
**abstract
book**



EHRG

PRAGUE 2022

9th meeting of European Hedgehog Research Group

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edited by: Barbora Černá Bolfíková

Partners



Organizing committee

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Foreword

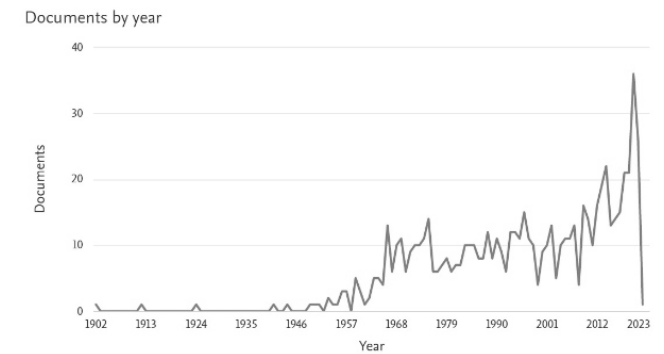
The analysis of search results in databases of scholarly literature indicates a substantial rise in the number of scientific papers focused on hedgehogs in the last decade, compared to the previous fifty years. Apart from a general intensification of the publication process, this trend also mirrors the establishment and rising popularity of hedgehogs as model organisms in several fields of biology. In the recent era of “omics” biology, there is an increasing number of genomic and molecular biology focused papers on hedgehogs, whereas traditionally, these hibernating insectivores rather attracted the attention of physiologists. The role of hedgehogs in the transmission of zoonotic diseases has also raised increasing attention from veterinary scientists. The climatic envelope of these medium-sized mammals is the basis for their sensitivity to climate fluctuations and is related to their model status in Pleistocene phylogeography and speciation research. And last but not least, the hedgehog, as synanthropic and synurbic mammals, also attracts the attention of ecology and environmental sciences.

Parallel to the spinoff in primary research, there is also a rising turnover of hedgehogs in European rescue centres. This trend mirrors the increasing changes in human-dominated landscapes in the Great Acceleration period of the Anthropocene. Of course, primary research and conservation effort

facilitate each other. Population management is not possible without detailed knowledge of the respective species. On the other hand, obtaining relevant evolutionary interpretations and providing ultimate context of biological data is unfeasible without healthy animal populations.

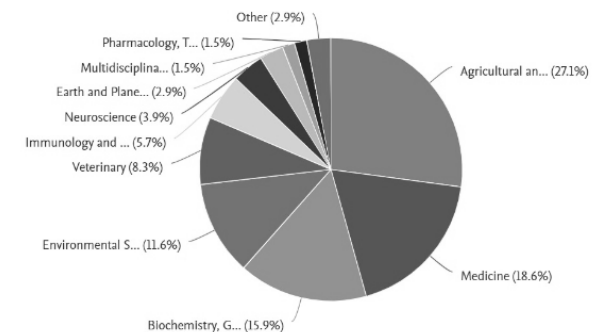
The European Hedgehog Research Group (EHRG) is a key platform integrating the efforts of researchers and wildlife conservationists interested in hedgehogs. After workshops held in Wageningen (Netherlands), Münster (Germany), Gemmano (Italy), Lund (Sweden), London (UK), Vienna (Austria), and London (UK), the meeting comes to Prague (Czech Republic) in 2022. Central Europe is considered a “crossroad” for hedgehogs from a phylogeographic point of view, as it is characterized by the frequent occurrence of secondary contact and hybrid zones of lineages previously isolated during ice ages. For example, it is a zone of contact between the western hedgehog and the northern white-breasted hedgehog. However, Central Europe is also a cultural crossroad. Thus, we hope that the meeting will contribute to the further evolution of EHRG’s framework, and will bring novel ideas and emergent properties into hedgehog research and conservation.

Barbora Černá Bolfíková and Pavel Hulva



Scopus search for *Erinaceus europaeus* – documents by year (January 2022)

Documents by subject area



Scopus search for *Erinaceus europaeus* – documents by subject area (January 2022)

Methicillin-resistant *Staphylococcus aureus* in hedgehogs

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Methicillin-resistant *Staphylococcus aureus* (MRSA) continues to be one of the most common antibiotic-resistant bacteria causing invasive disease in humans. It is estimated that in Europe alone MRSA causes approximately 171.000 invasive infections each year. MRSA is resistant to all β -lactam antibiotics, including penicillin. This has serious implications for the treatment of severe infections and MRSA is now considered to be one of the world's greatest threats to human health by the World Health Organization. MRSA was first described in patients in 1961 shortly after the introduction of methicillin as a therapeutic option. Many MRSA reservoirs have since been identified in hospitals and other health care facilities, the community and most recently in food animals. The seeming link between the use of antibiotics in human and veterinary medicine and the emergence of MRSA in these reservoirs have led to the generally accepted belief that methicillin resistance is a modern phenomenon. Recent studies from Sweden and Denmark showed that two distinct MRSA clones, CC130 and CC1943, are highly prevalent in wild hedgehogs and that the hedgehog dermatophyte *Trichophyton erinacei* produces penicillin, which provide a natural selective environment where

MRSA CC130/CC1943 isolates have an advantage over methicillin-susceptible isolates. MRSA CC130/CC1943 have been a cause of human infection in Western Europe at least since the 1970s and have also been found in grazing farm animals, especially cattle, sheep, goats and horses, as well as in other wildlife, but at frequencies that are much lower than in hedgehogs. These findings support that hedgehogs could be a naturally occurring reservoir for MRSA CC130/CC1943 from where they can spread to humans, either directly through contact to hedgehogs or indirectly via other animals or the environment.

An investigation of endoparasites and the determinants of parasite infection in European hedgehogs (*Erinaceus europaeus*) from Denmark

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The European hedgehog population is declining in Europe. It is therefore important to investigate the causes for the decline and monitor the general health of the species. We investigated the endoparasite occurrence in 299 dead European hedgehogs. Of these, endoparasites were detected in 69% of the individuals tested. We identified *Crenosoma striatum*, *Capillaria aerophila* (syn. *Eucoleus aerophilus*), *Capillaria* spp., coccidia, *Cryptosporidium* spp., and one incident of *Brachylaemus* spp.. We also examined the hedgehogs for *Giardia* spp. and *Echinococcus multilocularis* but all were negative. Coccidia (n= 7, 2.5%) and *Cryptosporidium* spp. (n= 14, 5.2%) were only detected in individuals from Zealand, Lolland and Jutland south of the Limfjord, and *Brachylaemus* spp. (n= 1, 0.4%) was exclusively discovered in Jutland south of the Limfjord. These results indicate a regional difference in the endoparasite species carried by European hedgehogs in different regions of Denmark. This stresses the need for hedgehogs to be cared for

locally when admitted to wildlife rehabilitation centres, and to be released within their area of origin, to prevent spread of endoparasite infections among hedgehogs. Additionally, we explored the following possible determinants of parasite infection in the hedgehogs: sex, age, mortality category (in-care, natural and roadkill), infection with MRSA, genetic heterozygosity, month of death, geographical location and habitat type, and found that only age had a statistically significant effect on endoparasite prevalence, as we detected a lower occurrence of endoparasites in juvenile hedgehogs (<1 year) compared to the other age classes. However, pairwise comparisons of geographical regions did show significant differences in endoparasite occurrence: Zealand vs. Jutland south of the Limfjord and Zealand vs. Falster. We conclude that, in line with previous studies of the European hedgehog throughout its range in Western Europe, endoparasite infections are common and a natural part of their ecology.

This project was supported by Beckett-Fonden [grant number 44200]; Iwan Kliem Larsens Mindelegat [grant number: 108060]; Bodil Pedersen Fonden [grant number: 16-2015]; 15. Juni Fonden [grant number: 2015-B-134]; Svalens Fond; Fonden til Værn for Værgeløse Dyr; Ingeniør K. A. Rohde og hustrus grant.

Hedgehogs, small mammals with a great potential to host pathogens.

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Hedgehogs serve as hosts for a broad spectrum of blood-feeding arthropods including ticks and fleas; therefore they represent an important reservoir of pathogens transmissible to humans and other animals. Hedgehogs commonly populate urban, suburban, and rural areas. In addition, the hedgehog rescue centres represent another interface between people and animals. Our project targeted the major vector-borne pathogen groups for which hedgehogs serve as a reservoir. In 2016-2018, hedgehogs were

collected from urban, suburban and rural areas in three main localities in the Czech Republic: Brno, Prague, České Budějovice, and their surroundings. In total, 125 (41 *E. roumanicus* and 84 *E. europaeus*) cadavers were collected as a roadkill, killed by other animals, or were received dead from the rescue centres. The morphological identification of hedgehog species was confirmed by mitochondrial DNA sequencing. At necropsy, 976 tissue samples (ear/skin, muscle, blood, lungs, liver, spleen,

urinary bladder, kidney, brain) were obtained and preserved. Samples were screened for a range of pathogens using multiplex real-time PCR in order to preselect positive animals for subsequent analyses with a set of pathogen specific conventional PCR assays. The highest prevalence was detected for *Anaplasma phagocytophilum* (97.6%), including the ecotype with the zoonotic potential in both hedgehog species. *Borrelia*



burgdorferi s. l. was detected in 84.5% of E. europaeus and in 65.8% of E. roumanicus. Three genospecies (B. afzelii, B. garinii, B. burgdorferi s.s.) were identified in E. roumanicus. In E. europaeus, additional four genospecies (B. bavariensis, B. spielmanii, B. valaisiana, B. bissettii/carolinensis) were also detected. The total of six Bartonella species were identified by DNA sequencing. Three well-established species, B. washoensis, B. grahamii and B. melophagi, were accompanied by 'Candidatus B. rudakovii' and two putative novel species. Real-time PCR revealed Rickettsia helvetica in 65.9% of northern white-breasted hedgehogs while a lower rate was found in European hedgehogs (38.1%). Neoehrlichia mikurensis, Borrelia miyamotoi, Babesia microti-like and Francisella spp. were observed in less than 5% of European hedgehogs while northern white-breasted hedgehogs tested negative. None of the hedgehogs were positive for Spiroplasma spp. We demonstrated that both hedgehog species play an important role in circulation of several vector-borne pathogens, dominated by Anaplasma, Borrelia, and Bartonella spp., which makes them ideal sentinel hosts. Hedgehog cadavers from urban and suburban areas have a great potential for the elucidation and prediction of transmission dynamics of vector-borne pathogens in highly populated areas.

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Metastrongylid nematode *Angiostrongylus cantonensis*: emerging threat for insectivores?

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Due to their specific position in trophic webs, hedgehogs host a broad spectrum of protozoan and metazoan parasites. Although several helminths parasitizing hedgehogs are known to alter health status of individuals, larger impact at the population scale is not expectable due to long process of coevolution and complex character of life cycles of majority of parasites that affect hedgehogs. Recent rise of emerging infectious diseases, largely attributable to various aspects of Global Change, has growing impact on populations of wild animals. The emergence of several pathogens can commonly be linked directly to invasive species, making the resulting diseases one of the most detrimental aspects of biological invasions. Diseases classified as emerging caused by parasitic helminths are typically driven by changes in trophic webs (commonly by ecosystem alteration) or by invasion of their specific hosts (such as rodents) into new geographic areas. Among invasive rodent species, three taxa (*Rattus exulans*, *R. rattus*, and *R. norvegicus*) are the most widely introduced vertebrates, all being important hosts

of *Angiostrongylus cantonensis*, a rodent-borne metastrongylid nematode originating from the Far East, that currently represents a global emerging threat. *A. cantonensis* affects a range of hosts. The typical life-cycle involves rats as definitive hosts and gastropods as intermediate hosts, however, involvement of paratenic hosts and aberrant infections of accidental hosts represent a growing threat for vertebrates feeding on molluscs (intermediate hosts) or poikilothermic vertebrates (paratenic hosts). In areas close to Europe, *A. cantonensis* was first reported in Egypt a couple of decades ago and in the Canary Islands in 2010, gradually expanding its range at Tenerife since. In warm blooded vertebrates the larvae of *A. cantonensis* actively seek a way to central nervous system, where they attempt to continue their development. While in some murine rodents the young adult nematodes migrate to lungs and reach maturity, other mammals and birds are considered aberrant hosts, where dying *A. cantonensis* larvae in various stages of their development, together with the immune reaction of the host, impact

the function of the central nervous system, peripheral nerves, lungs or other organs. Most recently, parasite was found in Mallorca based on series of infections of Algerian hedgehogs *Atelerix algirus* with significant health alteration but unknown impact on their population. The case of Mallorca *Atelerix* shows yet unexpected impact of *A. cantonensis* on small and medium-sized carnivores and insectivores and possible sentinel role of hedgehogs for monitoring of ongoing invasion by *A. cantonensis* in the Mediterranean.

Research on A. cantonensis is supported by the Czech Science Foundation (grant number 22-261365)



Life traits of hedgehogs and their model status in speciation phylogeography and conservation biology

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Temperate hedgehogs are medium-sized plantigrade insectivore mammals with spines and hibernation phenology. Their evolutionary history is related to Cope's rule and diversifying role of predation selection on body size and opening the mid-size gap, occupied by lineages with marked anti-predator apomorphies. Evolution of low basal metabolic rates and defensive weaponry reflects energetic constraints associated with the unpredictable distribution of resources and predation. As a consequence, their ranges have oscillated in relation to past climate changes. In the western Palaearctic, hedgehogs are a typical example of allopatric speciation scenarios associated with southern Mediterranean glacial refugia and formation of interglacial contact/hybrid zones in the north, with respective microevolutionary consequences, as for example character displacement. Therefore, hedgehogs become model organisms for Pleistocene phylogeography and speciation studies. Trade-offs and steady-state between metabolic and antipredator

constraints are mirrored also in the population status of hedgehogs in the Anthropocene. As the semi-open landscape managed by megafauna disappeared, hedgehogs adapted to the human-dominated environment and food-webs and become more synanthropic and synurbic. This shift raised new microevolutionary processes, including the impact of mesocarnivore release, anthropogenic mortality related mainly to traffic or novel pathways of zoonotic pathogens, but also the establishment of invasive populations, for example in New Zealand. Thus hedgehogs become one of the flagship species also for recent conservation biology.



Evolutionary history of Hedgehogs in Europe

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Hedgehogs from the genus *Erinaceus* went through the typical retractions of area of distribution during the Quaternary climate oscillations. After the last Ice age, European hedgehogs and Northern White-breasted hedgehogs expanded from their glacial refugia and created a broad zone of sympatry within Central Europe. Such interactions between closely related species are known to generate strong evolutionary forces responsible for niche differentiation. Although hedgehogs are well-known examples of postglacial recolonisation, the specific processes that shape their population structures are still poorly studied. Our studies suggest that the Northern White-breasted hedgehog is expanding in the Czechia and is preferably inhabiting lowlands. In terms of genetic diversity, both species are comparable, they recently hybridize rarely and the main pattern of population structure correlates with big rivers as barriers of gene flow. Both species differ in various parasite infestations which may reflect diversification of trophic niches and habitat preferences. Animals living outside of the contact zone show marked differences between

the two species, while individuals within the contact zone are more alike with a smaller skull size and a convergent jawbone shape. Since the function of the lower jaw is mainly connected to feeding, we hypothesize that this pattern is due to the selection to size and shape related to competition for food resources.

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The story of hedgehog hybridization - comparison of two contact zones

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Hybridization and introgression have played important roles in the history of various species including two European hedgehog species, West European hedgehog and Northern white-breasted hedgehog. The distribution of both species was largely influenced by climatic oscillations during the Pleistocene period. After the end of Last Glacial Period both species expanded northward from the refugial area on the Southern European peninsulas and created two secondary contact zones in Central Europe and Russian-Baltic region. Using genomic SNP data we concluded that both contact zones differ in the intensity of interspecific hybridization. In the younger Russian-Baltic contact zone both species hybridize extensively whereas in the presumably older Central Europe the interspecific hybridization is uncommon. The signal of an old

introgression in the hedgehog genome suggests that the recent contact was not the first one but rather that the contact between species may have happened multiple times during Pleistocene. The asymmetry of hybridization toward Northern White-breasted hedgehog was also detected which suggest stronger reproductive isolating mechanisms in West European hedgehog.

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High throughput genotyping for population genetic investigations in Hedgehog

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Impact of humans on natural systems is increasingly influencing wild populations of animals. This relates to decreasing of population sizes but also to a change in genetic structure for example by dividing subpopulations by Infrastructure. As synanthropic species, Hedgehog might be especially affected by such disruption of connectivity, in addition, individuals are frequently overwintered in shelters and might be translocated after release. These mechanisms might artificially influence the genetic structure of the species with effects on patterns of local adaptation and genetic diversity. Population genetic methods using NGS based, high throughput genotyping of Microsatellites are now available that allow for continuous monitoring of populations. Because of the high reproducibility of the marker system, a high number of individuals can be continuously included into one dataset. The base of our research constitutes the establishment of a genotyping by the thousands approach, applied to codominant SSR markers including their measurements using second generation sequencing technology. Not only a higher number of markers can be measured but also SNPs can be included in the allele call that result in a higher number of alleles

in the analysis. Currently, a set of 55 Markers is available and is tested using samples across Europe. Hedgehogs are one textbook example of postglacial allopatric speciation in the context of postglacial range shifts. This results in contact zones for example between *Erinaceus europaeus* and *E. roumanicus* in central Europe where hybridization can influence the patterns of genetic structure but could also cause exchange of adaptations between species. The primer set was developed including both species. It can now be used to determine the occasional hybridization and the level of overlap of range can be determined.



Hedgehogs in the city: a look at populations of two species of hedgehog based on the data from a wildlife rehabilitation centre.

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Hedgehogs belong among most frequent patients of Prague Wildlife Rehabilitation Centre. About 550 hedgehogs in total is received every year, which makes 14% of all patients. Of the received hedgehogs, 60% are Northern white-breasted hedgehogs (*Erinaceus roumanicus*) and 40% are European hedgehogs (*Erinaceus europaeus*). The higher number of the received Northern white-breasted hedgehogs may be related to the fact that the urban environment suits them better, but also because, unlike European hedgehogs, they usually have two litters per year. Life in the neighbourhood of people brings for hedgehogs both advantages and disadvantages. An advantage is probably more varied environment in the city, the presence of many gardens and parks and also availability of food – hedgehogs often profit from the food left by people for outdoor cats. An disadvantage of living in the city is a number of dangers – car traffic, trimmers and dogs. Up to 1/5 hedgehogs that are transported to the rehabilitation centre is received due to injuries caused by people (or their dogs). Probably also a part of orphaned baby hedgehogs come to the rehabilitation centre because people killed their mothers.

An exploratory investigation of glucocorticoids, personality and survival rates in wild and rehabilitated hedgehogs (*Erinaceus europaeus*) in Denmark

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The European population of hedgehogs (*Erinaceus europaeus*) is declining. It is therefore essential to optimise conservation initiatives such as the rehabilitation of sick, injured and orphaned hedgehogs. Wild animals placed in captivity may be prone to chronic stress, potentially causing negative health effects. Therefore, the effects of these rehabilitation efforts should consequently be evaluated. Furthermore, hand-raising orphaned hedgehogs is a laborious and costly task, and it is therefore relevant to document whether they have equal post release survival rates compared to their wild conspecifics. The objectives of this research were therefore to conduct an exploratory study of glucocorticoid levels in hedgehogs from different backgrounds and compare the post release survival of translocated, rehabilitated and wild, juvenile hedgehogs as well as the possible effect on survival of differences in shy or bold behaviour (personality) exhibited by individuals. We

measured glucocorticoid levels in 43 wild-caught (n = 18) and rehabilitated (n = 25) hedgehogs and compared the post release survival and spatial behaviour of 18 translocated juvenile hedgehogs (eight hand-raised and ten wild) until hibernation. The possible effect on survival of differences in shy or bold behaviour (personality) exhibited by 17 juvenile individuals (seven hand-raised and ten wild) was also examined. Rehabilitated individuals and females had higher levels of faecal corticosterone metabolites compared to wild individuals and males, respectively. Rehabilitated individuals showed higher levels of saliva corticosterone than wild. The personality tests labelled 13 individuals as shy and 11 as bold. Post release survival was 57% for rehabilitated and 50% for wild individuals. Neither background nor personality affected post release survival. Home range measures were 3.54 and 4.85 ha. Mean dispersal length from the release sites was 217 ± 100 m. The higher levels of corticosterone

observed in rehabilitated compared to wild hedgehogs calls for consideration of the duration of admission to wildlife rehabilitation centres to reduce stress levels in the patients. Hand-raised juveniles appear to have the same prospects as wild, and personality does not seem to affect post release survival in hedgehogs, indicating that hand-raising of orphaned juvenile hedgehogs is a relevant contribution to the conservation of this species.

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Is the hedgehog in danger of extinction in France? Construction of a myth and consequences for protection and conservation

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The European hedgehog (*E. europaeus*) is classified as LC (least concern) by the INPN in France, for the country as a whole and for all sub-regions. Despite this, many nature, animal and hedgehog protection organisations claim that the species is in danger of extinction. Few admit that it is not. This idea of the French hedgehog being endangered seems to derive originally from its situation in England, where it is now classified as VU (vulnerable). Indeed, in the 2000s, the English situation, which was then considered worrying, was transposed to France by the first specialised care center (the „Sanctuaire des hérissons“, Somme). This idea then spread in France and the French-speaking world, without being discussed. The time frame for the disappearance („2020“ or „20 years“) as well as the supposed sharp decline in numbers (30 millions in the 1960s to 1 million today) were also taken up, despite the absence of real data (census) in France. My paper, after giving the history and the state of play of this „false programmed extinction“, will evoke the way in which this idea was imposed and is still imposed in the social, political and practical fields. The ‚false programmed extinction‘ is closely linked to a widespread

social representation of a ‚hedgehog victim‘ of Man (Messieux, 2008), which derives basically from losses due to roadkill (Burgaud, 1996). The possible extinction reinforces this „victim“ effect and increases the prestige of being a „savior“ of hedgehogs, as well as the attention, means and sources of funding. It also brings hedgehog protectors and carers into the more prestigious and scientific circle of conservation. It introduces the hedgehog into the political arena with the setting up of petitions asking politicians to „save“ the species. I will also discuss the effects of this pseudo-disappearance on practices, notably protection, feeding and care. Indeed, if this animal can disappear, it becomes legitimate and desirable to save literally every individual - whatever the cost and consequences. Other practices such as breeding and releasing bred individuals are considered. The „endangered“ status of the species also allows an urgency to be invoked to overcome legal objections to, for example, the (sometimes even veterinary) advice given by groups that exist only on Facebook, or the fact that many hedgehogs are picked up by well-meaning people even though they do not really need it.

Urban ecology and European hedgehogs

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European hedgehog populations are declining across Europe, with the downward trend being even more pronounced in rural areas than in urban areas. Nowadays, European hedgehogs (*Erinaceus europaeus*) have been found in higher densities in green areas of settlements as compared to rural spaces. On the other hand, increasing urbanisation is a global phenomenon and has led to more than 50% of the world's human population living in cities. Global urbanisation means important impacts for biodiversity and ecosystem functioning: Although cities tend to be characterised by fewer natural resources, greater anthropogenic disturbance and more fragmentation than pristine systems, urban areas have greater habitat diversity, more (often anthropogenic) resources and fewer natural enemies. Anthropogenic influences create an urban landscape that varies greatly in habitat availability, climate, light and noise pollution levels, and species composition at small spatial scales compared to the non-urban environment. This extreme pressure can lead to profound behavioural adaptations in urban wildlife. Effective hedgehog conservation requires a deep understanding of the hedgehog's ability to adapt to a changing environment, especially urban

environments, as these have become particularly important for hedgehogs due to overall population declines. I will present study results on urban hedgehogs (especially hedgehogs in Berlin, Germany) about their genetic diversity and behavioural plasticity to anthropogenic disturbances. The study of urban hedgehogs also require an adaptation of the research methods and tasks to the urban conditions, in order to ultimately gather knowledge and contribute to hedgehog-friendly cities by evidence-based management decisions. Such cities can potentially maintain healthy populations in the long term and even provide source populations for the reintroduction of restored rural areas.

Using citizen science to understand and map habitat suitability for a synurbic mammal in an urban landscape: the hedgehog *Erinaceus europaeus*

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Urban environments are important for west European hedgehogs *Erinaceus europaeus*, yet the environmental relationships influencing where the species is present within these landscapes are not well understood. In this study, we constructed a multi-scale generalised linear model of habitat suitability for hedgehogs within the city of greater London, UK, using 3012 hedgehog occurrence records sourced from citizen-science based datasets. To reduce bias in the model, other mammal taxa records were used to infer hedgehog absences. We identified hedgehog's relationships with variables representing urban greenspaces, urbanisation gradients and built infrastructure, traffic and presence of the European badger (*Meles meles*, a competitor and predator) on hedgehog presence, and use this to predict habitat suitability across the study area. We find positive relationships with garden, allotments and park cover, the percentage of terraced housing, traffic volume and intermediate impervious cover, but negative relationships with high impervious cover, high human densities, woodland and

water cover, and badger presence. This study shows that despite complexities in using citizen science datasets, these data can be useful for developing understanding of large-scale species habitat relationships within complex urban environments.

This study is part of a PhD project funded by Natural Environment Research Council and Peoples Trust for Endangered Species. RF and CC are funded by Research England.

Understanding London's hedgehog populations with London HogWatch

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Hedgehogs have been in decline in the UK for the last few decades and are on the red list for British mammals. To aid their conservation London HogWatch uses systematic camera trapping surveys to understand their distribution and abundance in the capital. This method gives information not only on presence but also absence, revealing factors affecting distribution such as roads and badgers. HogWatch's recent expansion into surveying smaller green spaces such as gardens and allotments, in addition to parks, have revealed these are very important habitats for London's hedgehog populations. As our project progresses, we hope our findings will be used to inform conservation strategies across different sites from parks to private gardens to strengthen their distribution across the capital.

Project was supported by British Hedgehog Preservation Society and People's Trust for Endangered Species.

Road Impacts on the West European Hedgehog (*Erinaceus europaeus*): Understanding Mechanisms and Testing Solutions

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Transport infrastructure is a pervasive element in modern landscapes and continues to expand to meet the demands of a growing human population and its associated resource consumption. The field of road ecology has revealed the extensive role that roads play in direct and indirect habitat loss and alteration, fragmentation, animal-vehicle collisions and changes in animal movement in road-dominated environments. The West-European hedgehog (*Erinaceus europaeus*) is one of the most common roadkill sightings in the UK. Negative interactions with roads, either via road mortality or fragmentation, are posited as a significant contributor to the species' rapid and ongoing declines in the UK. However, current data is neither fine scale enough nor combined with relevant population context to confirm or refute this assumption. As part of my Ph.D., we have been using a combination of population density estimates, GPS tracking and roadkill monitoring to quantify the risks that roads pose to individual hedgehogs and their populations in several road networks. We have used additional camera trapping at 20 road tunnels

(underpasses) around the UK to assess their efficacy at mitigating hedgehog road mortality. We show that a large percentage of populations can be killed on roads every year, but that risk of road mortality is sex-biased, and that hedgehog movements can be substantially restricted by behavioural and physical barriers in roaded landscapes. Simultaneously, hedgehogs show a clear preference for road tunnel type, but that movement data in proximity to the tunnels is vital to understand limitations to their effectiveness.

This project is match-funded by Nottingham Trent University and the People's Trust for Endangered Species (PTES).



Applying research to practical action - how a petition can activate an audience.

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When I started the petition, change.org/saveourhedgehogs, I was not expecting much. The 'ask' was small - to get a change in planning law to ensure hedgehog highways are built into all new developments. But as the numbers started to rise I realised the potential to use the petition as a direct tool for communication - and now that over a million people received my updates every couple of weeks I wanted to share what I consider to be some of the victories. But there is more than just practical action from this audience. Research benefits enormously from citizen scientists. I am now investigating how to use these enthusiasts; to try and get them involved with the many research projects that benefit from the involvement of members of the public. This is an aspect of a virtuous circle that can be overlooked - the more we involve people in helping hedgehogs the more likely we are to encourage them to get involved with the process of research and, in turn, the more likely they are to see hedgehogs and be stimulated into taking action to help them.

This work has been supported by the British Hedgehog Preservation Society and the Felix Byam Shaw Foundation.

State of Britain's hedgehogs 2022

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The British Isles are on the western most edge of the range of the European hedgehog (*Erinaceus europaeus*). The species is widespread across Britain, and still common in some areas, but has suffered a worrying decline over the past two decades. In 2012 Peoples Trust for Endangered Species (PTES) and the British Hedgehog Preservation Society (BHPS) commissioned the British Trust for Ornithology (BTO) to analyse all datasets on UK hedgehogs and assess their potential for long-term monitoring. The report validated the efficacy of the surveys and also confirmed the decline of hedgehog populations over the period the surveys had been running. Since then, PTES and BHPS have produced regular State of Britain's hedgehogs reports, detailing evidence from national surveys, highlighting the trends in both rural and urban areas. In the early 1990s, volunteers were recruited to record hedgehog road casualties as a way of monitoring the population in the wider landscape. Ten years on, PTES relaunched the survey as Mammals on Roads. Alongside BTO's Breeding Bird Survey, these data provide national trends of how the species in faring in the rural landscape, dominated

by agricultural land. To assess the urban population, data from PTES' Living with Mammals (LwM) were analysed. LwM, which has run since 2003, provides maximum counts (the largest number of animals seen at one time) and signs of hedgehogs recorded weekly through April, May and June. Around 1300 gardens and green spaces in the built environment (predominantly urban areas), surveyed in two or more years, were used in the analysis. MoR collects records of hedgehog road casualties outside urban areas, together with information about the length and location of the route. For BBS, transect surveys are walked each year at randomly selected OS grid-squares, optionally recording mammals, including live animals, field signs, dead animals, and local knowledge of presence. The number of surveys has increased over time (in 2019, 3,605 squares were surveyed for mammals). Trends from these surveys, alongside other data, are published as part of State of Britain's hedgehogs 2022. These trends will be presented, alongside discussions around why the species is declining, and information about measures being undertaken to understand and reverse the decline.

This work was supported by PTES and BHPS, with data contributed by BTO and the Game and Wildlife Conservation Trust.

Hedgehog Street: 10 Years of Hedgehog Conservation in the UK

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People's Trust for Endangered Species and British Hedgehog Preservation Society

Hedgehog Street is a UK-based hedgehog conservation project set up in 2011 by two British wildlife charities; People's Trust for Endangered Species (PTES) and the British Hedgehog Preservation Society (BHPS). PTES has been working for over 40 years to protect wildlife and their habitats both in the UK and overseas. BHPS was founded in 1982 and is dedicated to helping and protecting the west European hedgehog in the UK. The joint Hedgehog Street campaign was launched in response to widespread hedgehog declines with the aims of raising awareness of the threats hedgehogs face and the ways people can help them. Threats faced by hedgehogs in the UK include habitat loss and fragmentation; significant land use change in the decades since the second world war has resulted in widespread population declines. It is estimated that UK hedgehog numbers have fallen by 50% in rural areas and 30% in urban areas since 2000. Agricultural intensification, road mortality and extensive urbanisation have also contributed to declines so catastrophic that this once abundant species has been classified as 'vulnerable to extinction' on the IUCN UK red list. In order to tackle the threats hedgehogs face, the Hedgehog Street campaign engages with the general

public as well key stakeholders such as farmers, developers, land managers and ecologists. Partnerships with various local and national housing developers have resulted in pledges to provide hedgehog access on all new-build sites, as well as increased awareness of 'hedgehog highways' within the industry. Tailored advice has been produced for developers, as well as farmers and land managers, and a dedicated hedgehog ecology and land management course allows practitioners to expand their knowledge. Engagement campaigns, social media and extensive press interviews have also increased the profile of hedgehog conservation in the UK, and now over 100,000 people are registered as 'Hedgehog Champions', making changes in their own garden to benefit hedgehogs.

An assessment of a conservation strategy to increase garden connectivity for hedgehogs that requires cooperation between immediate neighbours: A barrier too far?

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The conservation campaign 'Hedgehog Street' was launched in 2011 to promote the improvement of connectivity between gardens. The campaign encourages householders to construct gaps – termed 'hedgehog highways' – in their garden boundaries to provide access points for hedgehogs. To assess engagement with Hedgehog Street, we used a series of online questionnaire surveys to gather data on factors that might influence householders' decisions to create hedgehog highways, as well as barriers to engagement. Householders were more likely to have created a highway if they were already aware of the Hedgehog Street campaign, if their garden contained a high number of wildlife-friendly features and if they considered watching wildlife to be important. Of those respondents who had not created highways, the most common reasons cited were that their gardens were already accessible to hedgehogs, followed by concerns relating to boundary ownership and / or communicating with neighbours. Future studies need to identify strategies for overcoming these obstacles to maximize citizen engagement, particularly with those householders who are

not innately "wildlife-friendly", and to quantify the degree to which networks of highways affect patterns of individual movement and, ultimately, populations.

Wildlife Conservation at a Garden Level: The Effect of Robotic Lawn Mowers on European Hedgehogs (*Erinaceus europaeus*)

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Injured European hedgehogs are frequently admitted to hedgehog rehabilitation centres with different types of cuts and injuries. Although not rigorously quantified, a growing concern is that an increasing number of cases may have been caused by robotic lawn mowers. Research indicates that European hedgehogs are in decline. It is therefore important to identify and investigate the factors responsible for this decline to improve the conservation initiatives directed at this species. Because hedgehogs are increasingly associated with human habitation, it seems likely that numerous individuals will encounter several robotic lawn mowers during their lifetimes. Consequently, this study aimed to describe and quantify the effects of robotic lawn mowers on hedgehogs, and we tested 18 robotic lawn mowers in collision with dead hedgehogs. Some models caused extensive damage to the dead hedgehogs, but there were noteworthy differences in the degree of harm inflicted, with

some consistently causing no damage. None of the robotic lawn mowers tested was able to detect the presence of dead, dependent juvenile hedgehogs, and no models could detect the hedgehog cadavers without physical interaction. We therefore encourage future collaboration with the manufacturers of robotic lawn mowers to improve the safety for hedgehogs and other garden wildlife species. We tested the effects of 18 models of robotic lawn mowers in collision with dead European hedgehogs and quantified the results into six damage categories. All models were tested on four weight classes of hedgehogs, each placed in three different positions. None of the robotic lawn mowers tested was able to detect the presence of dependent juvenile hedgehogs (<200 g) and all models had to touch the hedgehogs to detect them. Some models caused extensive damage to the hedgehog cadavers, but there were noteworthy differences in the degree of harm inflicted, with some

consistently causing no damage. Our results showed that the following technical features significantly increased the safety index of the robotic lawn mowers: pivoting blades, skid plates, and front wheel drive. Based on these findings, we encourage future collaboration with the manufacturers of robotic lawn mowers to improve the safety for hedgehogs and other garden wildlife species.

This project was supported by The British Hedgehog Preservation Society. The APC was funded by the QATO Foundation and Dyrenes Beskyttelse (Animal Protection Denmark).



How many hogs could a hog dog find if a hog dog could find hogs?

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Monitoring changes in populations is fundamental for effective management. The West European hedgehog (*Erinaceus europaeus*) is of conservation concern in the UK because of recent substantial declines. Surveying hedgehogs is, however, problematic because of their nocturnal, cryptic behaviour. We compared the effectiveness of three methods (infra-red thermal camera, specialist search dog, spotlight) for detecting hedgehogs in three different habitats. Significantly more hedgehogs were detected, and at greater distance, using the camera and dog than the spotlight in amenity grassland and pasture; no hedgehogs were detected in woodland. Increasing ground cover reduced detection distances, with most detections (59.6%) associated with bare soil or mown grass; the dog was the only method that detected hedgehogs in vegetation taller than the target species' height. The additional value of surveying with a detection dog is most likely to be realised in areas where badgers (*Meles meles*), an intra-guild predator, are and/or where sufficient ground cover is present; both would allow hedgehogs to forage further from refuge habitats such as hedgerows. Further consideration of the effectiveness of detection

dogs for finding hedgehogs in nests, as well as developing techniques for monitoring this species in woodland, is warranted.

Status, distribution and conservation of lesser known South Indian Hedgehog (*Paraechinus nudiventris*) in Tamil Nadu, India

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The South Indian hedgehog *Paraechinus nudiventris* (Horsfield, 1851) is one of the least studied, small mammals endemic to India. Although it is listed as Least Concern by the International Union for Conservation of Nature (IUCN), its distribution is still unknown due to the paucity of data. This study reports the distribution data of the South Indian hedgehogs from 16 districts in Tamil Nadu, India. The distribution records were retrieved from field surveys, published records, interviews, trade survey, local newspaper reports and museum specimens. From 2012 to 2017, there were 103 localities and 18 live sightings recorded. Its major habitats are grassland, shrubs around urban landscapes, small hillocks and thorny shrubs. In Tamil Nadu, it is found at low elevations; in sandy patches, dry areas and on scrub dominated plains. Hunting, habitat loss, roadkill and local trade were found to be the main threats responsible for the species' declining population. This study discusses details such as distribution, habitat and ongoing threats, with a view to contributing to future species conservation and legislative decision making. The confirmed locations of *P. nudiventris*

from our field surveys and existing sight records were pooled. These geocoordinates were then used as the "occurrence location" to predict the potential distribution range of *P. nudiventris* in southern India based on a set of climatic and terrain variables using the MaxEnt algorithm. The predicted model shows the suitable ecological conditions in the districts of Erode, Tirunelveli, Tuticorin, Coimbatore and Tiruppur in Tamil Nadu, making them highly probable sites for its presence. Most of the predicted suitable range and high potential range fall in the non-protected semi dry zones characterized by low annual rainfall with sparse savanna vegetation, lowland [0–750 m above sea level (asl)] and the rural areas of southern Tamil Nadu. Our findings establish the potential distribution range of this species in parts of Karnataka, Andhra Pradesh, Kerala and most of Tamil Nadu.

Project was supported by Ravi Sankaran Inlaks Foundation – small grant (Mumbai) in 2016.



European hedgehogs (*Erinaceus europaeus*) admitted to rehabilitation centres in the Czech Republic due to exhaustion and starvation

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Rehabilitation centres help to protect wildlife by providing care to injured or otherwise weakened animals with the aim to return them back to the wild. The European hedgehog (*Erinaceus europaeus*) is one of the most frequently admitted species to rehabilitation centres in the Czech Republic. The aim of this study was to assess the numbers of European hedgehogs admitted to rehabilitation centres in the Czech Republic due to exhaustion and starvation and their outcomes (release, death or euthanasia) in relation to their weight. A total of 2,018 exhausted or starved European hedgehogs were admitted to 31 rehabilitation centres in the period from 2014 and 2020. There was an increasing trend in the number of hedgehogs admitted for these reasons in the monitored period ($r_{Sp} = 0.8571$, $p < 0.05$). The numbers of hedgehogs that died and those that recovered and could be subsequently released were almost equal (37.02% and 38.16%, respectively). For additional analysis, hedgehogs with a known weight upon admission ($n = 728$) were divided into the following groups: pre-weaning young (< 200 g), weaned young (200-399 g), juvenile hedgehogs (400-599 g) and

adult hedgehogs (> 600 g). Among the admitted hedgehogs, the two smallest categories (up to 200 g and 200-399 g) prevailed (42.58% and 31.32%, respectively). Furthermore, for these two categories, the probability of survival was the lowest, death or euthanasia was the outcome for 40.21% of hedgehogs weighing up to 200 g upon admission and 27.76% of those weighing 200-399 g. Significantly fewer animals died or had to be euthanized among hedgehogs weighing 400-599 g (17.08%) and over 600 g (14.95%) upon admission to the rehabilitation centre. Factors leading to the exhaustion and starvation of European hedgehogs in the wild may include immobility due to injury that prevents the hedgehog from foraging, severe infections causing diarrhoea or apathy, or lack of food per se in a given locality. Although it is often difficult to determine the actual reason, analysis of data from rehabilitation centres may indicate the high-risk groups both in terms of suffering from this condition and their chances of survival. The release rate of exhausted and starved hedgehogs in the Czech rehabilitation centres was 38.16%. However, the results show that the smaller a hedgehog was

upon admission, the less chance of survival they had. Current treatment options are still limited, especially for young hedgehogs that are more susceptible to starvation and less likely to survive in the rehabilitation centre.

This study was funded by ITA VFU Brno (Project No. FVHE/Vecerek/ITA2020).



Ectoparasitic infestations of the Northern white-breasted hedgehog (*Erinaceus roumanicus*) in Serbia

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Hedgehogs are small mammals, insectivores and fall under the family Erinaceidae. Hedgehogs usually move at night and spend most of the day sleeping in a hole in the ground or hidden under grasses, shrubs and stones and this is their home range. These mammals are quite common in urban environments (for example in gardens, parks and backyards, city forest, picnic area, cemeteries, and etc.). At last few years these animals have become increasingly popular as an exotic household pet due to being unique, cute, low and easy maintenance pets. Research of parasitic fauna of hedgehogs are mostly made in Europe and the Middle East. In Serbia we had only one examination of its helminth fauna and this was the first research of ectoparasitic fauna of hedgehogs. Between April 2018 to November 2019, we examined 58 hedgehogs. Total of 37 animals were caught from Belgrade areas, Zasavica (nature reserve northwest of Belgrade) and Pančevo and released after examination. At same time we examined 12 pet hedgehogs and 9 animals died at traffic accident. All examined animals belonged to Northern white-breasted hedgehogs (*Erinaceus roumanicus*). Fleas and

feeding ticks found on hedgehogs were removed with tweezers and stored in 70 % alcohol. Where mange-like lesions were present; the spines or hair around affected area were removed and a skin scraping was made with a scalpel. Ectoparasites were morphologically identified with a stereo microscope (Leica DMIL 090-136-002). Infestation with ectoparasites was found in 41.37 % (24/58) animals. Pet hedgehogs have not been infected. During our examination, hedgehogs are commonly infested with hedgehog flea *Archaeopsylla erinacei* found in 24.13%, *Ctenocephalides felis felis* in 13.79% and *C.canis* in 8.52%. The most abundance tick species was *Ixodes hexagonus* found in 48.27%, followed by *I.ricinus* (12.06%) and *Rhipicephalus sanguineus* (10.34%). *Sarcoptes scabiei* occurred at only one animal.

Gammaherpesviruses in hedgehogs from central Europe

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Herpesviruses from subfamilies Alpha- and Gammaherpesvirinae have been associated with numerous, sometimes even fatal, infections of hedgehogs. While infections caused by alphaherpesviruses were mostly reverse zoonotic transmissions of human Herpes simplex virus and were often fatal for the hedgehogs, infections caused by hedgehog specific gammaherpesviruses were mostly asymptomatic. Molecular analyses at British Isles showed high (almost 50%) prevalence of hedgehog specific gammaherpesviruses, namely Hedgehog gammaherpesvirus 1, 2a, and 2b (HHGHV-1, 2a, and 2b) in western european hedgehogs (*Erinaceus europaeus*). To test presence of gammaherpesviruses in hedgehogs living in central Europe from the contact zone between western european hedgehog and northern white-breasted hedgehog (*Erinaceus roumanicus*), we screened over one hundred of tissue samples (including tens of brain samples) by PCR using pan-herpesvirus specific primers as well as HHGHV specific primers. None of the tested samples showed to be positive for herpesviruses despite the positive controls were able to detect

artificial DNA. If we would confirm these results on a higher number of samples, it would show that prevalence of HHGHVs on British isles is either much higher than in central Europe or that the gammaherpesviruses are absent here.

This study was supported by FTZ IGA 20213106.

The Irish Hedgehog Survey

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While the hedgehog is one of Ireland’s most distinctive mammals, it is one of the least studied. Introduced to Ireland around the 12th Century, it is neither an invasive species nor a pest but is regarded as part of the naturalised Irish fauna. While not considered a species of conservation importance, it is protected by the Wildlife Acts. There is a perception that hedgehogs are widespread and common in Ireland, but no census of the population has been carried out to date. The Irish Hedgehog Survey is a citizen science initiative to gather data on the distribution of hedgehogs on the island of Ireland across urban and rural habitats. The hedgehog survey has three elements: a casual recording scheme, a volunteer survey and a garden survey. The Irish Hedgehog Survey launched in the spring of 2020 when the public were asked to record hedgehog sightings via a designated portal on the National Biodiversity Data Centre’s website. In summer 2021, the volunteer survey was started whereby participants conducted hedgehog surveys according to the method devised by researchers from Trent-Nottingham University for the National Hedgehog Survey in England. This requires that 10 footprint tunnels are placed throughout a 1km²

area for 5 nights and to determine hedgehog occupancy. The Garden Hedgehog Survey is an online questionnaire which gathers information on the use of gardens by hedgehogs. In 2020 and 2021, the public were asked to survey their home or school garden using a footprint tunnel or trail camera positioned in their garden for one week over the summer. Additionally, householders that know they regularly have hedgehogs visiting their garden were invited to complete the questionnaire. The Hedgehog Survey has attracted positive media and public interest. In 2020, nearly 2,000 hedgehog sightings were submitted, with a further 2,900 records received in 2021. These figures are approximately 9 and 14 times the average number of records received in the years 2000 to 2019. Interestingly, the survey records for 2020-21 show a significantly higher proportion of live animal sightings as opposed to roadkill animals which were the dominant record type in previous years. This is likely due to the high numbers of garden-visiting hedgehogs reported by citizens confined to base during lockdown. By the end of the first season of the volunteer survey, 101 individual 1km squares have been surveyed by volunteers throughout Ireland. While

the analysis of the results is currently ongoing, the initial results indicate that hedgehogs were detected at 43% of the sites surveyed. The volunteer survey will continue in the summer of 2022. Nearly 500 people have contributed to the Garden Hedgehog Survey over the last two years. Most of these are householders who have hedgehogs regularly visiting their garden.

The project is supported the National Biodiversity Data Centre, NPWS, the Ulster Wildlife Trust, the Hogsprinkle Wildlife Rescue and the Heritage and Biodiversity Officers in the County Councils of Galway, Mayo, Roscommon, Kilkenny, Dun Laoghaire Rathdown and Dublin City.



Hosting institution

The Faculty of Tropical AgriSciences (FTZ), at the Czech University of Life Sciences Prague, is a unique institution within the Czech Republic and boasts over 60 years of research activity in tropical agriculture, rural development, and sustainable management of natural resources in the tropics. FTZ is the only faculty focusing exclusively on tropical agriculture in the northern hemisphere, with nearly 600 students and 60 staff members currently. With climate change becoming an increasing reality, the significance and relevance of FTZ has increased internationally. FTZ experts and students are primarily engaged in education and research in low-income countries, and in many places of the world, development aid activities are based on the research of FTZ students and its academic staff. The recent appointment of our Belgian Dean, Prof. Patrick Van Damme, adds to the Faculty's uniqueness within the Czech Republic. FTZ prides itself with its "Fair Trade Faculty" label, as well as its own Botanical Garden that houses various tropical and subtropical edible crops and plants, and a research farm with African common eland antelope and South American guanacos. Furthermore, for the past 20 years, our researchers at FTZ manage a conservation program for the critically endangered Derby eland in Senegal. The Faculty itself has nine modern laboratories, including laboratories for detection and characterization of pathogens, molecular genetics, food processing technology, chemistry and bioactivity of underutilized crops of tropical and subtropical origin, amongst others.

The mission of the Faculty:

The mission of the faculty is the higher education of foreign and Czech students in the fields of tropical agriculture, rural development, and the sustainable management of natural and energy resources in the tropics. An integral part of our mission is Research and Development in the field of tropical life sciences and the application of R&D results to the specific conditions of tropical and/or developing countries.

The vision of the Faculty:

To be an excellent and unique institution in the Czech Republic orientated towards the transfer of the latest knowledge and technology between the Czech Republic, the EU, and tropical regions whilst respecting the traditional values and shared benefits of the local communities of the developing world, as well as supporting local socio-economic and technological development.



**Faculty of Tropical
AgriSciences**

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Jones Emily	Institute of Zoology, Zoological society of London	Taucher Anouk	SWILD - Urban Ecology & Wildlife Research
Klaarmond Merel	Egelwerkgroep Nederland	Teixeira Rodrigues Clarisse Inês	Amigos Picudos - Associação para a Preservação e Protecção dos Ouriços
Klimeš Jiří	Pomoc Ježkům, z.s.	Tornkjær Inge	Pindsvine Plejerne
Kumar Brawin	Indian Institute of Science Education and Research	Truss RVN Bev	The Hogsprinkle Helping Hedgehogs
Larsen Jesper	Statens Serum Institut	Turner Jessica	Institute of Zoology and Queen Mary University of London
Lawson Becki	Institute of Zoology, Zoological Society of London	Vass Fay	The British Hedgehog Preservation Society
Leyland Kelly	Haydock Hedgehog Helpers Rescue	Veitch Darren	Writtle University College
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Lukešová Gabriela	University of Veterinary Sciences Brno	Villeneuve Ysaline	Faculty of veterinary medicine Zagreb
Lund Rasmussen Sophie	Wildlife Conservation Research Unit, University of Oxford	Warwick Hugh	British Hedgehog Preservation Society
Maas Miriam	National Institute for Public Health and the Environment	Wembridge David	People's Trust for Endangered Species (PTES)
Maria Lesiczka Paulina	Faculty of Veterinary Medicine, University of Veterinary Sciences	Zanella Alessandro	UNIPD
Meimberg Harald	University of natural resources and life sciences, Vienna		
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