less efficient and selective. To reduce the risks, device surveillance protocols must be adopted in order to guarantee intervention time intervals appropriate to the species and the type of trap. To minimize intervention times, capture devices can be equipped with various types of alarm systems (active or passive) that use VHF, GSM signal, or satellite communication network. These systems operate autonomously with respect to the trigger device, increasing the risk of the capture-alarm system not functioning. The increase in efficiency, selectivity and the reduction of capture costs, especially in the wildlife management programs, is a major challenge. For this purpose, we have developed an integrated system (IS) in which the alarm system is an integral part of the trigger system, thus reducing strongly the probability that the alarm is not activated when traps are closed.

We have developed the IS which includes various functions in one device that can be used independently or modularly so that they can be adjusted for different types of traps and capture requirements. The IS requires the simultaneous presence of a magnetic or mechanical trigger device (capable of supporting heavy weights) and of a device that notifies the closure of the trap via GSM network (transmission of SMS only, SMS and call or call only up to 8 operators). The IS is completely switched off, therefore without energy consumption, until when the animal activates the trigger, ensuring a safe operation for long periods and reducing management costs. The integration of the trigger system with the alarm system guarantees that in the absence of energy the trap does not close, eliminating the risks for the animal in the event of its alarm system failure. A variant of the IS allows the remote activation or deactivation of the trap without direct operator intervention, in the event that the capture activities must be suspended. The IS can be equipped with different trigger mechanisms, mechanical or electronic, to increase the selectivity of the trap. It is also possible to integrate a remote control to the system to optimize captures by closing the trap at the desired and most appropriate time according to the capture objectives. A remote control allows you to cover very long distances in maximum safety with minimum current

consumption for the receiver only (Long Range – Lo.Ra). When the trap is closing, the system also provides for the possibility of turning on an internal photographic trap for an immediate images transmission. In the event that non-target species are captured, it is possible to open the capture device without direct operator intervention with a simple no cost phone call. The alarm system is also activated in the event of vandalism of the trap if suitably configured.

We have applied these devices to different systems of capturing wild animals: box traps for roe deer, corral for deer, different kind of traps for wild boars and wandering dogs, traps for fossorial mammals (coyapu, porcupine, badger, marmot), snares for mouflon and marmot. The modification and integration of the trigger systems has made it possible to reduce the capture of non-target species. In the period of use we have never encountered any failures in the alarm system when this has been set correctly. Only in rare cases the system has failed due to incorrect configuration by the operator, in these cases, however, the IS prevents the active of trigger systems and the trap remain open. The application of the IS in a Capture Project to reduce the impact of fossier species on above-ground embankments has made it possible to highlight the potential of IS to increase efficiency and reduce the management costs of capture. The capture plan provided for the simultaneous use of 4 traps all equipped with the IS positioned in different sites. During the project period we recorded 392 days/traps. In this project we applied in parallel the IS protocol and a “classic protocol” for periodic control of the traps. The “classic protocol” provided for a control twice a day for a total of about 10780 km traveled. With traps equipped with IS, the protocol provided trap control only when the notification arrived. The interventions carried out only following the activation were 26 for a total distance of 1040 km, with a maximum intervention time of 45 minutes. The knowledge of actual capture times (IS alarm) made it possible to estimate that without the alarm system, the animals would stay inside of the trap from 2 to 11 hours. In no case did the periodic checks verify the closure of the traps without the activation of the alarm system. By evaluating the specific emissions of the vehicle used according to the most recent European standard Worldwide Harmonized Light Vehicles (Commission Regulation EU 2017/1151) for a Toyota Hilux, and for the kilometers traveled with the “classic protocol”, 2287–2880 kg of CO<sub>2</sub> and 490–718 g of NO<sub>x</sub> were released into the atmosphere (depending on the parameter considered). With the IS protocol the values are reduced to 202–278 kg of CO<sub>2</sub> and 47–69 g of NO<sub>x</sub>. Moreover, for the entire capture session, only one set of 8 AA batteries was used for the management of the system and they were still almost fully charged at the end of the session.

**Adaptation to invasions: when does it occur?**

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Despite the negative impacts on biodiversity, ecosystems and human wellbeing, biological invasions also offer a unique opportunity to investigate population evolution in a timescale compatible with human life. Indeed, many mechanisms are known to be involved in the ability of non-indigenous species (NIS) to survive, establish and spread in the habitats. These mechanisms are particularly interesting when the invading population establishes and becomes invasive starting from a small propagule, a process that gave rise to the concept of “genetic paradox”. Founder events and genetic bottlenecks related to the introduction of NIS would be expected to decrease the genetic variability of the introduced population, thus reducing the invaders’ ability to persist and spread in the novel environment.

Many mechanisms are known to play a role in the ability of the introduced organisms to adapt to the new habitat. Still, there is a general lack of focus on the chronological order in which these mechanisms operate. In this review, we define three temporal stages in which adaptation to invasion can take place, and for each stage, we show which mechanisms of adaptation are involved and how they operate.

The first stage is in the native range, where many forms of pre-adaptation to the invasion may evolve: pre-adaptation may be due, for example, to the evolution of phenotypic plasticity, or it can be mediated by human activities (the so-called “Anthropogenically Induced Adaptation to Invade”), or it may even be related to life-history traits of the (future) invader.

Our second stage corresponds to the founding event, during which genetic bottlenecks can alter the genetic pool of invading organisms, with (not consistently negative) consequences

on their fitness. The second stage also includes the captivity/cultivation phases, during which genetic admixture between genetically-differentiated individuals is possible and could help the invaders overcome the loss of genetic variability associated with the founding event; however, the admixture process is mainly investigated after the introduction (third phase). Lastly, once in the new habitat, introduced organisms can undergo adaptation thanks to various processes: among these, we find the activity of transposable elements (TEs) and epigenetic modifications (such as DNA methylation); furthermore, NIS’ adaptation can be facilitated by the human alteration of natural environments. Of the three temporal phases we identified, the first and third phases are the most studied and relevant during invasions. To date, there is no mammalian study regarding the second phase. Despite the numerous mechanisms known to be involved in the adaptation of NIS to the new habitat, and despite the abundance of studies which aim to shed light on the “genetic paradox”, works on mammal species are scanty, and most of the mechanisms of adaptation remain uninvestigated in this animal group. In particular, a large part of current literature investigating the process of adaptation in non-indigenous mammals regards their behavioral plasticity and capacity to solve the new problems faced in the introduction range. This is not surprising, given the cognitive abilities of mammal species; however, other mechanisms such as epigenetic modifications and TEs activation following introduction still remain unexplored in mammal invaders, and there seems to be no reason why they should not be relevant in the context of biological invasions.

**Stone martens *Martes foina* in agricultural landscape in the Po plain**

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P077

The Stone marten *Martes foina* has high adaptability to the environment and it is usually found in forests, open and rocky areas. The species is normally not bothered by human presence and can be found in cultivated areas. *M. foina* has long been absent from the Po valley, where the intensification of agriculture has often completely erased natural areas such as hedgerows, bushes, and groves but also fields edges, ditches and riparian vegetation of the canals. Human pressure on this environment due to modern processing techniques and the switching to industrial agriculture compared to traditional agriculture pose a high price to pay for the ecosystems of the Po valley. In this context, only recently has there been a recovery by some species typical of agricultural spaces areas. In a project that is following the gradual entry into these ecosystems of predators such as *Canis lupus*, *Meles meles* and *Hystrix cristata*, large agricultural areas of the Municipality of Argenta, in the Po Delta Park, as well as neighboring mu-

nicipalities in the Ferrara province for a total of approximately 550 km<sup>2</sup> have been investigated for the presence of *Martes foina*. Buildings, ruins and shelters were checked for traces, such as footprints and food remains, as well as photographic data collected from camera traps. Out of a total of 90 sites checked to date, 80% of them showed signs of *M. foina* presence. In 22 cases it is believed that the inspected buildings had housed the stone marten for reproductive events. The species is widespread and constantly present in the territories considered where it shows a diversified diet, for now explored in an opportunistic way with fecal sample analysis. It looks like the percentage of fruit, as well as predation on small rodents and various other species tend to increase in late summer and autumn. Local interviews show a scarce knowledge of the species and practically no damage to poultry animals. Research is continuing to verify distribution and role in agroecosystems.

## Polecats in the north eastern Apennines: timid signs of recovery and dangers from introduced species

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The polecat *Mustela putorius* is a shy mustelid and appears linked to environments with little anthropization, albeit with some differences. Its distribution has seen a rapid decline since the middle of the last century and the sightings or specimens found have decreased significantly in many areas. The ongoing investigations on small carnivores in the Apennine area located between Romagna and Tuscany have led to the collection in recent years of some signs of presence that bode well for an increase in presences, as well as the first findings also in the plains. Po Valley. Here are collected the reports collected by enthusiasts and authors by means of camera trapping (also from a project of the Biodiversity Carabinieri Department of Pratovecchio for the Tuscan forests) and the findings of road killed specimens. The

area includes the hilly and mountainous areas of the Apennine ridge from both regions. In the elevated area there are some of the largest deciduous forests in Italy and the valleys are crossed by several rivers that maintain a good level of vegetation in the beds. There is a significant increase in sightings (No. sightings in years, total area) and a positive trend of presence. However, the area is affected by the expansion of populations of alien species of *Neovison vison* and *Procyon lotor*, well recognized as competitors for the native species considered. This note emphasizes the need to intervene to limit the damage deriving from those aliens and consolidate the populations of this interesting small carnivore.

## Monitoring wild boar (*Sus scrofa*) population using a rooting activity index: preliminary data from Monte Rufeno nature reserve (central Italy)

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P056

Wild boar (*Sus scrofa*) has become a very difficult species to manage; in recent years, this species has caused an increase in the likelihood of disease spread, car accidents, damages to crops and to natural vegetation. In particular, wild boar is playing an important role in the transmission of many livestock, wildlife and human diseases such as swine fever, brucellosis, tuberculosis, salmonellosis, etc. Its management and control would benefit from accurate information on species distribution and abundance.

Since Monte Rufeno Nature Reserve is completely covered by forests, and because of the ecological traits of the species (e.g. complex social structure, nocturnal activity pattern, preference for dense vegetation, and high inter- and intra- annual variability in reproduction rate), direct observations are more difficult than for other species and the detection of indirect signs, such as faecal droppings, tracks and rooting activity, seems to be a good option to collect useful data to estimate density and distribution of wild boar populations.

Since 2017 the Monte Rufeno Nature Reserve staff is monitoring wild boar population using a rooting activity index to evaluate potential changes through time. To detect rooting signs a set of 60 transects 200 m long, 4 m wide and homogeneously distributed throughout the protected area was created, paying attention to select them along roads and pathways where vehicles are banned and at least 500 m far from each other to ensure independence of data. Rooting intensity was calculated as the ratio between the number of diggings and the amount of transects, similarly to a previous study implemented in the Siena territory. Preliminary data are presented, showing the trend of rooting activity index during the last 5 years. A comparison among different types of forest is considered to verify possible habitat preferences.

As data collected so far are limited, more study of different environmental variables and a long term monitoring are needed to assess the significance level of observed trends.



## Bat and small mammal diversity in the post-Vaia windthrow area. The Latemar massif case study (South Tyrol, Italy)

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P057

In autumn 2018, parts of the South Tyrolean forests were badly affected by a large and single windstorm event named “Vaia”. A total of 6000 hectares of forest in 86 South Tyrolean communities fell due to the disruptive windthrow. The surroundings of the Latemar massif (Western Dolomites) were particularly affected, with severe impacts on forests and their biodiversity. This is particularly relevant for specialist species relying on forest habitats and which can be threatened through time by the lack of tree cover. In this context, this study aims to understand how animal communities respond to a windthrow event in terms of relative abundance and community composition. In particular, here we show the results for small mammal and bat species in relation to different habitat types affected by the windthrow event.

For the summer of the second year after the windthrow event, we selected 10 sampling plots in the windfall area west of Passo Carezza. All the sampling plots are located at a similar elevation (between 1500 and 1800 m a.s.l.), exposure and on the same limestone substrate. The potential natural vegetation in all sites consists of coniferous forests of mainly spruce and silver fir belonging to the class Vaccinio-Piceetea. The sampling plots were equally distributed in two different habitat types: forest areas not affected (F) and affected (A) by the windthrow event. Within the affected areas the dead trunks were removed, mainly during the first year after the windthrow event. Bats were surveyed with Batlogger A+ bat detectors for four consecutive nights at each sampling plot, and small mammals (rodents and shrews) were collected with a standardised square grid of 25 live traps (Longworth traps) for three consecutive nights.

In total, we identified 15 bat species/groups in 4763 bat passes (*Myotis* sp. 42.45%, *Eptesicus nilssonii* 22.82%, *Pipistrellus pipistrellus* 22.74%, *Nyctalus/Vespertilio/Eptesicus* 6.53%, *Nyctalus leisleri* 2.08%, *Hypsugo savii* 1.47%, *Tadarida teniotis* 0.76%, *Eptesicus serotinus* 0.31%, *Myotis myotis/Myotis blythii* 0.23%, *Barbastella barbastellus* 0.13%, *Plecotus* sp. 0.10%, *Pipistrellus* sp., 0.08%, *Myotis nattereri* 0.06%, *Nyctalus noctula* 0.06%, *Vespertilio murinus* 0.06%, *Myotis emarginatus* 0.02%

and *Pipistrellus kuhlii/nathusii* 0.02%). In not affected forest areas, the most abundant genus was *Myotis* sp. (54.80%) but in the affected areas the two most abundant species were *E. nilssonii* (29.00%) and *P. pipistrellus* (29.00%). The number of species was higher in affected areas compared to the not affected areas (F: 10/15; A: 15/15; Wilcoxon signed-rank test, <0.05) whereas forest specialists were active the most in not affected forest areas (total number of passes F: 1553/2739; A: 597/2024; Wilcoxon signed-rank test,  $p < 0.05$ ).

For small mammals, we captured 91 individuals using live traps and, in addition, we occasionally detected 18 individuals in pit-fall traps used for the research of ground-dwelling invertebrates. In total, we identified 4 species of rodents (*Apodemus flavicollis*, *Microtus lavernedii*, *Microtus subterraneus* and *Myodes glareolus*) and 2 species of shrews (*Sorex araneus* and *Sorex minutus*). Species abundance and richness of rodents and shrews were in both methods two times higher in affected forest areas than in not affected ones (F: 36/109; A: 73/109; Wilcoxon signed-rank test,  $p < 0.05$ ). In not affected areas, we found 3 species: *M. glareolus* (77.80%), *S. araneus* (16.70%), and *A. flavicollis* (5.60%). In affected areas, we found 6 species: *M. glareolus* (46.60%), *M. lavernedii* (20.50%), *S. araneus* (20.50%), *S. minutus* (6.80%), *A. flavicollis* (4.10%), and *M. subterraneus* (1.40%). Small mammal communities were significantly less diverse in dense spruce forests than in affected areas. In the latter, especially voles and shrews may take advantage of the high structural richness in the form of ground trunks, burrows and rich undergrowth to feed, escape predators and find shelter.

Overall, our results indicate that both small mammals and bats seem to have taken advantage of the windthrow event, however, forest specialist species are less abundant in affected areas. Future repetition of these surveys aims to further improve the understanding of the specific effects of windthrows on animal communities to find optimal strategies for conservation and management of threatened species while increasing the resilience of forest environments.

## A scientific approach to resolve impacts from invasive alien species. a first example for the raccoon in Lombardy

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PO58

**Introduction** – Invasive alien species (IAS) are one of the greatest threats to biodiversity, ecosystems and human well-being. The EU Regulation no. 1143/2014 requires the Member States to eradicate species that are listed as of concern. One of the most destructive mammalian IAS in Europe is the Northern raccoon (*Procyon lotor*), an opportunistic mesocarnivore native to North and Central America, but which has been introduced into 27 European countries. Raccoons can impact bird and amphibian populations, kill domesticated animals, cause damages to buildings and crops and carry several disease agents. Here, we report the steps taken during an eradication campaign in Lombardy in the framework of the project “Nature Integrated Management to 2020 – LIFE14 IPE/IT/000018”.

**Materials and methods** – We first assessed the presence of raccoons through visual surveys (sightings or signs), interviews to stakeholders and official reports. We then carried out an intensive 3-month camera trapping survey on an area of 120 km<sup>2</sup> (gridded as 120 1×1 km cells). We applied occupancy modeling to camera trap data to identify the habitat features that could influence the species' presence and detection. The final step, performed on 33 grid cells, aimed at detecting any remaining individuals through a combination of stakeholder interviews and systematic survey of raccoon signs and camera trappings. When raccoons were detected, traps were activated opportunistically to remove the last individuals. The captured raccoons were immediately euthanized by CO<sub>2</sub> excess and the carcasses were analysed using standard parasitological techniques to verify the presence of the zoonotic nematode *Baylisascaris procyonis*.

**Results** – During the first trapping period we removed 30 animals from the known presence areas. The second phase revealed that the detectability of raccoons ( $0.27 \pm 0.07$  SD) increased in the proximity of the river and their occupancy ( $0.15 \pm 0.09$  SD) was higher in urban areas. These results allowed to increase the trapping success and reduce overall effort, leading to the capture of 29 more raccoons. The systematic collection of catch and effort data allowed to estimate the population size ( $68 \pm 7.8$  raccoons). In the final phase we captured 14 more raccoons. No evidence of *B. procyonis* was found in all examined raccoons and all individuals showed a limited parasitic community.

**Discussion** – The synergy between camera and live traps can be considered the key to the success of the campaign and allowed to identify the intervention area and the habitat features that influenced the species' distribution. Systematic collection of catch and effort data allowed to timely estimate the population size and adaptively adjust the trapping effort. Camera traps can also be used in trapping sites that are temporarily inactive to detect the presence of any remaining individuals, thereby reducing the number of active traps and consequent operating costs. Finally, the direct involvement of stakeholders, who provide access to their lands, report sightings and support the trapping activities, can significantly increase the success of the eradication program. This is particularly relevant when few individuals are present on a wide area. Through the constant monitoring with the combination of these different methods for the last two years (2020–2022), we can assume the total eradication of the northern raccoon from the interested area.

## Fallow deer (*Dama dama*) management plan in the “Foresta Demaniale” of Circeo National Park



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The fallow deer Management Plan in the Circeo National Park, written in 2016 and approved by the Italian Institute for Environmental Protection and Research (ISPRA) in 2017 aims to reduce the species consistency in the Foresta Demaniale, a lowland forest relict of the ancient Selva di Terracina, extended 3300 hectares, dominated by Turkey oak and English oak (Habitat 91M0), which represents one of the largest lowland forests currently present in Italy. The management plan's goal is to mitigate the impact of the fallow deer on the forest ecosystem, to reduce the risk of roadkill and to avoid potential future damages to agricultural activities of the area. According to the DM, January 19 2015, the species is considered “para-autochthonous” and to the “Guidelines for the management of Ungulates – Cervidae and Bovidae” – ISPRA, only “the historical nuclei in the Mediterranean environment (Tenute di S. Rossore, Castelporziano, Maremma National Park) and some established populations in the central-northern Apennines” can be preserved with densities compatible with forest regeneration. Instead for the other nuclei “the systematic removal of individuals in dispersal should be realized to contain the population range. The small isolated nuclei and those of recent formation, often originated from escapes from fences or from intentional introductions, should be totally removed”. The nucleus living into the Foresta Demaniale State Forest of the Circeo National Park is certainly among those of recent formation (fallow deers escaped in the 1960ies from an enclosure) and therefore should be completely removed.

Using nocturnal thermal imaging and distance sampling, in summer 2020 we estimated the population of fallow deer at 1767 (SE=255.89; CV 0.14). Estimated density is about 58 fallow deer per 100 hectares. Dividing the forest into 3 sectors along the main roads we obtain an increasing density from south to north (sector A: 1100 hectares, n=523 SE=142.4; sector B: 1244 hectares, n=549, SE=105.3; sector C: 663 hectares, n=695, SE=174.3). In addition, a camera trap survey was also carried out in order to identify the most frequented areas of the forest. Monitoring was performed in summer 2020 in a grid (1 × 1 km)

for a total of 36 placements. Camera traps were placed in the centroid of each square, for a total of 411 days of detection and an average of 12 days/camera trap. Capture rate index (number of fallow deer per day) has higher values in the sector C of the forest, as well as the cluster size index (number of fallow deer per photo).

According to the mentioned Management Plan, in order to reduce the fallow deer population, between 300 and 400 animals must be removed annually. Two techniques can be used: 1. shooting (carried out by trained operators) and 2. trapping (with both fixed and mobile corral). After removal animals can be: 1. transferred for ornamental purposes (after surgical sterilization), 2. used for food consumption and 3. used for hunting activity, prior to any use of fallow deer, it was considered appropriate to perform a sanitary screening on a representative sample of 117 individuals (the sample was calculated taking into account a prevalence of 20% of *Mycobacterium bovis* in free-living fallow deer populations and an estimated population within the Foresta Demaniale of 1767 individuals). In addition the presence of other pathogens such as *Brucella* spp., *Toxoplasma gondii*, *Coxiella burnetii*, Bluetongue virus, Hepatitis E virus, Paratuberculosis, will be investigated, while spleen and ticks will be searched for hemoparasites, such as: *Theileria* spp., *Babesia* spp., *Anaplasma* spp., *Rickettsia* spp. and tick borne Encephalitis virus. Removal activities for screening began in January and ended in April with 8.4 fallow deer removed per week. Screening was performed by Istituto Zooprofilattico Lazio e Toscana.

Considering that the eradication of an ungulate population attracts public attention, it could disappoint animal rights activists and can be manipulated, a specific communication plan was written with the aim to inform, involve and explain the necessity of the initiative in the framework of biodiversity conservation: indeed before the start of the removal activities, the public, key stakeholders and interested organizations have been involved using different communication instruments.

## The bats of the Aosta/Pré-Saint-Didier railway line: a case of conservation concern

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The Aosta/Pré-Saint-Didier is a single-track railway line. It is 31.3 km long, including about 9 km of tunnels. It was inaugurated in 1929 and powered by electricity until 1968, when diesel trains were introduced. On 24 December 2015, the circulation of trains was suspended due to the low use of the line and the need for extraordinary maintenance work. Since that date, the rail tunnels have remained almost undisturbed: no works have been carried out and the human presence has been limited to occasional visitors. It is known that bats may roost in abandoned rail tunnels. Therefore, as part of the surveys funded by Regione Autonoma Valle d'Aosta (Dipartimento Ambiente – Struttura biodiversità e aree naturali protette) for the implementation of the Habitats Directive, we performed some bat surveys in the tunnels of this railway line. In view of a possible reactivation of the railway line, the results of these surveys should be properly considered.

We inspected the tunnels in August 2017, February 2020 and January 2021, searching for bats, droppings and prey remains. Additional surveys, limited to one tunnel only, were conducted yearly, from 2018 to 2021, in the month of June, and in September 2020. Since we did not use endoscopes, the presence of individuals deeply hidden in crevices may have been overlooked. Bats were identified based on their morphology, without handling them, excepted for two dead individuals, which were identified from skull and dental measurements. Colony counts were performed from photographs. Bat droppings were dissected and hair, if present, identified under optical microscope.

In August 2017, we found a maternity colony of mouse-eared bats in one of the tunnels. The photographs and the finding of a dead individual proved the occurrence of *Myotis myotis*, while that of *Myotis blythii* was neither ascertained nor excluded (all the individuals of the photos lacked the pale forehead spot between the ears which is a distinctive, but not always present, trait of *M. blythii*). The colony has continued to use the tunnel, showing an increase in numbers: bats aged one year (i.e. with the exclusion of those born in the year) in 2018, 2019, 2020 and 2021 were respectively 68, 77, 96 and 105. During summer we also observed some isolated mouse-eared bats, presumably males, roosting in the tunnel of the colony and in the four nearest tunnels: they hanged from the ceiling, occupying small cavi-

ties clearly marked (brown colored). In September, groups of 2–4 individuals were observed at the same sites, presumably gathered there to mate. In other three tunnels we collected prey remains and droppings proving that, at least occasionally, they are used by individuals belonging to the genus *Plecotus*. In winter we did not observe any bats in the tunnels used by mouse-eared during summer, but in other five tunnels we found a dead *Myotis crypticus* and some hibernating bats belonging to *Rhinolophus ferrumequinum* (3 individuals in 2020 and 1 in 2021), *Barbastella barbastellus* (2 individuals in 2020 and 1 in 2021) and *Pipistrellus* spp. (6 individuals in 2021)

The results confirm the importance of rail tunnels for bat conservation, even after only a few years from the closure of the railway lines. In the Aosta/Pré-Saint-Didier line we recorded the occurrence of at least 6 species, using the tunnels for different biological roles (day resting, maternity, mating, prey consumption, hibernating). The component of main interest is represented by the maternity colony of mouse-eared bats. Previously, a similar colony had used the Aymavilles Castle. All the individuals of the castle that were directly examined (N=17) belonged to *M. myotis*, but the occurrence of *M. blythii* could not be excluded. In 1994, at least 170 bats aged one year were counted at that site, but according to local witnesses the colony had been formerly much larger and had faced eradication attempts in the '70s and '80s. During the '90s the presence of the bats was discontinuous and after 2002 the colony did not return to the castle. In spite of intensive search, the colony that once used the castle was not found elsewhere until 2017, when the roost of the Aosta/Pré-Saint-Didier railway line was discovered: the small distance between the two sites (1.5 km) suggests that the colony of the rail tunnel is the same as that of the castle. Currently, only six reproductive colonies of *M. myotis* are known in the whole territory of the Aosta Valley, Piedmont and Liguria and that of the railway tunnel is the only one known in the Aosta Valley. Moreover, no breeding colonies of *M. blythii* are known in the Aosta Valley, although the species occurs in the region. If the Aosta/Pré-Saint-Didier railway line is reactivated, as planned by the Regional Administration and Rete Ferroviaria Italiana, *M. myotis* could risk extinction in the Aosta Valley. Negative consequences on *M. blythii* cannot be excluded as well.

## Let's do the time warp again! On the distribution of social interactions in male Alpine ibex



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In polygynous ungulates, access to females is mainly dictated by males' dominance hierarchy, which is generally established close to or during the mating season through a peak in aggressive intrasexual interactions. Intra-male interactions are highly energetically expensive. Coupled with the reduction in food intake and the increase in time devoted to reproduction, they can reduce males' survival during the following winter. Yet male Alpine ibex (*Capra ibex*) shows a higher survival than other ungulates until about 10 years old. Indeed, this capital species evolved energy-saving strategies: for instance, the rut-induced hypophagia and the costly intra-male interactions are reduced during the mating season. Accordingly, we hypothesised intrasexual interactions to peak in spring and to decrease as summer advances and hence stable dominance relationships to be defined prior to the mating season.

We explored the seasonal and daily phenology of males' Alpine ibex aggressive interactions. We collected 10426 hours of observations on 74 marked animals, ranging from 3 to 17 years old, in the Gran Paradiso National Park, Italy. Observations were carried out between April and November from 2014 to 2019. The animals interacted more during spring and at the beginning of autumn while the frequency of interactions declined during the hottest periods of summer. The air temperature played a pivotal role in shaping the daily distribution of the interactions: they were more frequent during the morning and especially the evening and they started declining when the maximum daily air temperature was higher of 10 °C. Our findings support the hypothesis that male Alpine ibex have evolved a peculiar life history strategy to live in the demanding Alpine environment.

## Citizen science project on Alpine ibex (*Capra ibex*) in the Orobie Alps

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PO17

On the 30<sup>th</sup> anniversary of the first ibex reintroduction in the Orobie Alps, a three year long Citizen Science Project (2017–2019) named “Stambecco Orobie e Lombardia” started in June 2017 after being commissioned by Club Alpino Italiano (CAI) Bergamo Section and Central Scientific Committee (CSC CAI). The aim of our project was to get local people and trekkers involved in wildlife monitoring and to educate them to the observation of Alpine wild animals, above all of Alpine ibex (*Capra ibex* L. 1758). The gathering of updated information (through data analysis and photo collection) about the Alpine ibex colonies spatial distribution in Lombardy and its health status was another important goal achieved by the project, in order to improve the species conservation policies after 30 years from its reintroduction in the study area.

The project took place in the central Italian Alps, more specifically in the mountainous Orobie Alps area (Lombardy, Italy). It is a 750 km<sup>2</sup> area with altitudes varying from 1100 meters in the valleys to 3052 meters a.s.l. at the highest peak (Pizzo Coca) and it is characterized by a continental temperate climate. The project lasted three-year (from 2017 to 2019). From 1<sup>st</sup> June to 30<sup>th</sup> November of each year, Alpine ibex observation and data collection process started within the study area via photos taken by citizens. Dedicated social media accounts (Facebook and Instagram) promoted the Citizen Science Project and 10000 flyers have been distributed to the Lombardy Alpine refuges and the main mountain shops in the cities. The project’s Facebook and Instagram page (@stambeccoorobie) received the photos, with a maximum of five photos per participant. Each photo was complemented by technical information (photographer name, date, time, altitude a.s.l., site description and GPS coordinates). All data have been stored in Microsoft Excel spreadsheets and georeferenced on the ArcGIS platform and a web mapping application. The use of wildlife camera traps and animal foraging was banned. Through the project website and social media pages, participating citizen scientists received guidelines for species recognition and data collection. All the received photos were checked on a daily basis by the project’s scientific committee, then feedback was given to individual photographers and photos were posted on the project’s Facebook and Instagram page. Each image was analysed separately in order to establish species,

sex, age category, altitude and surrounding environment. Photos not corresponding to the study area, or with no proper animal subject were deleted. In the meantime, a photo contest was also organised each year with a jury awarding prizes to the best 10 photos.

Over the project’s three-year period, 2530 photos the Alpine ibex were sent: 612 in 2017, 803 in 2018 and 1115 in 2019. Data gathering and observations were performed by 735 citizen scientists (225 in 2017, 248 in 2018 and 262 in 2019) with more men (76%) than women (24%) taking part. The Facebook page (@stambeccoorobie) has 2746 followers (43% of whom are women and 56% men) with the best represented age group being 35–44 (26%), followed by 45–54 (23%) and 25–34 (22%). The analysis of the georeferenced photos shows that 38% (427/1115) of observations (year 2019) took place close to trails paths over 2300 meters.

After ten years from the last census (2008), photo georeferencing highlighted the current distribution of the ibex colonies within the Orobie Alps. In particular, it was found that the most commonly frequented areas, especially in the summer, are more extensive than the ones that were identified in the preliminary study (year 1991). This leads to the assumption that the census methods currently used in order to estimate wild ungulate populations could be completed with new methodologies like citizen science projects. Photos also turned out to be of support in monitoring the health of the population. Sequences of photos of adult males with one or both horns broken, were of particular importance. The photos also showed the presence of several male ibex affected by *Trombicula autumnalis*. Overall, this three years project proved to be an effective tool with which to raise people’s awareness of Alpine ibex population issues and to extend knowledge about wild animals and the importance of biodiversity. The use of social media proved to be a valid tool in getting citizen scientists involved and in educating people to a responsible approach to fauna resources. These study methods should be used in the future and their full potential exploited, including the strength of new technologies such as artificial intelligence which may help to avoid data dispersion and favour an increase in public awareness of ibex conservation policies.

**Evidence for social learning of conflict behaviour in Alpine bears (*Ursus arctos arctos*)**Peppi G.M.E.<sup>1</sup>, Filacorda S.<sup>2</sup>, Pedrotti L.<sup>3</sup>, Frangini L.<sup>2</sup>, Fattori U.<sup>4</sup>, Groff C.<sup>3</sup>, Mucci N.<sup>5</sup>, Davoli F.<sup>5</sup><sup>1</sup>Department of Biological, Geological and Environmental Sciences (BiGeA), University of Bologna, Italy.  
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PO64

**Introduction** – The theory of social learning represents a cognitive process that takes place in a social context through observation or direct learning, even in the absence of direct reinforcement. This theory shows that learning is not only based on direct contact with objects, but also on indirect experiences gained by observing other conspecifics. This theory is of primary importance among animals — such as bears — which provide parental care. Two ways of learning can be observed: through direct experience with the surrounding environment, or through indirect learning from observing the mother's behaviour. Social learning theory becomes an important starting point to understand both mechanisms and stimuli that can make an individual overconfident or even dangerous for humans and their activities (causing conflict behaviours). For this reason, the aims of the project were to i) verify if the attitude for a bear to develop conflict behaviours might be a result of genetic inheritance; ii) if not, verify the social learning theory through a significant statistical relationship between problem mothers and their offspring.

**Methods** – The twenty-year Italian national reference database contains information on 9 individuals reintroduced from Slovenia in the Adamello Brenta Natural Park from 1999 to 2002 (Project Life - Ursus. LIFE96NAT/IT/3152) and their successive generations. Contingency tables  $2 \times 2$  have been used to verify whether a relationship between problem mothers and problem offspring may be proved. The information on 100 bears (1999–2019) has been analyzed in order to subdivide individuals into generations, obtained by biomolecular reconstruction of kinship relationships. Parents were assigned to each individual. Where verified, conflict behaviours were marked for parents and offspring. Afterwards, in contingency table  $2 \times 2$  were reported data concerning problem and non-problem offspring assigned to each parent (problem and non-problem mothers and fathers). The contingency tables have been used to perform the Barnard test, which analyses the association between the two categorical variables in each table. The Barnard test is an exact test used in the analysis of contingency tables and is a more powerful

alternative than Fisher's exact test for  $2 \times 2$  contingency tables. The Barnard test was performed with two different approaches implemented in the packages RStudio and Matlab, to verify the reliability of the results obtained.

**Results** – Out of 100 individuals analyzed, 15 were problem bears (4 mothers, 3 fathers, 4 female offspring, 9 male offspring). We evaluated 31 mother-offspring and 6 father-offspring relationships. Tables  $2 \times 2$  permit to compare the incidence of problem and non-problem offspring (males and females separately) with respect to problem and non-problem mothers and fathers. When the relationship between problem mothers and problem offspring (males and females together) is considered, Barnard's test ( $p=0.0005$ ) shows that 32% of offspring from problem mothers were problem bears (10/31, 1 female e 9 males). There was no evidence that offspring is more likely to be involved in conflict behaviour if fathers are problem bears (Barnard's test,  $p=0.1582$ , 1/6=17%, of offspring from problem fathers, was found to be problematic). Similarly, we have not found statistically significant relationships between female progeny and problem mothers (Barnard's test,  $p=0.2475$ , 1/12=8%, of female offspring from problem mothers, was found to be problematic). Only male progeny of problem mothers is more likely to be involved in incidents or human-bear conflicts (Barnard's test,  $p=0.0005$ , 9/19=47%, of male offspring from problem mothers, was found to be problematic).

**Discussion** – Conflict behaviours might be the result of social learning, genetic inheritance, or both learning and inheritance. Our preliminary results do not support the genetic inheritance theory of conflict behaviour in bears because only male cubs are significantly associated with problem mothers. Therefore, these results support the social learning hypothesis for male cubs only and suggest that proactive mitigation to prevent bear females from becoming problem individuals will likely help prevent the protraction of conflicts through social learning. Evidence of this relationship allows us to know more about the social learning of cubs as well as to improve the management of the bear population in order to reduce potential human-bear conflict.

## Wild boar habitat selection and use in a protected area of the Po valley

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PO65

**Introduction** – The great adaptability of the wild boar to environmental conditions seems to be the basis for the increase and expansion of its populations in Europe and Italy. Understanding the ecology of the species is therefore fundamental for the correct management and conservation of this ungulate. The study aims to analyze the selection and use of habitats by wild boar in the North of Italy, within the Ticino Valley Regional Park, a protected natural area of 22000 ha of lowland forest (38% of the study area) inserted in a context of 47200 ha used for cultivation (10%) and 21740 hectares of urbanized areas (3%).

**Methods** – For this study the indirect method of sampling paths with detection of signs of presence was used. In the study area, 30 paths were traced (average length of 8.02 km, SD=2969.76) which were then covered on foot in two different sessions: one during the autumn-winter period and one during the spring period. To define the abundance of the wild boar and the selection of the habitat, the number of signs of presence per km of itineraries (IKA) and the Manly index  $\alpha$  were calculated respectively. Correlation and regression analyses were carried out between the IKA values and the extension of the habitat types considered. To estimate the presence of the wild boar a resource selection probability function (RSPF) was calculated by binary logistic regression analysis (BLRA). All analyses were performed considering both the entire sampling year and the

seasons separately.

**Results** – This study has shown that wild boar preferably selects woodland habitats, but the choice varies according to the season. During spring the species prefers deciduous forests ( $p < 0.001$ ) and avoids ecotonal zones ( $p = 0.001$ ) and heavily populated areas ( $p = 0.001$ ). During the winter there is a greater use by the species of the cultivated areas.

**Discussion** – The results obtained from the study confirm that wild boar is a typical species of wooded and bushy habitats, but its great adaptability to apparently unfavorable areas, such as those cultivated and anthropized, is one of the main characteristics involved in the population's expansion process in recent years. In addition, the choice of habitat varies according to seasonality and particularly with the different availability of food that different habitats provide during the year. During the spring, the beginning of the vegetative season of the palatable species for wild boar ensures adequate nourishment in the forest habitats. However, in winter the species actively selects different type of habitats and also feeding outside forests, attending cultivated areas where the crops that are sown in winter or early spring can be more threatened. According to our results, the Ticino Park, where natural areas are close to the highly cultivated ones, represents a high suitable context that can promote the success of the wild boar population.

## On the presence of *Dryomys aspromontis* in Aspromonte National Park and Serre Regional Park

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PO67

A recent study showed populations of forest dormouse in Southern Italy belonging to a distinct, previously unrecognized species *Dryomys aspromontis*. Current knowledge about its distribution in the Calabria region is still lacking and available data consist only of few trapping records in Aspromonte, Sila, and Pollino mountain massifs.

The aims of this research are to provide an up-to-date picture of *Dryomys aspromontis* distribution in Aspromonte National Park and to show the first result obtained in a limited area of the Serre Regional Park.

The research is based on collected data from 3 different studies conducted between 2008 and 2020: two of these were commissioned by the Aspromonte National Park Authority to study forest dormouse in the protected areas (Aspromonte National Park and Serre Regional Park) and the other was the study of small mammals in more extended Environmental Impact Assessment

concerning the construction of a dam on the river Menta (Aspromonte National Park) by So.Ri.Cal (Calabria Water Resources Society).

The research involved the application of different methods, as use of 400 nest boxes placed on trees in 20 monitoring sites, live traps set on 15 square grids (1 ha) and 50 live traps set on the ground along 5 monitoring sites. The presence of *Dryomys aspromontis* in Aspromonte National Park was recorded in 10 new sites distributed between latitude 38°6'50" N and 38°13'21" N in an altitude range of 1250–1850 m asl. The first Calabrian forest dormouse observation in the protected area was reported in Serre Regional Park. The monitoring site is at 1000 m asl.

Individuals were found mostly in beech (*Fagus sylvatica*) dominated forests but were also observed in mixed forests with high conifer presence.



**Do quills no longer hurt? A new prey for *Canis lupus***Rizzardini G.<sup>1,2</sup>, Quinto F.<sup>1,3</sup><sup>1</sup>Movimento Azzurro – Ecosection of Murgia and Areas of natural interest<sup>2</sup>University of Basilicata<sup>3</sup>Basilicata Region – Regional Observatory for Biodiversity Natural Habitats and Wildlife Populations

PO69

**Introduction** – Several studies on wolf's food ecology (*Canis lupus*) have been conducted worldwide. In Italy the most studied areas are the central-Northern Apennines and the Alps. Very little is known about the wolf's eating habits in southern Italy, particularly in areas such as badlands and murgia's areas of Basilicata. The aim of this research was to study the diet of two packs present in the province of Matera (Basilicata) from two sites characterized by Mediterranean maquis, the first site mostly badlands and the second site murgia type.

**Methods** – Wolf's diet was assessed by analyzing fecal content. In the period between January 2014 and December 2015, a total of 186 excrements from the "Badlands Pack" (BP) and the "Murgia Pack" (MP) were analyzed. Prey species were determined by hair analysis. A reference hair bank has been created with the prey species of the territory. The preys have been grouped into 5 food categories: "domestic ungulates" (cattle, sheep, goats and horses), "wild boar" (*Sus scrofa*), "porcupine" (*Hystrix cristata*), "accessory prey" (*Lepus europeus*, *Meles meles* and birds) and "vegetable".

For each food category was assigned a volumetric class: 0–5%, 6–25%, 26–50%, 51–75%, 76–100%, in each sample. Relative frequencies of the food categories were estimate. The chi-square test was used to calculate the differences between the diets of the two flocks for the "domestic ungulates", "wild boar" and "porcupine" food classes.

**Results** – The wild boar was the principal species predated by

the wolf in Basilicata (42%), followed by domestic ungulates (31%) and porcupines (21%). However, considering the two packs separately, there were significant differences in the use of the food categories ( $p < 0.001$ ). The main differences were found in the prey "wild boar", mostly used in the MP (about 77% against 6% of the BC pack), and in the "porcupine" prey, used in the BP (about 42%) and not found in the MP. Both packs of wolves have consumed domestic prey, although in different quantities (MP=16% and BP=47%).

**Discussion** – This study confirmed the great adaptability, flexibility and opportunism of the predatory behavior of the wolf. Despite the presence of the same prey species in the two sites analyzed, the pack of badlands did a large use of a prey species that was rarely used before by the wolf: the porcupine. This outcome can be the result of the great adaptability of the predator. Until a few years ago the wild boar, one of its main prey, had completely disappeared from this area. We assume that the BP has adapted, learning to hunt the porcupine and has identified it as an attractive prey. *Hystrix cristata* had become its main prey to date, in which the renewed presence of the wild boar for hunting inputs had not changed this preference. For the MP, instead, the wild boar represents the most predictable and profitable species. Livestock was used by both packs, probably because of its high accessibility, often due to the absence of protective and preventive measures.

## Telemetry monitoring: two case studies of released adult male wolves (*Canis lupus italicus*) after different periods of rehabilitation at the rescue centre

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P093

M1 and M2 are two rescued male wolves, respectively in 2016 on March 29<sup>th</sup> and in 2020 on February the 8<sup>th</sup> in two different areas of Umbrian Apennine. They were released in the wild equipped with a satellite radio collar (Followit Tellus Medium) in order to follow up on their health status and behavior after a period of rehabilitation at the Rescue Centre.

M1, an approximately three-year male wolf, was rescued laying on the ground of a roadside, presenting neurologic conditions, he was eventually tested positive to IgM for Canine Distemper Virus (Arctic-like). M1 was transferred to a wildlife rescue centre where its sanitary situation was strictly supervised until ISPRA approved its release of subsequent negative tests from different laboratories on October the 24<sup>th</sup> of the same year.

M2, a two-year-old male wolf, was found roadside presenting severe condition due to poisoning. Its health status recovers within a few days and it was released shortly afterwards.

The purpose of this paper is to compare the different behavior of these two similar wolves (same sex, age, and analogous provenance area) distinguished by a crucial divergence or rather the time of rehabilitation: six months (M1) counter to five days (M2). The last-mentioned wolf was monitored for a full year (February 2021–February 2022) contrarily to M1 which was observed 45 days until its regrettable murder. In order to make the two wolves' comparison statistically adequate, M2 data were elaborated both for the total period of monitoring as well as for the first 45 days.

Radiotelemetry locations were pre-processed (outliers removal, fields harmonization, coordinates reprojection, sunrise/sunset times calculation, and consequent night/day assignment) with spatially enabled (PostGIS extension) PostgreSQL, then analyzed by mean of the R statistical framework equipped with the `tidyverse`, `mapproj`, `rgeos`, `sf`, and `moveud` packages. The Kruskal–Wallis test and the Wilcoxon rank sum test were used to compare overall differences among the daytime and nighttime distances from buildings and streets and analyze the motility variation. When the overall  $p$ -value was  $<0.05$ , intergroup comparisons were conducted using the Wilcoxon test for multiple comparisons with the Bonferroni correction. A Brownian bridge model was used to create the empirical estimates of wolf movement paths and their probability densities, derived from connecting each pair of successive locations.

The first outcome regards the home-range estimated from the probability densities: foremost it is remarkable how M2 already established his home range in just 45 days; hence, it is to be

pointed out that comparing partial data with total ones, the most frequented areas are inter engaging. Furthermore, following up on M2 by using camera traps, it has been observed the individual rejoined that packs' territory. Oppositely, due to six months of captivity, M1 was unattainable to define a proper home range in view of the fact that it couldn't rejoin a former pack in an established area.

The movements of the two wolves accord to an additional dissimilarity: M1 wandered a total amount of 197 km predominantly traveling by nighttime and partially during dawn hours; on the other hand, M2 had doubled the amount of kilometers in 45 days, specifically 461 km, walking mostly night time and during crepuscular hours. Furthermore, comparing weekend movements, a more relevant uniformity in M2's tracking than M1's alternating weekends of activity to weekends of inactivity is noticed.

The proximity analysis proves that the day/night frequency of M1 in closeness from roads and buildings has slight differences, with buildings approached more during night time. As far as the M2 case study, a difference is noted between 45 days and the whole data analysis that tends to normalize to a regular trend: M2 got most frequently close to roads and buildings overnight. It is remarkable to be said that the Apennine region consists in detached minor towns or small groups of buildings for both M1's and M2's monitoring areas. M1, in a just single episode crossed a four lanes expressway. Vegetational categories draw the attention, for both individuals, to the fact that deciduous forests and grasslands are the most used categories within daytime as well as nighttime, whereas cultivated fields are subject to a nighttime and hunt time frequency. Presumably, M2 utilizes shrubs, orchards and riparian forests as passages through the night and crepuscular hours. This behavior is significantly less prominent for M1 which is to be noticed as more discreet and cautious by taking refuge in wooded environments during daytime.

To conclude, it has been noticed that radio-telemetry along with camera trapping are two, whenever possible, valuable monitoring methods for what it concerns wolves released after a period of rehabilitation in a Wildlife Rescue Centre. These two released wolves' behavior attests that a briefer permanence at the rehabilitation facilities ensures a more immediate and complete reintegration of the individual in its pack. What is mentioned before will guarantee a proper to the specie's greater recover and a more appropriate spatial behavior. For that reason, it is crucial to release rescued wildlife as soon as health condition allows it.

## Testing a standardized approach for monitoring bats at the national scale: challenges and experiences from Italy

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PO70

Bats are key elements of ecosystems, and as such they are recognized as important bioindicators and conservation targets, so that their populations and conservation status are regularly monitored across EU, according to art. 17 of the 92/43/EEC “Habitats Directive”. Due to their secretive habits, small size and nocturnality, bats pose serious challenges to large scale monitoring schemes, so that various attempts have been recently conducted in order to design effective and standardized protocols, to be applied at large scales.

In Italy, the latest attempt is represented by the “National Plan for Biodiversity Monitoring” (NPBM), coordinated by ISPRA following a concerted process with experts from several fields. The aim of the NPBM is to generate a standardized approach, possibly applicable to all species to be monitored (including both plant and animal taxa), providing an effective and reproducible tool for monitoring biodiversity, at a national scale.

Here, we outline the main points of the rationale behind this monitoring scheme, focusing on bats as target group, including species prioritization and categorization processes, and identification of species-specific monitoring units. Secondly, we present preliminary results from two field campaigns testing the effectiveness of the NPBM scheme applied to bats, at sites

falling within the Natura 2000 network of protected areas (PAs) from two Italian regions (Abruzzo: Gran Sasso and Monti della Laga National Park, and Calabria: Pollino National Park and surrounding territories).

Following the NPBM scheme and monitoring site designation, we highlight a number of challenges emerged when monitoring is conducted at regional or PA scales, e.g. in terms of spatial coverage. This issue was resolved, in the presented case studies, by combining the sampling units identified by the scheme with supplementary ones, selected according to a habitat-stratified approach.

Secondly, the species-specific approach in assigning sampling monitoring units, as per the NPBM, proved to be only partly successful: target species were in fact successfully detected in their assigned units, i.e. yet this was not true for all species or all cases, suggesting that this approach is effective only to species with clear and relatively well-known habitat preferences.

The scheme designed by the NPBM is certainly ameliorable, yet provides the foundations for a large scale monitoring of bats, particularly if further campaigns will be systematically conducted across regions and PAs following a coordinated effort.

## Small *Myotis* and coniferous forest: explore relations in Foreste Casentinesi National Park

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PO71

Forests are universally recognized as a critical habitat for bats, but the extent to which their structure and composition affects the community is still under investigation, especially as regards the different conservation values of conifers, when planted outside their range. The National Park of the Casentinesi Forests represents a perfect study area to investigate the potential effect that conifers have on the bat communities, presenting a forest cover mainly with beech woods equal to about 14600 ha and 7930 ha of artificial plantations of conifers, mostly however represented by overgrown stands with modern naturalistic management. From 2014 to 2021, standardized surveys were carried out throughout the Park area, traveling through transects by car and recording bats' presence data by bat-detector in time-expanded mode, locating contacts using GPS. The identification of the species was done manually using the BatSound software and comparisons with author's own library and literature.

By focusing on the 5 smaller species of the genus *Myotis*, for which the acoustic identification was verified blindly by 3 experts, the contacts following sure contacts were detected: *Myotis bechsteini* (6), *Myotis daubentonii* (106), *Myotis emarginatus* (66), *Myotis mystacinus* (88), *Myotis nattereri* (35).

Using MaxEnt, we built two different ecological models for each

species: a first model of environmental suitability using climatic, morphological, anthropogenic and environmental variables, which were grouped by PCA, and a second model focused on the variable “coniferous forests” at different spatial scales, respectively 100, 300 and 600 meters, with respect to the location of the contact.

The criterion for choosing between models was the AICc, which, respecting the principle of parsimony, evaluated the increase in information that is obtained by adding the new variable. The validation was done considering the performance aspects, based on the Emission Error Rate and significance by performing a one-tailed binomial test. The results obtained show that in 2 out of 5 cases the variable “coniferous woods” determines an improvement in the effectiveness of the model, with a particularly evident positive effect for the species *M. nattereri* and *M. emarginatus*, both at a spatial scale of 300 m. As regards the other species, in *M. daubentonii* a particular difference between the two models was not highlighted; *M. bechsteini* presented not enough data to compute while for the *M. mystacinus* species no particular preference for the type of forest under study was highlighted.

## Diet shapes the skull morphology of the otter in UK. A 3D geometric morphometric approach

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PO06

Otters are semi-aquatic carnivores specialized in hunting aquatic prey in a variety of freshwater and marine coastal habitats. However, adaptive traits related to feeding in different habitats have been little explored up to now. We aimed at analysing phenotypic variation and adaptive traits of the skull of the Eurasian otter *Lutra lutra* across its range in the United Kingdom using 3D geometric morphometrics. We analysed 43 skulls of adult specimens from 18 sample localities and three previously identified genetic clusters (Scotland, Shetland Islands, and Wales). A total of 30 landmarks were identified using Meshlab on 3D models reconstructed from 108 pictures of each skull using photogrammetry. Each sample locality was assigned to either inland, coastal, or island waters. Also, for each sample locality, we recorded latitude, longitude, 19 CHELSA climate variables,

and diet composition derived from the literature in terms of frequencies of prey categories and fish families. Original landmarks coordinates were first aligned through GPA. Shape and size variation of the skull were first analysed to evaluate any sexual size or shape dimorphism. ANOVA, Procrustes ANOVA, MANOVA, PCA and PLS were performed using the R package geomorph to evaluate the effects of genetic clusters, climate, and diet composition on skull size and shape variation, and to reveal specific adaptive traits. Results revealed high plasticity of the otter skull, showing significant differences both among the three genetic clusters and between otters exploiting marine vs freshwater prey communities. Main adaptive traits included the shape of the rostrum, orbits, and nasal cavities.

## Long-term monitoring shows temporal but not spatial avoidance of human disturbance by a community of wild mammals in a touristic area of the central Alps

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PO72

In the last decades, outdoor recreation in natural areas has become an increasingly popular activity, resulting in diffused human presence within protected areas and potential direct disturbance to wildlife. Wild mammals can avoid people in space and/or lower their activity rate when human activity peaks. Though the responses to human presence have been studied at the level of single species, long-term effects at the level of biological community are poorly known. We aimed to assess whether a community of eight medium-to-large mammals under diffused tourism presence avoided humans in space, time or both, and to evaluate if the high rate of human outdoor recreation in the study area affected the mammalian community occurrence in the long term.

We studied mammals in the Parco Naturale Adamello-Brenta and surrounding areas, in the central Italian Alps. We monitored mammals by systematic camera-trapping during seven summers from 2015 to 2021. We selected 60 uniformly spaced sites on hiking trails and forestry roads that we sampled consistently over the years. We first estimated occupancy, persistence, and colonization probabilities of the mammalian community through a dynamic-community-occupancy model, testing the effect of human disturbance rate and distance from the closest settlement. We then derived the Wildlife Picture Index (WPI) to obtain a weighted trend of community occupancy over the years. Final-

ly, we evaluated whether the observed temporal co-occurrence between wild mammals and humans was lower than expected through a randomization test.

Overall, 70% of the 522564 pictures collected depicted humans. This widespread presence, which increased over the 7-year-period, did not cause spatial avoidance at the site level in the mammalian community, but a strong temporal avoidance. Given the positive WPI and the increase in species-level occurrences during the monitoring period, the mammalian community was seemingly not affected in the long-term. Martens, brown bears and red deer were the species showing the strongest positive trends in occupancy, while roe deer was the only species for which the trend was negative, even if weakly.

Our study shows that when human outdoor recreation is intense and widespread, wild mammals respond mainly by concentrating their activities at times of lower human presence. This strategy seems an effective coping mechanism, that allowed the community to increase its distribution over the years. However, the pervasive and growing presence of humans within and around the park calls for the need to regulate human access to natural areas to decrease the pressure on wildlife. Finally, our approach represents a valuable example to standardize monitoring of mammalian species and communities.

## Difference in small mammals community in biodynamic vs conventional farms in Venetian plain

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PO73

The agroecosystems are losing greater part of their diversity for the intensification to increase productivity and the use of industrial concept in the production of food. Small mammals are considered keystone species in agro-ecosystems, and they are good indicators to study landscape transformations related to intensification and steppization. In this study are analysed small mammals community in agricultural fields of the Venetian plain. The study area is characterized by high degree of anthropization and land use is purely agricultural. Two different methods were used to analyse small mammals community: live trapping session and pellets analysis. Live trapping was performed in two adjoining farms with different management: biodynamic and conventional. We carried out three trapping

sessions of ten nights, for a total of 1680 trap-nights. Barn owl pellet analysis give us information about small mammals community at landscape scale. Pellets were gathered in a ruin near the farm. Results show a great difference in the number of captures in the two farms: in biodynamic farm were captured 128 individuals and 7 in conventional farm. The most abundant species were generalist species like *Apodemus sylvaticus*, *Mus musculus* and *Crocidura suaveolens*. Pellets analysis allowed the identification of 12 different small mammals species, confirming the high biotic potential of the study area, but anyhow, the most abundant species were the same generalists. The study confirms the importance of restoration of small biotopes for the conservation of small mammals populations in agro-ecosystems.

## Efficiency of IAS species control strategies: the management of Pallas squirrel (*Callosciurus erythraeus*) in the province of Varese

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PO74

In Italy the first reports of the presence of *Callosciurus erythraeus* date back to December 2007 in Brezzo di Bedero (province of Varese) at less than 10 km from the Swiss border. This town represents probably the place of first introduction, by voluntary release or escape of specimens held in captivity, prior to the entry into force of a national law in 2013 (GU Serie Generale n.28, 02-02-2013) by which the purchase, the holding, the breeding and the trade of this species has been prohibited. Later the species has been introduced also in the annex of the EU Regulation 1143/2014 and the Italian Regulation D.L. 230/2017. The presence of uncontrolled populations of Pallas squirrel causes serious ecological damage as it competes with the native European red squirrel (*Sciurus vulgaris*) for space use and trophic resources and determines a progressive decrease in population size and subsequent local extinctions. *Callosciurus erythraeus* is also responsible for damage to the forest heritage due to the intense debarking of trees, as well as causing damage to irrigation pipes and fruit trees, with loss of the fruit crop. Here we present a comparison between efficiencies of two different methods used in *Callosciurus erythraeus* control activities in the north of the province of Varese.

Two different types of management have been applied to this species. (1) Control with firearms, carried out from 2016 to 2019 by officers of Polizia Ittica Venatoria della Provincia di Varese as established by regional laws and decrees (LR 26, Art.41 16/8/93, DR 4972 9/04/2018) using a shotgun with caliber 12 broken bullets. (2) Control by traps was carried out from 2011 to 2019 using live traps model Tomahawk live traps (type 202), and

Longmeadow multi-catch traps, positioned against the trunk of a tree on trapping grids. Trapped squirrels were euthanised with CO<sub>2</sub> excess. We also investigated the economic side, providing general estimates of the costs incurred for the implementation of these two activities.

The analysis of shooting data led to calculate an average daily efficiency of 10.5 individuals shot with a firearm (calculated on 6.5 hours/day shooting) and a daily capture efficiency by traps and euthanasia suppression of 0.73 individuals per day. From 2016 to 2019 we had 103 shooting days with 657 different shooting points and a total of 1624 squirrel removed. Trapping session started in 2011 and lasted until autumn 2019, for a total of 954 trapping days with 330 trapping points and a total of 711 squirrel removed. Overall trapping costs was about 120000 € with annual cost of 15000 € (daily cost 125 €) and cost for every removed squirrel of 170 €. Overall shooting costs was about 27000 € with annual cost of 6700 € (daily cost 260 €) and cost for every removed squirrel of 16 €.

The results obtained showed a greater removal effectiveness by control with a firearm and also from an economic point of view this system proved to be the cheapest. However, it emerged that the control with a firearm, although more efficient, presents critical issues, such as distance from buildings, intensity of woodland utilization by humans, that indicate the use of multiple methods for efficient management of the Pallas squirrel. These results could help to prepare the *Callosciurus* National Management Plan.

***Panthera onca* social interactions in Santa Rosa National Park, Costa Rica**

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PO75

A total of 35 out of the 37 wild Felids have been described as asocial and solitary outside the breeding and caregiving periods. However, there are contradictory observations in the literature on their intra-specific interactions. The jaguar (*Panthera onca*) is the largest Felidae in the Americas, and one of the least studied large cats in the world, especially as regards its socio-ecology. Jaguars are known to be highly territorial and asocial, but felid sociality may be subject to significant variations and is contingent upon the availability and distribution of key resources such as water, prey, and females.

In this study I tried to explain the presence of rare social interactions in jaguars, following three hypotheses: 1) the resource dispersion hypothesis, which states that the cost of sharing territory with conspecifics depends on resource availability: the abundance of resources makes intraspecific competition less necessary; 2) the land-tenure hypothesis, which states that carnivores regulate their density and distribution through spatial and temporal avoidance; 3) the kinship hypothesis, which predicts that kinship is linked with the spatial organization of territories and that animals exhibit tolerance or cooperation with their related conspecifics because there is an increase in the inclusive fitness.

The current study has the aim of documenting the presence of social interactions in the population of jaguars present in the area of Nancite beach (Santa Rosa National Park, Costa Rica), taking advantage of the predation of such jaguars on olive ridley sea turtles (*Lepidochelys olivacea*) and green sea turtles (*Chelonia mydas*). For this purpose, morning surveys and night patrols on the beach were conducted to search for recently preyed sea turtles. In addition, camera trapping was adopted to document a) the simultaneous presence of more than one jaguar at the time of prey utilization and b) any use of the same paths in the forest by several individuals together. This was possible because jaguars could be identified individually in the photos (or videos) by the spotted pattern of the coat. Camera traps were also used to identify the potential prey for jaguars in the study

area and to calculate a relative frequency index. I personally collected camera trap data from the 17<sup>th</sup> of May 2021 to the 3<sup>rd</sup> of October 2021, then I combined my data and the data collected between the 3<sup>rd</sup> of October 2018 to the 17<sup>th</sup> of May 2021 by Luis Fonseca's team to increase my sample size data.

A total of 14 jaguars (4 females and 10 males) were observed in the study area, for a total of 1049 single capture events. Fifty events involved two or more animals photographed walking together in the forest, and in 14 out of 134 cases, preys were shared by more than one individual.

Dyads recorded walking in the forest were formed mostly by non-kin males (31%), while prey-sharing was observed predominantly between related individuals (36%, immediately followed by unrelated individuals: 21% unrelated males and 21% adults of different sex).

Camera-traps revealed a rich community of mammals that may be prey to jaguars. Furthermore, jaguars prey on only a minimal fraction (0.46%) of the sea turtles that come to the beach to reproduce. Therefore, sea turtles are probably an important but not a primary food resource for this carnivore. During the research, it was not possible to weigh the jaguars, but the comparison of their photos with those of other populations indicates well-fed and healthy animals. This probably indicates that jaguars have an adequate diet and exploit the turtles as supplementary food. Given the results obtained, the resource dispersion hypothesis seemed to be the hypothesis that best fitted the situation present in the study area. Observing relationships between interacting individuals, not a strong support was found for the kinship hypothesis, and because of logistical problems, it was not possible to investigate the land-tenure hypothesis accurately.

This research can help to better understand the socio-spatial ecology of jaguars and their ability to adapt to several circumstances. However, further studies are needed to confirm the validity of the resource dispersion hypothesis as a driver of sociality in this species.

## Founding Micronuclei: The Buccal Micronucleus assay as useful method to evaluate genomic damage in mammal species

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P079

At individual level, genomic damage is one of the most important causes of degenerative and cancer diseases, whereas at population level it represents a factor that could increase the extinction risk. It is known that the levels of genomic damage may be influenced by endogenous factors, like genetic polymorphisms, and by exogenous causes, like environmental exposure to xenobiotics. Among markers of genomic damage, Micronuclei (MNi) were widely used in many population studies.

They originate from whole chromosomes or chromosome portions that lag behind during anaphase of nuclear division. MNi can be easily assessed in different cell types, such as erythrocytes, lymphocytes, buccal and exfoliated epithelial cells.

The MNi test in exfoliated cells of the buccal mucosa is a non-invasive assay successful used for the evaluation of the genomic damage level in different taxa. This assay was firstly developed for humans, in order to provided data about the genotoxic effects of pollutants, and successively was used to monitoring the

health status of different invertebrate and vertebrate organisms, mammals included.

Few data are present in literature about the frequency of MNi in mammal species. For example, bats were used to evaluate the effect of air pollution and of different trophic levels on the amount of genomic damage; aquatic mammals (*Tursiops truncatus*) were used as bioindicator of aquatic pollution and micro-mammals (*Sciurus aureogaster*) were used to evaluate the level of MNi in relation to age.

In our study, this technique was successful used in order to evaluate the possible stress-induced genomic damage in shelter dogs and cats. We observed a significant difference in the level of genomic damage between shelter and family animals.

In conclusion, we can affirm that the MNi assay represents an efficient, reliable, economic and non-invasive technique useful to measure the genomic instability in human and animal populations.

## Density estimation of the Italian hare, in the Circeo National Park, using camera trapping

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P090

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In conclusion, we can affirm that the MNi assay represents an efficient, reliable, economic and non-invasive technique useful to measure the genomic instability in human and animal populations.

## Consistency over time in male Alpine ibex hierarchies

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P080

Engaging in fights to establish dominance relationships is a highly costly behaviour. In male Alpine ibex (*Capra ibex*), the frequency of interactions was observed to peak between spring and early summer. Unlike most mountain ungulates, little time is spent in agonistic behaviors during the rutting period. Since hierarchy in male Alpine ibex is determined by outcomes of fights and it is supposed to affect the access to females during the mating season, we hypothesized that it may be established in early summer and maintained with little variation until the rutting period. To test this hypothesis, we used the Elo-rating system to calculate individual hierarchical scores in summer and autumn. Summer and autumn scores were positively correlated suggesting stability in the hierarchies after summer. We then estimated the autumn scores by simulating the outcome of dyadic interactions occurred after July, assigning winning probability based on three alternative assumptions: (1) winning probability proportional to the individual scores of July, (2) winning probability predicted by age and (3) random winning probability. Simulations were repeated 1000 times for each

assumption and the correlation coefficients between summer and autumn scores were compared with the correlation coefficient of the observed data. The correlation coefficient found in observed data was consistent with assumption 1. Age alone (assumption 2) was not capable of accurately predict the observed correlation coefficient and assumption 3 (random assignment of winning probability) was even further from the observed values. Our results are in accordance with the hypothesis that hierarchy is established long before the rutting period and that little variation occurs in the late summer and early autumn. As the mating season of ibex occurs at the beginning of winter, engaging in fights to increase the access to females might be too costly in the demanding environmental conditions of the Alps. A mismatch between dominance relationships establishment and the mating activities could represent a strategy to minimize energy expenditure in winter and therefore to heighten the chances of survival and of future reproduction. Surprisingly, this hierarchy seems to be defined as far as six months before.

## Temporal activity patterns of sympatric alien lagomorphs in Northern Italy

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P082

Alien lagomorphs can compete with native ones, mainly through phenomena such as trophic competition, disease transmission, as well as inducing hyper-predation. In Italy, the eastern cottontail (*Sylvilagus floridanus*) and the European wild rabbit (*Oryctolagus cuniculus*) are alien lagomorphs that have been introduced from America and the Iberian Peninsula, respectively. Regarding rabbits, some Italian peninsular populations also derive from the release of domestic individuals. To manage — and eventually eradicate — alien mammals is pivotal to know their activity rhythms. Despite this, knowledge on temporal behaviour of these species is scarce in Italy, with no studies carried out where the two species live in sympatry. In this study, we implemented a camera trap survey in Northern Italy (Oasi Levadina, Milan, Lombardy) to determine the seasonal temporal activity patterns of these two alien lagomorphs, as well as the overlap of their diel patterns. The analyses were implemented

in the software R, mainly through the package `overlap`. At the end of the survey, we will also determine, and compare, the activity patterns of the main predators of the area (i.e., *Vulpes vulpes* and *Felis catus*) with those of the lagomorphs. Between May and August 2021, we collected 2650 and 689 independent records for cottontails and rabbits, respectively. Both species presented a bimodal activity, with two peaks at dusk and dawn, thus showing to be crepuscular in the warm season. The overlap of the temporal activity patterns resulted to be high, indicating a low level of direct competition, at least at the population densities of the monitoring period. In addition, rabbits and cottontails were more active in darkest nights, presumably to reduce encounters with predators. Overall, these results seem to indicate a low level of interspecific competition between rabbits and cottontails, probably due to the wide availability of food and microhabitats provided by our study area.



## Phylogeographic analysis of *Arvicola* populations in north-eastern Italy reveals an unexpected genetic diversity of water voles

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PO24

The taxonomic status of the water voles of the genus *Arvicola* Lacépède, 1799 have been widely investigated in the last years through morphological and phylogeographic approaches. The case study is interesting either because of the wide Palearctic distribution of genus either for presence of two different ecotypes, fossorial and aquatic.

In literature the presence of three species is reported for the genus in Europe. *Arvicola sapidus* is present in the Iberian Peninsula and in France. The second species, the most widely distributed, is *Arvicola amphibius*, with two distinct mtDNA clades, the first clade has an Euroasiatic distribution (England Germany and Belgium to western Siberia) and the second clade is found in Western Europe (Switzerland, Germany, Scotland and Belgium). The two clades coexist in sympatry in Belgium and Germany. Finally, the Italian population of water voles form a divergent clade and have been recently attributed to a distinct species, *Arvicola italicus* Savi, 1838. From ecological perspective as general output of previous studies, the fossorial/montane voles result not genetically differentiated from the aquatic voles both in *A. italicus* and in *A. amphibius* and therefore the two forms should be considered as “ecotypes”.

We compared 22 new voles samples collected in 14 localities from Northern Italy (Alto Adige and Friuli-Venezia Giulia) to the

97 samples of *Arvicola* (with the exception of *A. sapidus*) available in GenBank and coming from the entire genus distribution, by the means of two mitochondrial markers (cytb and control region) to identify the species and the lineages present in this understudies part of Italy and to investigate the origin of those clades and the effect of postglacial events shaping the nowadays distribution.

All the voles from Alto Adige, belong to the Western European clade of *A. amphibius*, with shallow genetic divergences respect to European haplotypes and clearly divergent from *A. italicus*. The individuals from Friuli-Venezia Giulia resulted to represent a new, separated and well supported lineage of uncertain phylogenetic position. From the taxonomical perspective, the first evidence is that two species of *Arvicola*, i.e. *A. italicus* and *A. amphibius*, are present in Italy and an additional mtDNA lineage, worthy of more detailed study, inhabit Friuli-Venezia Giulia. Furthermore, the comparative analysis show that the Northern lineage of *A. italicus* includes individuals from Switzerland evidencing in this last area the presence of both the two species, *A. italicus* and *A. amphibius*. For this reason, it can be hypothesized a contact area between *A. italicus* and *A. amphibius* extending through Switzerland and Trentino.

## An update on the Italian distribution of the European wildcat

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PO83

The published distribution of the wildcat in Italy includes three main disjoint sub-areas: Apennine ridge (and ecologically connected areas) from Calabria to Romagna, Sicily and the North-East part of the country. In the last years the species has undergone a significant expansion of its range and several detections have been reported in areas where it was absent until a few years ago.

During 2020 and 2021, a project focused on study the activity rhythms of this species was started. The project involved the collection of video-photographic data on the presence of the wildcat in peninsular Italy. Data, coming from various research and monitoring projects (from 2009 to 2022), span from Friuli Venezia Giulia (NE Italy) to the Aspromonte National Park (Calabria Region, S Italy), and are based on camera-trapping, both specifically focused on the European wildcat or focused on other carnivores. European wildcat have been identified using a blind approach by at least three experienced operators who independently analysed the coat pattern of the species following specific literature.

At the same time, a comprehensive, stable national project on the species has been established. The "Italian wildcat project"

builds upon the vast expertise of the National Biodiversity Network, managed by ISPRA for the Ministry of Ecological transition. It has been ideated and it is managed by the Maremma Natural History Museum. The database is made up by the historical dataset of late Prof. Bernardino Ragni, the genetic databank of ISPRA, and includes the sightings provided by institutions, associations and members of the public, through the project website ([www.gattoselvatico.it](http://www.gattoselvatico.it)), in an integrated Citizen Science approach. Data are validated and verified before being uploaded in the national map of the species, following a reliability classification criteria. The inclusion of the data collected by the former project in the "Italian wildcat project" has allowed us to produce a first update of the actual distribution of the species on a national scale. Remarkably, several signs of presence are outside of the formal distribution of the wildcat in Italy. For the realization of the map, we plotted our results, comparing them with the most recently published data ("Data from 3<sup>rd</sup> National Report Italy ex-art. 17 Habitat Directive (92/43/EC), 2013") on a 10×10 km grid. All data were projected on the grid identified by Regulation (EU) No 1089/2010 and INSPIRE Directive 2007/2/EC (ETRS89/LAEA EPGs:3035).

**Bat action plan in Umbria**Spilinga C.<sup>1</sup>, Montioni F.<sup>1</sup>, Ancillotto L.<sup>2,3</sup>, Roscioni F.<sup>3</sup><sup>1</sup>Studio Naturalistico Hyla S.r.l., via Baroncino 11, Tuoro sul Trasimeno (PG)<sup>2</sup>Wildlife Research Unit, Dipartimento di Agraria, Università degli Studi di Napoli Federico II, via Università 100, 80055 Portici (NA)<sup>3</sup>Ecomodel Soc. Coop., via Tiberina 149, 00188, Roma

PO84

Twenty-four bat species are known to occur in Umbria (central Italy), including several species listed in the annex II of the Habitat Directive (e.g., barbastelle, long-fingered bat, and Rhinolophids), and comprising species with “bad” and “decreasing” conservation statuses at the national scale, so that timely actions are urgently needed to secure their populations also at the regional level.

The LIFE19 IPE/IT/000015 project — “Integrated Management and Grant Investments for the N2000 Network in Umbria” — provided the instruments to produce the Action plan for bats in Umbria Region, i.e., the first planning tool for conserving bats at the regional scale for the next ten years (2022–2032).

A first step was to identify the main pressures and threats hampering bat populations in Umbria, by reviewing the available literature on each species’ biology ecology and distribution, as a way to plan and prioritize conservation actions to reduce their negative impacts on bats. Subsequently, we designed the Action Plan with a hierarchical structure, where objectives represent the baseline structure, and each is composed by several concrete actions, according to the overall structure of National Action Plans, i.e. with specific timelines, actors, costs, success indicators, target groups and plan. Five clear and reachable objectives were thus identified, also considering similar efforts conducted in previous years in different administrative regions, e.g. Piedmont and Lombardy. Such five objectives which the present Action Plan is based on, cover different topics and approached related to bat conservation, and namely: 1) general objectives regarding legislation in order to foster collaboration among different stakeholders, as well as a reexamination of plan-

ning and managing administrative tools; 2) defining concrete pilot interventions that may secure species’ conservation in the next decade, e.g. by increasing the availability and suitability of roosts and drinking sites; 3) implementing an integrated monitoring network aiming at an ameliorated knowledge on species’ regional distributions, as well as providing essential tools for epidemiological surveillance and coordinated data collection; 4) education and involvement of different stakeholders that cover key roles in landscape management and, as a consequence, on bat conservation on large scales, e.g. forestry and agricultural managers; 5) public involvement of citizens in bat monitoring and conservation activities, with a special focus on schools and on the organization of events such as bat nights.

Each objective of the Action Plan includes several specific actions (n=29), aiming at either i) protecting individual bats and colonies (e.g., by managing known roosts and identifying new potential ones), ii) conserving the suitable ecological conditions of bat habitats, and iii) restore such conditions wherever these have been modified by anthropogenic activities, with a special focus on forest habitats and agroecosystems.

As a last yet fundamental step, the Action Plan includes the production of Guidelines and Good practices recommendations for managing bat habitats.

This Action Plan represents the first systematic effort for Umbria to plan and implement a coordinated conservation strategy for bats, and one of the few produced to date in our Country, thus possibly providing an effective model to be applied in other contexts.

## On the way back home: predicting the natural expansion of the otter in north-eastern Italy using habitat suitability models

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The Eurasian otter (*Lutra lutra*) was once spread throughout Italy, but during the late '900 Century the species gone extinct from all the north and central Regions, mainly due to river pollution, habitat loss and poaching. In recent years, the legal protection of the species as well as habitats in which it lives, allowed a recovery in Europe. Nowadays the otter is classified as "Near Threatened" by the International Union for the Conservation of Nature (IUCN). In NE Italy, the neighbouring Austrian and Slovenian population are increasing, thus allowing the natural expansion in Friuli Venezia Giulia (hereafter, FVG) and other Italian Regions. In FVG, the presence of otters is confirmed in the Alps and Pre-Alps till 2011, and after about 50 years of absence also in the Friulian plain. Using presence-only data obtained from the species monitoring, a Habitat Suitability Model (HSM) was developed to understand which factors mostly affect the presence of the species and, consequently, predict the species' expansion. Considering the increase of neighbouring populations, identifying the ways of expansion used by the species assumes remarkable importance. We would expect that both the Alps and Pre-Alps are the most suitable areas for the species' expansion because of the presence of natural areas. Conversely, lowlands are expected to be less suitable as a consequence of the high anthropic pressure.

To calibrate the HSM for our study area, we used MaxEnt algorithm with presence-only data obtained from systematic surveys conducted between September 2020 and March 2022, as well as opportunistic data. During the surveys, the FVG Region was divided into 113 10×10 km grid cells, and within 53 cells the bridge survey was conducted, searching for signs of presence under four bridges in each cell (on average). Moreover, in 23 grid cells, four transects of 100 or 500 m were conducted for each side of the riverbanks, starting from the surveyed bridge. To avoid model overfitting, the presence-only data were spatially thinned using the `spThin` R package (R Software, v. 4.1), considering a minimum distance of 0.5 km. Considering the species' ecological needs, seven covariates within a 200 m buffer around rivers were used to build the model: land cover; fish communities, using data from surveys and the suitability map for FVG; water quality of the rivers, considering the biological and physiochemical and chemical quality elements; Strahler order, indicating the hierarchy of tributaries; slope of riparian areas; elevation; human population density. The correlation between covariates was assessed through the Variance Inflation Factor (VIF). Covariates were represented as 100 m raster layers. To find the best settings configuration, we tested for different regularization values and feature classes using `ENMeval` R package, resulting in 48 model combinations. We used "checkerboard2" as a partitioning method and sampled 10000 background points. The model with the lowest Akaike Information Criterion corrected for small sample sizes (AICc) value was considered as

the best model and evaluated through the Area Under the Curve (AUC).

From bridge and transect surveys 75 and 69 signs of presence were collected, respectively, mainly spraints (number of spraints: 68 and 55, respectively). Moreover, 39 signs of presence were opportunistically sampled. Overall, 183 signs of presence were collected. Most of these were collected in the Julian Alps (n=90), bordering with Austria and Slovenia, as well as in the morainic hills (n=45). Secondarily, in the Julian Pre-Alps (n=27) and in the eastern part of the Friulian plain (n=14), along the border with Slovenia. As for the covariates, the VIF values were all <5. Therefore, none of these were discarded. The best model had a regularization multiplier set to four, included linear + quadratic + hinge + product feature classes and showed predictive performance based on the AUC (0.828, var=0.004). The covariates with the highest percent contribution to the model were the slope of riparian areas (36.36%), land cover (24.58%), elevation (21.37%) and fish communities (8.86%). The remaining covariates together contributed to less than 10%, with the human population density which did not produced any contribution. The mountain area revealed as suitable (n=44, cells with suitable areas), due to the presence of natural land cover and steep riverbanks. These findings match those reported in other studies realized in Southern Italy. The HSM indicates the upper and medium course of the rivers of the Friulian Alps and Pre-Alps as the most suitable. Some of these, are already inhabited by otters, such as in the Julian area where, as reported in a recent study, a reproductive nucleus is established. Individuals were also reported in the Carnic area, but during our survey no signs of presence were collected, except for a road-killed juvenile. For what concerns the hilly areas, most of the suitable areas (n = 10) include the morainic hills, which are already occupied by otters. However, also a nearby river basin could be considered as attractive because of the presence of fish communities and suitable land cover. In the upper plain there are no natural rivers with constant flow, whereas in the lowland plain there are only three suitable rivers inside n=6 cells, even if an historical colonization was reported, when the area was mainly composed by wetlands. Nevertheless, the landscape has changed since the otter disappeared in the area 50 years ago, mainly as a consequence of urbanization. In this context, the recent colonization of the lowlands bordering with Slovenia (within which the otter population is reported as in expansion) could drive the recolonization of the low plain from its eastern part. To conclude, our model showed that in FVG there are suitable areas for the species, but mainly concentrated in the mountainous areas, where the anthropic pressure is lower. Conversely, in lowlands, suitable areas are scanty. Therefore, there is a lot to be done to encourage the otter expansion.

P085

## An update on the distribution of the common genet in north-western Italy

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P087

The common genet (*Genetta genetta*) is a medium-sized nocturnal carnivore belonging to the family Viverridae. It is found over much of Africa, a few parts of the Arabian Peninsula and as part of an introduced population in south-western Europe. Since its probable introduction from North Africa, the common genet has expanded into south of Europe: stable genet populations can be found throughout the Iberian Peninsula, south-western France, and very recently the species has been observed quite regularly in north-western Italy. It is a generalist species: is very adaptable to different habitats and has few strict ecological requirements, although is scarce or even absent in high mountain areas and it does prefer areas with dense vegetation cover. The objectives of our study were to i) update the distribution and ii) evaluate the potential range expansion of the species across an area of recent occurrence located in coastal north-western Italy.

The study area encompassed western Imperia province within the Liguria region and covered a total surface of 274 km<sup>2</sup>. To investigate the potential range expansion of the common genet, we statistically compared the environmental characteristics of locations used by the species with those of random locations using the algorithm MaxEnt. To overcome the sampling bias, we produced a probability density map using a kernel density estimator based on the occurrence locations and we used this bias map to generate the pseudo-absence locations. We considered 12 variables to model species expansion corresponding to 9 land-use variables expressed as % cover (urban areas, permanent crops [mainly vineyards and olive groves], sclerophyllous vegetation, broad-leaved woodlands, mixed woodlands, coniferous woodlands, shrublands, transitional woodland-shrub, meadows) and 3 orographic variables (elevation, slope and exposure). We selected the most important uncorrelated variables and adjusted the MaxEnt regularization parameter by running multiple combinations of uncorrelated variables for each regularization setting. We set the variable contribution threshold 5%, the Pearson's correlation coefficient  $r < 0.7$ , and tested regularization values ( $\beta$  multiplier) from 1 to 6 at increments of 0.5. We selected the best performing models based on the lowest AICc. To obtain robust model, we used 10 replicate bootstrap proce-

dures and we limited the type of species-variable relationships to linear and quadratic to avoid overfitting. Model performance was measured by the area under the receiver operating characteristic curve (AUC). We produced predictive maps of the potential distribution of the species using the logistic output format and, to calculate species potential range, we reclassified it into a binary map (suitable vs. unsuitable) adopting as threshold the maximum training sensitivity plus specificity value.

Occurrence data of the common genet within the study area were mostly collected as occasional data either during the samplings of other wildlife species or as stochastic sightings; no specific monitoring project was carried out, but few independent and scattered small-scale sampling attempts, using camera-trapping, were performed during the last decade. The used georeferenced dataset counted 21 observations recorded from 2007 to 2022 and included direct observations (n=7), camera-trapping events (n=12) and carcasses (n=2). The model with the lowest AICc describing common genet suitability used a  $\beta$  multiplier = 1 and it included 5 uncorrelated variables with a contribution >5%, which were broad-leaved woodlands, mixed woodlands, permanent crops, sclerophyllous vegetation, and transitional woodland-shrub. The receiver operating characteristic (ROC) curve averaged over the 10 replicate runs was  $0.783 \pm 0.035$  (SD), indicating that the model predictions were better than chance (AUC=0.5) and the model could be used to predict common genet potential distribution within the study area. The suitable area for the common genet was 102 km<sup>2</sup>, indicating that few environmental factors may limit species expansion.

The Ligurian Alps, the mountain range bordering Piedmont in the north and Liguria in the south, may represent an environmental suitable narrow corridor supporting common genet expansion in Italy; widespread dense vegetation cover and climate may favour the process, although it currently appears quite limited, considering collected occurrence data, and slow. On the one hand the elusive behaviour of the species may hinder its detection, on the other hand the low population densities in the area would require a specific and massive sampling effort.

## Preliminary results on microhabitat variables influencing the sett-site choice of the Eurasian badger in north-western Italy

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PO88

The Eurasian badger (*Meles meles*) is a semi-fossorial species, spending daylight hours underground. The species is considered unusual amongst carnivores: despite being solitary foragers, badgers can form stable social groups of mixed age and sex whose members share a territory and occupy a communal diurnal resting site: the sett. Setts are used for breeding and as sleeping places and refuges.

Little is known about the environmental characteristics driving the sett-site choice at a fine-scale; many examples among carnivores showed that different species tend to construct dens in locations that can be predicted from topography, pedology, aspect and habitat characteristics.

The aim of our study is to find out which are the main environmental determinant factors driving the locations of badgers' setts.

The collection of data was carried out in seven different study areas located in north-western Italy (extent of the study areas: from 18 to 27 km<sup>2</sup>), which are very different from the environmental perspective. These areas are: A) "Triangolo Lariano" (CO – LC); B) "Boschi Negri e Moriano" (Natural Park of the Ticino Valley, PV); C) "Basso Monferrato" (Natural Park of the Po River, AL) D) "Riserva Naturale Torrente Orba" (AL); E) "Colline dell'Oltrepò Pavese" (PV – PC); F) "Val Tidone" (PV – PC); G) "Alta Valle Staffora" (PV – PC). Two study areas (A and G) are characterized by a predominant natural landscape with abundant woodlands. The other two study areas (B and F) are characterized by a mixed landscape with an alternation of woodland and cultivated patches. Finally, the last three study sites (C, D, E) are characterized by a predominant agricultural landscape with few patches of woodland.

In every study area, badger presence was investigated through non-invasive techniques, i.e. detection of species signs of presence along random itineraries, which were walked searching for badger scats and prints, and camera-trapping. Based on collected presence data, we searched for setts; we only considered active setts (i.e. used at the moment of the survey) discarding

abandoned ones. We collected data related to the size of the setts and we measured different variables related to the microhabitat of the site (i.e. light intensity, soil temperature, shading, distance to water, humus cover, herbaceous cover, shrub cover, slope and aspect) within a circular plot of 5 m radius centred on the sett. We measured the same variables in an equal-size control plot at a distance of 100 m from the sett. We compared sett- and control-plots using paired samples Wilcoxon test.

We located and investigated 35 occupied badger setts. They varied considerably in size, ranging from simple single-entrance burrows to complex tunnel systems with multiple entrances and, presumably, underground chambers. Interestingly, in agricultural landscapes (study areas: C, D, E) man-made embankments were particularly important sett sites and partially underground cement pipes were often used as tunnels and entrances for setts. Among considered variables related to the microhabitat, only two resulted significantly different between sett- and control-plots: soil temperature ( $W=392.5$ ,  $p=0.005$ ) and shrub cover ( $W=345$ ,  $p=0.021$ ). We observed a much warmer soil temperature within the sett plots compared to the control plots and, similarly, a higher foliage cover, pertaining to shrubs, within the sett plots compared to the control plots.

Soil is a particularly important variable for a semi-fossorial species able to rest underground for, on average, half of the day each day. Underground temperature may be influenced by soil type, aspect, and vegetation cover; moreover, because endothermic mammals dissipate heat into their environments, burrow systems can warm up due to occupancy by animals. Thus, both abiotic and biotic factors can explain our results related to soil temperature.

Interestingly, despite the differences among the study areas, the foliage cover of shrubs represents an important variable describing the microhabitat surrounding badger setts. Dense shrubs offer shelter and cover, which are essential characteristic for a sett, and abundant wild fruits (i.e. brambles and blackthorns), a seasonally important food category for badgers.

**Living on the edge: morphology and personality of red squirrels in marginal habitat**Tranquillo C.<sup>1</sup>, Wauters L.A.<sup>1,2</sup>, Santicchia F.<sup>1</sup>, Preatoni D.G.<sup>1</sup>, Martinoli Ad.<sup>1</sup><sup>1</sup>Unità di Analisi e Gestione delle Risorse Ambientali – *Guido Tosi Research Group*, Department of Theoretical and Applied Sciences, Università degli Studi dell'Insubria, via J.-H. Dunant 3, 21100 Varese, Italy<sup>2</sup>Evolutionary Ecology Group, Department of Biology, University of Antwerp, Campus Drie Eiken Universiteitsplein 1, 2610 Wilrijk, Belgium

P095

Local environmental conditions, that characterize a specific habitat, can influence both personality and morphology of individuals, which can result in phenotypic differences among populations living in different areas. For instance, the extreme environmental conditions of a marginal habitat on the edge of a species' distribution, can exert selective pressure on body size and personality, but also on behavioral plasticity of mammals. Therefore, in this study, we predicted smaller phenotypes with a lower body mass in marginal habitat; with higher levels of active and explorative personality traits, and a more pronounced behavioral plasticity, that should be better adapted to the more extreme conditions in a low-quality habitat.

We studied three populations of Eurasian red squirrels (*Sciurus vulgaris*) in alpine study areas characterized by different elevations and habitat quality (average seed-crop size and annual fluctuations in seed production): Cancano was the marginal edge-habitat; Bormio and Valfurva were the higher-quality areas. To test our predictions, we measured body weight and right hind foot length of squirrels trapped during Capture-Mark-Recapture sessions and performed arena tests (Open Field Test, OFT followed by Mirror Image Stimulation test, MIS) to study personality traits. We applied the expert-based approach to obtain scores of activity and exploration from OFT, activity-exploration and social tendency from MIS. Furthermore, we calculated the among-individual and the within-individual variances and the estimates of the correlations among the behavioral traits for each study area.

We found that morphological traits changed with areas in male

squirrels, that were smaller and lighter in the edge habitat, a relationship that was less marked among females. Also personality was different in squirrels living in the edge, which showed higher activity, exploration and sociability scores, than individuals in higher-quality habitats. However, we found smaller behavioral plasticity in the marginal habitat, but only for the trait exploration. Furthermore, our data suggest the presence of a behavioral syndrome, more active individuals were also more explorative and social.

Sex-specific morphological patterns suggest differential selective pressures for males and females in the marginal habitat than in the populations in the other areas; smaller and lighter males have an advantage in Cancano, probably due to their lower energy requirements, while females' pattern was affected by a strong association between body mass and reproductive success. In accordance with previous studies, the non-random distribution of individuals' personality traits between heterogeneous areas suggests an individual's choice of the habitat that best fits its personality, in our case squirrels that settled in the marginal poor-quality habitat were more active and explorative, probably due to the advantage that these traits confer in acquiring resources. Moreover, in contrast to our predictions, the among- and within-individual variance in personality traits documented here suggest that behavioral plasticity was not strongly associated with habitat selection. This study provides information about the role of personality in habitat selection, and how variation in habitat quality can shape morphological adaptations.

## Wild rabbit (*Oryctolagus cuniculus*), density estimation in 14 hunting areas of Sicily through pellet count technique

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P089

**Introduction** – The wild rabbit, *Oryctolagus cuniculus* (Linnaeus 1758), has been introduced in Sicily in ancient times. Perfectly integrated in the complex Mediterranean ecosystem of the island, it represents an important game species and a trophic resource for threatened predators like Bonelli's eagle (*Aquila fasciata*), Golden eagle (*Aquila chrysaetos*) and Wild cat (*Felis silvestris*). Mainly due to viral diseases (Mixomatosis, RHD and RHD2), in the last decades, Sicilian wild rabbit population underwent a reduction in terms of numbers and distribution. Despite its high importance, only few surveys about wild rabbit's biology and ecology have been carried out in specific Sicilian areas and only when the species was well preserved.

In 2019, Sicily Region has set up a Monitoring Plan to investigate about actual wild rabbits preservation conditions in Sicily's Hunting areas (ATC). In collaboration with Sicilian hunters associations (FIDC, ecc), 14 (PA1, PA2, TP1, TP2, AG1, AG2, CL1, CL2, ME1, ME2, CT1, CT2, RG1 e RG2) of the 18 ATC present in Sicily, were monitored with the faecal pellet count method.

**Methods** – The survey area was divided into cells (100 ha of surface each one), by overlaying a grid UTM WGS84 with a kilometre mesh. For each ATC were randomly extracted 10% of the cells and within each one were chosen 5 sample stations (1 sq m surface area). Counting the number of faecal pellets piled up in a given time frame (about 28 days) and supposing the

average daily defecation rate, by applying the Eberhardt and Van Etten algorithm (1956), it was possible to estimate the number of individuals in each surveyed cell and the density.

**Results** – A total of 881 cells and 4405 sample stations were identified within the 14 investigated ATC. Samplings have been carried out between July 28<sup>th</sup> and September 10<sup>th</sup> 2019. The average density of wild rabbits was 7.2 individuals/ha ( $\pm$  s.e. 1.16). The lowest value, equal to 2.33 individuals/ha ( $\pm$  s.e. 0.75), was observed in the ATC TP1 (Province of Trapani) and the highest one, 19.36 individuals/ha ( $\pm$  s.e. 5.63), in the ATC AG1 (Province of Agrigento).

**Results** – The obtained results show that wild rabbits density is variable within the different investigated ATC; in some areas the species is well represented, in others not. The average density seems to be higher compared to previous values obtained, with the same methodology, in protected and hunting areas. This first analysis shows a good distribution of the species across all the investigated territory, with some gaps linked to local extinctions. Single density values of each area are acceptable. The detected differences highlight an inflection of population's abundance, potentially attributable to endemic viral pathologies. Given the ecological and socio-economic importance of the wild rabbit, it is appropriate to continue the Regional-scale monitoring activity over time. This will allow to acquire sufficient data to set up a management strategy of the species that aims at its conservation.



## Morphological and genetic analyses of the historical and contemporary Italian wolf (*Canis lupus italicus*) populations

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PO91

The Italian wolf (*Canis lupus italicus* Altobello, 1921) has been recently recognized as a distinct subspecies due to its unique morphological and genetic features. After experiencing a severe demographic decline over the last centuries, the subspecies started to naturally recover in the 1980s, thanks to legal protection, favourable ecological conditions and its environmental adaptability, recolonizing most of its historical range. However, though a number of conservation projects investigated ecological, genetic and demographic aspects of this subspecies, an exhaustive formal description of its distinctive morphological traits, as well as a detailed comparison of contemporary and historical samples to shed light on the origin of its variability, still lack.

Therefore, we morphologically and genetically analyzed historical and contemporary wolf samples collected from the first period after the bottleneck during the 90s until now. Then, we also tested the applicability of the innovative ancient DNA extraction method from the petrous bone (pars petrosa) in the individual multilocus genotyping of canid samples. We extracted DNA from 49 muscular tissues and 9 petrous fragments, belonging to 58 found-dead individuals collected from 1993 to 2000 in the Apennine ranges. DNA samples were genotyped using 500 bp of the mitochondrial DNA Control Region (distinctive of private Italian haplotypes), 12 unlinked autosomal microsatellites STRs (diagnostic between wolves and dogs), the Amelogenine gene (to sex individuals), four linked STRs located on Y chromosome (paternal haplotypes), and the K-locus marker on CBD103 gene (diagnostic for the coat colour). Among these 58 historical individuals, 41 skulls were measured using 17 craniometrical parameters, and 20 skins were observed for 8 phenotypic traits diagnostic also for possible wolf-dog hybridization (hind spurs, white nails, vertical bars on front legs). Moreover, to compare the genetic variability between historical and contemporary wolf

populations, we selected 59 individuals collected from the Apennine range from 2000 until now and genetically analysed using the same markers. Genetic variability estimates (Ho, He, Na, Ne, A, P), Bayesian individual assignment and Principal Component Analysis (PCA) were performed using both genetic and morphological data together with references dog and European wolf genotypes to verify historical sample origin and genetic status.

The observed genetic variability not resulted significantly different between historical and modern wolves both to autosomal and uniparental markers. All the genotyped individuals were assigned to the Italian wolf population except one sample which resulted belonging to the Dinaric population. Only 5.3% of genotypes displayed ancient dog signals. DNA extracted from petrous bone showed a very good quality, comparable to fresh muscle tissues, showing no genotyping errors. The craniometrical PCA confirmed *Canis lupus italicus* as a distinct subspecies, whereas skin visual inspections allowed us to identify only one sample showing phenotypic anomalies reflecting possible past anthropogenic hybridization or admixture with other wolf populations.

Our results show that the genetic variability of the Italian wolf has remained similar since 1990, suggesting no contribution from other wolf populations or from the domestic counterpart. Future morphological and genetic analyses of museum samples collected before the last bottleneck, and the possibility to extract good quality DNA from the petrous bone, could allow to perform genotype/phenotype association studies, investigate the effect of natural selection and detect ancient anthropogenic hybridization signals, contributing to shed light on the evolutionary history of the Italian wolf.

## Ethanol versus swabs: what is a better tool to preserve faecal samples for non-invasive genetic analyses?

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PO92

Faecal non-invasive genetic sampling is one of the most practicable, ethical and applied tools to investigate the biology and the ecology of elusive or endangered mammal populations. However, the reliability, accuracy and effectiveness of this technique may be deeply conditioned by several factors such as climate, habitat characteristics, seasonality, sample freshness and storage conditions. In this study, we compared the practicality, efficiency, safety and cost-effectiveness of two preservation methods widely applied to collect and preserve wolf excremental DNA: scats in 96% ethanol and faecal swabs in ATL lysis buffer, to be genotyped in non-invasive monitoring projects. Forty-six wolf faecal samples were collected using both storage methods in three different areas of the Central- Northern Italy during two seasonal (cold and hot) periods and their DNAs were genotyped

at 12 unlinked autosomal microsatellites through a multiple-tube approach. Genotyping performances and error rates obtained from the two methods resulted not significantly different. Nonetheless, faecal swabs showed to be more practical, safer and cost-effective than ethanol for the collection and analysis of faecal samples.

Our study, though conducted on a limited sample size, suggests that faecal swabs could represent a reliable alternative tool to routinely apply in non-invasive genetic projects to monitor the presence, distribution and dynamics of populations of elusive and endangered mammal species such as the Italian wolf, still threatened by illegal poaching, hybridization and conflicts with human activities.

## Reproduction of the Eurasian beaver in Central Italy

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PO94

The Eurasian beaver *Castor fiber* is reconquering its original European extent of occurrence by means of official and unofficial reintroductions. This species was present until about 1500 in Italy, with populations occurring at least in Northern and Central regions. Afterwards, the species went extinct because of hunting, habitat loss, and demand for castoreum.

In October 2018, a male Eurasian beaver was identified in the municipality of Tarvisio (province of Udine, northern Italy), as a result of natural dispersal from Austria. In November 2020, another individual has been recorded through camera-trapping in Val Pusteria (in the surroundings of Sesto Pusteria, province of Bolzano), near the Austrian border, where the last record of this species dated back to 1594 (Versciaco di Sopra, province of Bolzano).

In early 2021, several unequivocal signs of beaver presence (i.e. deeply debarked trees of *Salix alba* L. and *Populus* spp.) were

observed in Tuscany and in Umbria, in two river basins, 500 km far from the native known distribution of this species. The former site (Ombrone-Merse basin) included the municipalities of Civitella-Paganico, Murlo, Monticiano, and Montalcino (provinces of Grosseto and Siena), whereas the latter (Tevere river basin) ranges from Anghiari and Sansepolcro (province of Arezzo) to Southern Umbria (provinces of Perugia and Terni). The UK Beaver Trust financed a 1-year project, namely "Rivers with Beavers", whose main aim is to collect presence signs throughout Tuscany and Umbria to infer the local population size. Camera-traps were placed throughout the river basins to assess the presence of this large rodent. We confirmed the presence of juvenile individuals and females with evident nipples in both study areas. These evidences suggested that at least one reproductive event per year (2021 and 2022) have occurred in both river basins.

## Toward the harmonization of wildlife population monitoring and disease health surveillance



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PO96

The European Food Safety Authority (EFSA) recognized the need to improve and potentiate the systems of wildlife population monitoring and to develop standards for the collection and validation of wildlife population data. To effectively manage the emergence of zoonotic pathogens deriving from wildlife, or for the management of enzootic pathologies common to domestic and wild animals, the knowledge of the numerical consistency of wild populations, their territorial distribution, and temporal trends (numerical and geographic distribution) have become fundamental. European authorities recognized that wildlife health must be managed at a higher level by including, in addition to active and passive surveillance, also consistency values (abundance and density) and distribution of animal populations. This integrated system of epidemiological and demographic data constitutes a new health surveillance system composed of a “numerator” (number of infected individuals) and a “denominator” (population size). The Enetwild Consortium ([www.enetwild.com](http://www.enetwild.com)), is a network of wildlife professionals that work together, on EFSA’s mandate, to provide the basis for integrated wildlife health monitoring. To respond to the African Swine Fever (ASF) outbreak, which has been involving Europe and Asia since 2007, Enetwild has focused its attention primarily on the collection of wild boar abundance and distribution data, as on other groups of sensitive species such as ungulates and carnivores. The project has set up the standards of harmonized data collection in Europe by (i) building the inventory of available data through direct contact with local/national stakeholders in EU and non-EU European Countries, (ii) developing a data collection model

(standards), (iii) data collection through the network and collaborators, and (iv) integration in a common database. To fill the gaps in data availability, Citizen Science tools have also been developed and promoted ([www.mammalnet.net](http://www.mammalnet.net)). Mobile-phone applications, camera-trap interfaces, and platforms have been developed and are currently fully operative to promote citizens’ involvement and to extend data collection. These tools have been particularly helpful in ASF-affected areas (i.e. Balkans) to report wild boar carcasses and to promote timely carcass testing and removal. To make the harmonization and collaboration effort implemented by Enetwild permanent, the first European Observatory for Wildlife ([www.wildlifeobservatory.org](http://www.wildlifeobservatory.org)) has been recently established. Overall, Enetwild and the European Observatory for Wildlife have produced a number of tools and resources available to public veterinary and health authorities, as well as to wildlife managers that can be used for population and health management: i) standards for harmonized high-quality data collection, ii) density models for wild boar at a continental scale based on hunting-bag data iii) validated methods for density estimation of wildlife through camera-trapping and iv) tools for citizen science data collection. Mapping specific wildlife/livestock interfaces at a European scale is also among the next steps. Wildlife health surveillance is moving toward shared management at the European level. Enetwild provided a number of tools and a functioning network of professionals to implement an integrated approach to demographic and epidemiological wildlife data.

**Epidemiological insights on tick-borne parasites in Alpine marmots *Marmota marmota***Zanet S.<sup>1</sup>, Mochettaz G.<sup>1</sup>, Ferrari C.<sup>2</sup>, Bassano B.<sup>2</sup>, Ferroglio E.<sup>1</sup><sup>1</sup>Dept. of Veterinary Sciences, University of Torino, largo Braccini 2, 10095 Grugliasco (TO), Italy<sup>2</sup>Gran Paradiso National Park, Valsavarenche (AO), Italy

P036

Ticks and tick-borne pathogens (TBPs) are emerging worldwide as veterinary and human pathogens. The incidence of many tick-borne diseases has increased in Europe and in temperate regions. The territorial expansion in previously tick-free areas and the increase in incidence are mainly attributable to anthropic and biotic factors. On a global scale, the increase in winter minimum temperature allows ticks to overwinter and colonize previously unsuitable areas, resulting in an expanded range at higher latitudes and elevations. Understanding TBP dynamics in Alpine marmots *Marmota marmota* is a unique opportunity to understand the susceptibility and adaptation of a species to emerging pathogens of different etiology (protozoa, bacteria, and rickettsiae) and to assess how circulating strains in domestic livestock grazing on shared pastures might overlap with TBPs found to infect marmots.

Within a long-running project on Alpine marmot ecology in the protected area of Gran Paradiso National Park (Italy), a sample of whole blood was collected from 47 marmots captured in 2018 and 2019, in parallel from a herd of 21 cattle and 9 goats which graze on the same pastures during the summer months. All animals were tested by means of end-point PCR to establish the prevalence of infection with *Babesia/Theileria* spp. (ITS hypervariable region V4), *Anaplasma phagocytophilum* (16SrDNA), *Rickettsia* of the Spotted fever Group (OmpA) and *Borrelia burgdorferi* s.l. (23S rDNA). All positive samples were sequenced and results were compared to those available in

Genbank using MegaX. The environmental presence of questing Ixodidae ticks was assessed by dragging, repeated monthly along an altitudinal gradient ranging from 1500 to 2500 mt a.s.l. between April and October 2019.

In marmots, *Babesia* spp. was detected with a prevalence P=6.38% (95% CI 2.19–17.16%). All positive marmots belonged to family groups whose territories are close to forest and shrubs areas which are more suitable for Ixodidae presence. Sequencing allowed establishing the presence of *B. divergens* in one marmot which is among the main agents of bovine and human babesiosis in Europe. Marmots were negative for the other target TBPs while livestock showed higher prevalence of infection. DNA of *Babesia/Theileria* spp. was detected in 5 cattle and 1 goat respectively (P=23.81; 95% CI 10.63–45.09% and P=11.11%; 95% CI 1.99–43.50%), while *Anaplasma* spp. was detected with an overall prevalence of 50.00% (95% CI 33.15–66.85%). All tested domestic animals were negative for SFG *Rickettsia* (P=0.00%; 95% CI 0.00–11.35%) and 1 goat tested positive for *Borrelia burgdorferi* s.l. (P=11.11%; 95% CI 1.99–43.50%). To our best knowledge, this is the first report of tick-borne parasites in *M. marmota*. The prevalence of infection with TBPs is still a limited phenomenon in these mountain-dwelling rodents, but increasing presence of Ixodidae ticks must be carefully monitored to assess how environmental changes will affect the burden of disease in this species, which has previous limited to none, contact with TBPs.

**Could the availability of small mammals be an indicator of a shortage of vipers? First studies in Alpine pastures**

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P097

Small mammals are among the most important prey of vipers and represent in terms of biomass, diversity and nutritional value a fundamental element for the structure of predatory relationships in alpine pastures. In the framework of the studies in progress on the ecology of *Vipera berus* in the alpine environment, the availability of small prey mammals in high altitude grazing environments and their value as elective prey for the snake has been studied. At an altitude of 2147 m asl, in Malga Cercen Alta (46.389° N; 10.741° E), we looked for snakes in a typically alpine environment, with overgrazed pastures on low slopes at southern aspect. A total of 63 traps (Sherman and Multi-Capture Traps) were positioned in the pastures in transects at the sites where the vipers were found. 252 night traps have been made in this area. Then, to verify the availability of small mammals in similar environments but in non-grazed areas, we repeated the trapping method in two different areas: one just below Malga Cercen Alta, at the boundary between forest and grassland, at an altitude of 1850 m asl, and another on the right side of Val di Sole, nearby Malga Pozze (46.354° N; 10.759° E), at an altitude

of 2200 m asl. In the first site we used the same traps-set used in Malga Cercen Alta, with 126 night traps, while in the second one we used 61 traps (Sherman and Multi-Capture Traps for 122 night traps). The catches in the overgrazed area have been just 2 (1 *Myodes glareolus* and 1 *Apodemus flavicollis*), while in the lower altitude and non-grazed sites they were significantly higher, with a total number of 28 captures (7 around Malga Pozze and 21 on the forestry edge below Malga Cercen Alta). Even the diversity of species recorded in these 2 areas has been richer, with 3 species on both (*Myodes glareolus*, *Sorex antinorii* and *Apodemus flavicollis* nearby Malga Pozze; *Myodes glareolus*, *Sorex antinorii* and *Neomys fodiens* at the other site). The scarce presence of vipers recorded therefore appears strongly conditioned not only by grazing and by a considerable pressure of trampling and modification of the meadows by livestock, but also by how these actions drastically reduce the diversity and biomass of prey. The study will continue to evaluate communities of small mammals and their role as prey in other grazed and non-grazed systems.

**First telemetry evidences of the effects of aversive conditioning on wolves in Italy**Zanni M.<sup>1</sup>, Berzi D.<sup>1</sup>, Calderola S.<sup>2</sup>, Luccarini S.<sup>1</sup>, Costanzi L.<sup>1</sup>, Dartora F.<sup>1</sup>, Brivio F.<sup>1</sup>, Apollonio M.<sup>1</sup><sup>1</sup>Department of Veterinary Medicine, University of Sassari, via Vienna 2, 07100 Sassari, Italy<sup>2</sup>Regione Veneto, Direzione Agroambiente, programmazione e gestione ittica e faunistico venatoria, via Torino 110, 30172 Mestre (Venezia), Italy

P099

To our knowledge, there are many information gaps about wolves coexisting with humans in human-dominated landscapes, particularly in Italy. Predation by wolves (*Canis lupus*) of human-reared species is one of the main problems for the conservation of the species because of the persecution that this impact triggers. Therefore, the resolution or mitigation of these conflicts is a necessary condition to ensure the long-term survival of the species where the conflict is high. In Italy, the Veneto Prealps represents a critical territory for the development of strong conflicts due to the predation by recently established wolf packs on grazing livestock. With the goal of addressing this situation, we used fine-scale satellite telemetry to proactively monitor wolf spatial behaviour in this context and to test innovative technological devices to prevent conflicts.

Between 2019 and 2021, we captured 6 wolves using a foothold trap (Fremont™ Humane Foot Snare Wolf/Cougar 1/8 7×7 and Fremont™ Humane Foot Snare Fox/Coyote 3/32 7×7) and fitted 5 of them with GPS collars (VERTEX Plus Vecronic Aerospace GmbH).

During summer of 2021, one of the monitored wolves became particularly bold towards a transhumant shepherd in the alpine pasture. In 32 days, we have documented 18 guarded flock approaches. On this animal it was decided to perform an aversive conditioning (AC) intervention using rubber bullets (12 gauge). By analysing the intensive GPS data with the use of QGIS and R programs, the spatial and predatory behaviour before and after the AC event was studied.

Our study revealed that after just a single AC event, the wolf evidently changed its behaviour. By exploiting the unique fine resolution and detailed location data available before and after the AC event, along with careful retrospective field investigation, we demonstrated that the wolf increased its movements, changed its use of space by increasing its distance from humans, and decreased predation attempts on livestock.

This experience represents the first case in Italy of AC and of monitoring its effects of by GPS telemetry. Our results are similar to management experiences conducted in United States, where in 81% of AC cases with rubber bullets on wolves revealed successful in solving problems of wolves' habituation to man. Furthermore, in our case study, the effect appears to have lasted for the entire observation period, i.e., approximately 60 days, unlike what seen in other large carnivores such as bears.

The study of these behaviours, in similar contexts is complex due to several difficulties associated with data collection (e.g., very elusive animals, highly variable environmental conditions, effects of variables difficult to predict). Probably for this reason, the literature on similar case studies is almost absent. This study represents a first step on increasing knowledge on the effect of AC on the wolf, useful for comparison with other future studies that are warmly recommended. In particular, we encourage other researcher to conduct and publish similar studies with management purposes, in order to provide a useful and widely tested tools for administrations and operators involved in wildlife management in human-dominated landscapes.



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