Response to Human-Induced Changes

Of city mice and village mice: behavioural adaptations of voles and mice to urban environments

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A fundamental question of current ecological research is to illuminate the drivers and limits of species responses to human-induced rapid environmental change (HIREC). Understanding behavioural responses to HIREC have been identified as a key component because behaviour links across fundamental hierarchical levels of organisation, i.e. from individual responses to population and community changes. Ongoing urbanization provides an ideal setting to test the functional role of behaviour for responses to HIREC because they occur at a fast time scale. In a first step, we aimed at testing whether urban and rural populations of four rodent species differ in mean trait expression, flexibility and repeatability of behaviours associated to risk-taking and exploration of novel environments. Using a standardized behavioural test in the field, we quantified exploration and boldness for a total of 305 individuals (the majority repeatedly) of 4 rodent species (voles: *Myodes glareolus*, *Microtus arvalis*; mice: *Apodemus agrestis*, *Apodemus flavicollis*). We found differences in mean expression of behavioural traits and in behavioural flexibility between individuals from urban and rural populations in some species, with urban dwellers being bolder, more explorative and less flexible than rural conspecifics. In other species, no such differences existed. Therefore, behavioural responses to urbanized environments appear to be species-specific with some species adjusting behaviours to the novel environmental conditions of altered food availability and predation risk, while others retained species-specific patterns. As a result, individuals distribute themselves in a non-random way in response to human disturbance, which might play a key role in the successful coping with the challenges of human-induced environmental changes.

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Genetic structure, reproduction and physiology features of the common hamster (*Cricetus cricetus*) in urban populations

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Traditionally, urbanization is seen as a negative phenomenon for biota. However, changes in the environmental parameters induced by urbanization might be favorable for some species. Therefore, we can consider this process not only as formation of new adaptations, but also as the disclosure of the deposited capabilities of sinurbic species. Over the past half-century the common hamster actively populates the cities. Its settlements exist in some European, Russian and Kazakh cities. During 2014-2017 genetic and physiological methods were used to reveal adaptations of the common hamster (*Cricetus ctricetus*) to settle in the urban environment of several cities. Based on the allelic composition of 10 microsatellite loci and mtDNA sequences we shown that in urban territories the hamster population is divided into separate groups. The level of genetical distance between the groups is high and not dependent on spatial distance between locations inhabited by the groups. In outskirts of cities, on the territories adjacent to green areas and further to countryside, the level of distinction between neighbouring hamster groups decreased and intergroup genetic differentiation began to correlate with the spatial distances. Based on physiological methods we have shown that in urban territories the common hamster demonstrates extremely short hibernation (presumably because of additional food sources). This allows the species to start breeding very early (or even to breed all over the year) and to produce up to three litters. However, the life span of the common hamster in urban conditions is very short (less than 1 year) generally. We propose that the last phenomenon is due to high mortality as a result of dog predation, environmental pollution, and interspecies aggressions at the peak of breeding activity. This study was supported by RFBR No.17-04-01061.

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Population recovery of *Mus musculus* in poultry farms of central Argentina. The role of local and landscape features

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Poultry farms in rural areas of central Argentina are dispersed within a landscape dominated by cropfields. The composition of the rodent community differs between farms and neighbouring fields: In the first habitats there is a dominance of commensal exotic species, as *Mus musculus*, *Rattus norvegicus* and, occasionally, *Rattus rattus*, and native species are rare. In cropfields and longitudinal edges between fields or along roads there are native species, and commensal species are rare. In this work we want to answer the question: where the *Mus musculus* individuals that recolonise poultry farms after control come from? The alternatives proposed were: from the surrounding of the farms, from other farms, that they are transported by men, or from the population recovery of remaining individuals. To answer this question we have used different approaches: description of rodent communities in farms and surrounding habitats, genetic studies in order to estimate gene flow according to geographic distance, models that relate *Mus musculus* abundance and environmental variables at local and landscape scale, tracking movements with fluorescent powders, experimental application of control at different spatial scales and exclosure experiments. Our conclusion is that immigration is from nearby farms and not due to passive transport by human or from surrounding habitats, that this species normally travels short distances and that dispersal movements are along cropfield borders or riparian habitats, and not through cropfields. Recovery after control is mainly due to reproduction of remaining individuals, and the abundance of *Mus musculus* in poultry farms is mainly related to intrinsic characteristics of farms. An increase in poultry activity in the area with a shortening of distances among farms may cause an incresase in the levels of infestation by *Mus musculus* in these habitats, but probably not in other habitats.

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Synanthropic rodents of north-east Siberia: changes in rodent population caused by urbanization, agrarian, and industrial development

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One of the groups of mammals that successfully utilize anthropogenic territories is *Rodentia*. The rodent fauna of North-Eastern Siberia is comprised of 23 species, whose relationship with human presence varies from eusynanthropy to exosynanthropy. The eusynanthropes are represented by two alien species: *Mus musculus* and *Rattus norvegicus*; their distribution is limited and they do not immigrate into surrounding natural biotopes. Among aboriginal species the propensity to synanthropy is most pronounced in *Myodes rutilus*, which is consistently found not only in rural settlements, but also in old cities. The invasion of the house mouse did not result in the disappearance of the native species but in mosaic dispersion of both species. Suburban areas in recent years have seen an increase in the abundance of the squirrel *Sciurus vulgaris* and a decrease of the chipmunk *Eutamias sibiricus*. Development of the cities and roads in the north is accompanied by disruption of the permafrost and consequent swamping of the territory; this has led to a decrease in abundance of *Spermophilus undulatus*. The agrophilous rodent population is comprised mainly of *Microtus* species, they can also be found on the territory of villages. The industrial development of the north is connected with deforestation and consequent formation of grass cover. Resulting rodent populations consists of ecologically flexible species: residual forest fragments are dominated by the northern red-backed vole; and open areas, by *Microtus oeconomus* and *Microtus gregalis*. In the tundra, due to typical moss and dwarf-shrub habitats being replaced by anthropogenic meadows, such typical tundra dwellers as lemmings are being replaced by voles *Microtus* genus. Among the obligatory exosynanthropes are stenotopic species confined to mountains (*Alticola*, *Marmota*) and specialized briophages (lemmings). Thus, synanthropic rodent communities in the north-east of Siberia are characterized by the prevalence of indigenous hemisynanthropes; and in conditions of ruderal communities, of agrophiles.

Response to Human Induced Changes

Effects of artificial light at night on behavior of two small mammal species

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Natural light functions as an important zeitgeber in many animal species which use this external stimulus to adapt to predictable environmental changes throughout the day and season (Zordan et al. 2001). Besides the increasing spatial spread and intensity of nighttime illumination there is a shift towards new lighting techniques such as light emitting diodes (LEDs) that are characterized by a broad spectrum with a large proportion of blue light (Gaston et al. 2012). This portion of the spectrum is known to most affectively suppress melatonin production (Brainard et al. 1984) and thereby influencing activity rhythms. What is missing are experiments under more natural conditions that clarify if laboratory results are applicable to animals in the wild and take into account possible effects of artificial light at night on species interaction and competition. In this study, the effect of artificial light at night emitted by LEDs on the activity and space use of bank voles (*Myodes glareolus*) and striped field mice (*Apodemus agrarius*) was investigated in semi-natural outdoor enclosures via automated VHF radio telemetry. The data indicates that both species show an increased spatial range during nights with artificial illumination that is similar to their home ranges during daytime. Additionally, they are less active during the day that follows an illuminated night. Changes in home range overlap between individuals could not be found in dyads consisting of the two different species but within one species reduced overlap when subjected to light at night. These observations indicate that artificial light at night effects individual space use as well as interactions between individuals which potentially has severe ecological consequences for natural populations and communities.

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Microhabitat use of small non-flying mammals in a lower montane forest fragment in the central Cordillera, Luzon Island, Philippines

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Luzon Island in the Philippines is home to a diverse set of small mammals with 45 murid rodents endemic to the Island. Previous studies focused more on the general response of species to varying levels of habitat disturbances with very limited studies on microhabitat use. Patterns of microhabitat use of a community of endemic and exotic small non-flying mammals were investigated on a fragment of lower montane forest by employing live trapping techniques from February to April 2016. Canonical correspondence analysis was used to analyze patterns of habitat use using physical and vegetation variables, and capture data of six small mammal species. Two of the three endemic species, *Apomys abrae* and *Rattus everetii* were strongly associated with dense cover of broad-leaf trees while introduced species, *Rattus exulans*, *Rattus tanezumi* and *Suncus murinus*, preferred areas with dense cover of low-lying grass and forbs. The habitat characteristics associated with endemic and exotic species could be divided into montane forest habitats and open habitats, respectively, suggesting a macrohabitat-level preference. The preferences of two endemic species, *Apomys abrae* and *Rattus everetii*, were distinguished by difference in tree and forbs cover density, with the former associated with higher tree and forbs cover than the latter. In contrast, the third endemic species, *Apomys musculus*, preferred open areas with dense cover of the forb Eupatorium. Introduced species appeared to select microhabitats based on ground steepness and wetness, and tree density. *Rattus exulans* was more associated with areas steeper and higher in tree cover areas than *Rattus tanezumi*. In contrast, *Suncus murinus* preferred moderate slope and wet ground areas. These results suggest microhabitat level preference. However, these preliminary findings need to be validated by additional studies with larger sample sizes.

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Where the wild rats go: the relationship between the socio-environmental gradient and rat abundance in slum communities

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Leptospirosis is a zoonotic disease with multiple mammalian reservoirs. In urban settings, synanthropic brown rats are the main reservoirs. Understanding the relationship between habitat attributes in urban areas and the presence and abundance of rodent populations can guide the design of interventions. Reducing carrying capacity of rat populations via environmental modification lowers transmission risk by reducing the density of *Leptospira*-shedding individuals, and thus, environmental contamination. Track plates, designed to measure rodent activity and serve as a proxy for abundance, were installed in a hundred randomized points in public spaces of four slum communities in the city of Salvador. In each sampling point, an environmental questionnaire was used to standardize the collection of data on habitat. An exploratory principal component analysis will inform the choice of landscape features that will used in a step-wise model building to define the main environmental drivers of rat abundance. It is expected that the abundance of rats will be strongly correlated with the presence of pervious soil and vegetation patches (vacant lots, backyards, unpaved roads), indicating available burrow sites; and the presence of pet food dishes and points of solid waste accumulation, which act as constant food sources. Rat abundance is expected to have an inverse relationship with the distance of the sampled points to open sewers, and will show tendency to increase towards the lower altitudinal points of the communities, which are the bottom of the drainage valleys.

Response to Human Induced Changes

Peri-urban black rats host a rich assembly of ticks with no clear consequences for rat condition

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Zoonotic diseases have rapidly emerged as public health threats, alongside human modifications to the environment and ecological communities. Urban adapted human commensal species may support ectoparasite communities within and near urban areas, and in turn play a role in zoonotic disease emergence and transmission. The black rat *Rattus rattus* is globally distributed, and has been implicated in human disease for centuries; however its role in supporting ectoparasite communities in the cities that it has spread to around the world has not been fully explored. We examined the ticks parasitizing *Rattus rattus* in a remnant bush area within Sydney, Australia in order to explore the role of introduced rats in the ecology of ticks, and the relationship between *Rattus rattus* and ticks by testing rat characteristics as predictors of tick abundance. Here we show that six species of native Australian tick parasitize *Rattus rattus* in urban Australia. The majority of ticks parasitizing *Rattus rattus* are *Ixodes holocyclus*, a tick associated with significant impacts to companion animals, and some human health concerns. Two other species of *Ixodes*, *Ixodes hirsti* and *Ixodes tasmani*, were also common. Surprisingly, we found that ticks were more abundant on *Rattus rattus* in better condition. Our study shows that *Rattus rattus* supports a rich assembly of ticks in a remnant forest in urban Australia, and that as the *Rattus rattus* in best condition have the most ticks, tick parasitism at the level observed does not appear to negatively impact *Rattus rattus*. Urban human commensals, such as *Rattus rattus*, may play be important hosts for ticks in human modified environments, and further study should investigate the roles of these species in both tick and disease ecology.