Book of Abstracts

Reproductive strategies from genes to societies – Frontiers in animal and plant reproduction research

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A comparative genomics approach to analyse gene family size (GFS) and SSD variations across mammalian species

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Sexual selection has a profound impact on species evolution, shaping their morphology, physiology and behaviour. In mammals, males often face higher competition to find mating partners than females, and are often larger. Sexual size dimorphism –SSD; differences in body mass between males and females - is often taken as an indicator of the strength of sexual selection. Although the evolutionary implications of sexual selection have been a matter of intense research for many decades, the genomic signatures of sexual selection remain poorly understood. Gene family size evolution can reflect changes in the functional relevance of molecular pathways associated with the evolution of phenotypic traits. I will present our latest results using a comparative genomics approach to analyse gene family size (GFS) and SSD variations across mammalian species. Analyses are robust to phylogenetic correction and consider covariance between sex size dimorphism and body mass. This is, to our best knowledge, the first systematic analysis of genome wide scale changes in gene family size and an indicator of sexual selection across the mammalian tree.

Biparental care in the beetle *Lethrus apterus*

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Parental care is a behaviour that increases offspring fitness. An especially interesting form of care is biparental care, where both parents take part in raising the young. This situation is, however, far from trivial, because biparental care is a typical example of a social dilemma: both parents gain by care but its cost is only paid by the caring parent. Consequently, each parent prefers the other to care more. Here I show a model that offers a solution out of this dilemma by explicitly considering the case where more than one task is needed to raise the young. Furthermore, I present the (sometimes preliminary) results of our own study of a biparental beetle, *Lethrus apterus*.

How well do estimated reproductive values predict the genetic contribution to future generations?

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To study the costs and benefits of reproductive strategies in the wild it is important to use an adequate fitness measure. I study the evolution of sex ratio strategies in the Seychelles warbler (*Acrocephalus sechellensis*), where parents can change the sex ratio of their offspring in relation to their (social) environment. Ronald Fisher realized that, in order to quantify the evolutionary implications of a sex ratio strategy, it is not sufficient to predict the lifetime production of offspring associated with such a strategy. Instead, the offspring produced have to be weighted with their reproductive value, where the reproductive value of a daughter typically differs from the reproductive value of a son. By definition, the 'reproductive value' of a certain class of individuals (e.g. daugthers) corresponds to the expected genetic contribution of an individual in this class to the gene pool of the population in the distant future. In practice, reproductive values are calculated from the survival and reproduction parameters of a projection model. For example, in models with a limited number of states, the state-dependent reproductive values correspond to the dominant left eigenvector of the state-transition matrix. The projection model underlying this method does, however, make some strong assumptions that are often not met in natural populations. It is therefore not self-evident that the calculated reproductive values do indeed characterize the relative genetic contribution to future generations. To validate this, I will first derive reproductive values from a projection model tailored to the Seychelles warbler and subsequently compare these values with the realized state-dependent spread of genes, which can be estimated from a pedigree including more than 30 years of detailed data.

Plant dispersal strategies in transformed agricultural landscapes - Effects of landscape and habitat filters on grassland specialist species of habitat islands

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Dispersal syndromes are major drivers, which can influence plant species composition of terrestrial habitat islands. In our study we assessed the effects of landscape and habitat filters on the species richness, abundance and dispersal syndromes of grassland specialist plants in small habitat islands. We studied traits related to functional spatial connectivity (dispersal ability by wind and animals) and temporal connectivity (clonality and persistent seed bank) using model selection techniques. We sampled grassland specialist plants, landscape filters (level of local and regional isolation) and habitat filters (slope, woody encroachment and disturbance) in 82 grassland islands in Hungary, Central-Europe. We found that isolation decreased the abundance of good dispersers due to the lack of directional vectors transferring seeds between suitable habitat patches. Persistence by clonal reproduction was an effective strategy in small habitat islands, whilst persistent seed bank did not support the survival of specialist species in the studied habitat islands. We found that clonal plants could cope well with increasing woody encroachment due to their high resistance against environmental changes; however, they could not cope with high disturbance. Steep slopes which provided favourable dry habitat conditions and environmental heterogeneity for specialist plants had an overall positive effect on their species richness. Grassland specialist plants were influenced by the interplay of landscape filters influencing their abundance, and habitat filters affecting plant species richness. Landscape filtering by isolation influenced the abundance of specialist plants by regulating seed dispersal and thus the fitness of individuals. Habitat filters sorted species that could establish and persist at a site by influencing micro-site availability and quality.

Reproduction strategy of an endangered annual plant species and its consequences

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Ecological research focusing on rare species can be essential, as these species often have unique combinations of functional traits, and their contribution to the ecosystem's functioning can be high relative to their abundances. Furthermore, because of their low abundances, they are usually endangered and poorly known.

This presentation aims to summarise a study about the reproduction-related traits of *Vicia biennis* L., an endangered, poorly known species of Hungary, and discuss the conservation relevance of the results.

In relation to seed traits, we measured the mass, viability, and dormancy of fresh (half-year-old) seeds in five in-situ collected seed samples, while seed longevity was estimated from repeatedly germinating four ex-situ collected seed samples. Furthermore, plant survival, flower, and yield production were studied in different light-, soil-, and competition- conditions ex-situ and in-situ.

We found that seed attributes could spatially and temporally vary: 1) fresh seeds have high germination capability (78-100%); 2) and high level of physical dormancy (72-100%); but 3) their viability sharply decreases after five years, probably falling below 10% within ten years.

The results of the field studies suggested that: 1) the species is annual, not biennial; 2) it prefers sunny places to produce flowers/seeds (in ideal conditions it can have more than 1000 seeds per individual); but 3) the plant is not a good competitor, especially on sandy soil or in dry conditions.

Our results explain why the species' populations are 'continuously moving' and changing in size, despite protection, and can help to predict the population dynamics and future distributions, as well as understand other species with the same strategy.

Role of rodents in the reproduction of grassland plants– a review on the seed dispersal mechanisms by rodents

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Seed dispersal is a frequently studied mechanism of vital importance in the maintenance of plant populations and colonisation of new habitats, especially in unstable, dynamically changing environments. However, the role of rodents in this process is still unclear in some respects. In our literature review we reveal the mechanisms related to the seed dispersal process by rodents, focusing on the influencing factors (seed characteristics, abiotic and biotic environment, human-induced changes) and their consequences, and aiming to highlight research gaps. We found that the majority of the studies focused on the seeds of woody species in forest or shrubland habitats, whilst studies on herbaceous species and in grassland habitats were unreasonably few and sporadic. The most effective seed dispersing activities were scatter-hoarding and the abandonment of removed seeds, while the microhabitat-creating role was also mentioned. Dispersal types that are generally common in other animal taxa, like endo- and epizoochory, were hardly studied in relation to rodents. Many papers have already highlighted the negative effects of direct and indirect human-induced changes, such as habitat fragmentation and homogenisation, or the altered soil moisture content. These factors can highly influence seed dispersal services maintained by rodents. In turn, rodents have a strong impact on their environment through abundancy and can influence the dynamics of plant communities. In some cases this could enhance the success of restoration projects or even substitute the role of the disappearing megafaunal herbivores and frugivores.

Prolonged mate-guarding and male investment dynamics in Clouded Apollo butterflies, *Parnassius mnemosyne* (Papilionidae: Parnassiinae)

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Mate-guarding prolonged after the male had left his mate is widespread in insects, where males attempt to block the females' copulatory pore with plugs. In a few nymphalid and papilionid butterflies, large shields, often visible to the human naked eye, are built around the plug. Shields are agreed to be important in securing paternity, although why these presumably costly devices are produced has not yet been thoroughly understood. Male Clouded Apollos produce shields in most but not all cases.

We investigated a small protandrous Clouded Apollo population. High recapture rates allowed the studying of shield persistence. We marked and measured all individuals and shields. Many females lacking a shield bore a tiny plug or a thin filament. We regularly photographed these and compared their shapes within females to estimate exchange rates. Some females bore nothing visible, referred to as "no trace of mating" (NTM).

Twenty-two out of 394 shields were lost in 6 years. Shields lost, with two exceptions, were shorter than the population lower quartile. Shields were less likely to be lost than plugs or filaments. Transition from shield, plug or filament to new shield was extremely unlikely. NTM females were very likely to receive a shield later, but very unlikely to receive plugs or filaments.

These imply that males assess female quality, investing accordingly. Proportions of shielded females relative to other females, as well as proportion males versus females declined along the flight period in all years, indicating benefits from shields decreasing with decreasing male-male competition. Relative quality (age, body reserves) of a male compared to its mate in a specific moment maybe also be an important factor influencing male decision. Shield, plug and filament intensities varied annually over the flight period, possibly depending on sex ratios and body condition and influenced by fluctuating weather.

It's the brain, not the gonad, Oida! – Hormones and mating system differences in coucals

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Testis size predicts mating systems, suggesting that steroid hormones such as testosterone may be important proximate factors regulating mating decisions. Indeed, comparative data suggests that seasonal patterns of circulating testosterone are related to mating systems and testosterone manipulations affect mating decisions in some species.

The black coucal (*Centropus grillii*) is the only altricial bird with strong female competition for territories and obligate male-only care for offspring. Territorial aggression of females is modulated by progesterone and females have a higher sensitivity for testosterone in a part of their brain that regulates social behaviour. Hence, sex steroids seem to play a role in the regulation of the sex-role reversed behaviour of this species. Here, I ask if the steroid profiles of female and male black coucals differ from those of white-browed coucals (*C. superciliosus*), a closely related species with conventional sex roles. In this species, females and males form pairs and jointly defend a territory with both parents raising the offspring.

Based on the previous findings I predicted female black coucals to express higher levels of testosterone and lower levels of progesterone than female white-browed coucals. Additionally, male black coucals should express higher levels of testosterone than male white-browed coucals during the mating phase, because there is intense competition for fertilizing females in black coucals, but not in white-browed coucals. During parenting, I predicted low levels of testosterone in males of both species, but particularly so in black coucals, because testosterone has been shown to inhibit paternal care – and that would be fatal in a species with male-only care. Against predictions, sex steroid levels of both sexes were similar between the two species, regardless of breeding stage. Thus, the solution to proximate factors regulating differences in mating strategies of coucals seems to lie in the brain, and not in the gonads!

Mate choice in Darwin's finches

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Eighteen species of Darwin's finches have evolved in the Galápagos archipelago in the last 1-2 million years. They have diversified ecologically, but how have they become reproductively isolated from each other? Experimental studies in both laboratory and the field have demonstrated that mates are chosen on the basis of male song and morphological cues learned from parents early in life. Mate choice based on learning can be considered a reproductive strategy, and reproductive isolation of species is a consequence. There is no evidence of a genetic basis of mate choice. Observations of identifiable individuals in a long-term study on Daphne Major island are consistent with preferences being learned. Mating is positively assortative with respect to morphology, and male mates of females sing the same song as the females' fathers. Preferences are not always expressed. They are most strongly expressed in initial mate choice and when the sex ratio is strongly perturbed from unity. In the latter case pairs may be monogamous, polygamous or polyandrous. These are different mating tactics. Occasionally the normal learning process is perturbed, for example when a father dies during the nestling or fledgling stage and the young finches learn the song of another species. Males sing the same song as the other species and hybridise. Hybridisation is rare; typically, one to three pairs are interspecific in a breeding season on Daphne Major. Hybrids are remarkably fit, and pair according to the song type of the father. As a result of successful backcrossing, two interbreeding resident species have become progressively more similar morphologically and genetically. The evolutionary potential of genetic mixing is illustrated by an example of interbreeding of a resident species on Daphne Major and an immigrant species. After two generations the new lineage produced by them was reproductively isolated from other species on the island.

Some modern myths about seed dispersal and functional traits

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Strategies for dispersal of offspring are a vital determinant of fitness. Recently there has been a boom in ecological research based on functional traits. In the case of plants, it is fashionable to use morphological dispersal syndromes based on the inspection of diaspore or seed morphology, which are then assumed to reflect the major dispersal strategy for a given species. Based on these assumptions, past, present and future dispersal patterns are predicted for entire floras. For example, the mechanisms by which plants reached islands can be reconstructed, and the future spread of alien plants or the response of native plants to climate change can be predicted. We challenge this research trend and argue that it is fundamentally flawed and leading to misplaced conclusions that are becoming widely accepted. Seed dispersal may be the most important ecosystem service provided by birds, and migratory avian vectors provide seed dispersal over particularly long distances. We will use empirical studies of seed dispersal by migratory waterbirds to illustrate how dispersal syndromes are a poor reflection of reality in the field. In this case, functional traits are not a valid replacement for empirical work quantifying patterns in the field.

Mate fidelity in Plovers: a multi-population approach

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Mate choice and pair-bonding play important roles in the evolution of breeding systems. Retaining or divorcing a mate can have a substantial impact on reproductive success, especially in populations that breed multiple times within a year. Here, we investigate mate fidelity in plovers (*Charadrius* spp.), in which both males and females may have several breeding attempts within a breeding season, by keeping their mate or divorcing them. Using data from 14 well-monitored populations from 8 species, we investigated environmental, life history and social predictors of mate fidelity within breeding years. Pilot results suggest that successful nesting often leads to divorce in the same year, while re-mating to the same partner happens mostly after a nest failure. Therefore, divorced plovers, counterintuitively, achieve higher reproductive success than individuals that retain their mate. Taken together, understanding mate fidelity is important given the implications of divorce on reproductive success, and thus on population productivity that may have substantial importance especially in case of endangered birds.

Neural and molecular evolution of reproductive strategies

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Reproductive behavior can vary tremendously, depending on intrinsic and extrinsic factors, even within species. Behavioral ecologists have provided a fundamental understanding of the adaptive value of different reproductive strategies and how such social systems have evolved. In turn, by taking advantage of laboratory animals bred to lack variation, behavioral neuroscientists have gained a fairly detailed understanding of how the brain processes and stores socially salient information, how it generates context-appropriate behavior, and how behavior and its neural substrates develop during ontogeny. More recently, investigators have begun to integrate these seemingly disparate disciplines to (a) unravel the causes and consequences of individual and population variation in brain and behavior in diverse species; and (b) reconstruct the evolution of the neuromolecular mechanisms that regulate and generate complex behavior. These studies show remarkably conserved roles of hormonal and neuromodulatory systems in the regulation of social behavior, even in cases of social systems that evolved convergently in distantly related taxa. Recent genome-scale studies provide support for the intriguing hypothesis that similar gene sets underlie independent evolutionary transitions to similar social phenotypes. Also, neural circuits such as the vertebrate Social Decision-Making Network are highly conserved, suggesting that much of the behavioral diversity in nature reflects variations of an ancient theme. This suggests that the most recent common ancestor of all animals already had to meet challenges imposed by fluctuating internal states and external environments (finding mates, defending resources, avoiding predators, etc.). The mechanisms used by these ancestral organisms to maintain homeostasis likely served as the building blocks for the evolution of more derived behavior. I will introduce a conceptual framework and present results from experimental and comparative studies that together provide insight into the origins and evolution of complex behavioral and neuromolecular phenotypes.

Females and stability in marmot social networks

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Social relationships are composed of both positive (affiliative) and negative (agonistic) interactions, representing opposing effects. Social network theory predicts that positive relationships should be transitive; thus, the friend of a friend is more likely to be a friend. Furthermore, when considering both positive and negative relationships jointly, structural balance theory predicts that certain configurations of positive and negative relationships in a triad are inherently less stable (unbalanced) and should tend to be eliminated. However, structural balance has rarely been examined in nonhuman social systems. We tested for transitivity and structural balance in social networks of socially flexible yellow-bellied marmots (*Marmota flaviventer*) and asked if group size, network density, or group composition affected the degree of structural balance. We found a consistent pattern of significant transitivity in positive interactions, some transitivity in negative interactions, and some evidence of structural balance. In particular, a "weak" definition of structural balance is probably more common than "strong" structural balance, which used a stricter definition of balance. Network size limited the ability to detect these social processes, and smaller networks were less likely to show significant transitivity or structural balance. The proportion of adult females in a group affected the level of transitivity but did not affect the degree of structural balance. Our study suggests that there are intriguing similarities in social processes across diverse animal societies and that studying triads and network motifs may help identify basic social mechanisms linking local to global structure.

Females' reproductive state influences temperature-dependent locomotor performance differently in two Lacertid lizards (*Lacerta viridis, Podarcis taurica*)

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In ectothermic animals, the effectiveness of maintaining their body temperature within their operative temperature range influences various aspect of the organism's life history, such as physiological performance and reproductive patterns. Lizards might not be able to evolve rapidly enough to adapt to global climate change because of constraints of the genetic architecture of their thermal preference, emphasizing the importance of plastic changes of behaviour and reproductive physiology.

To characterize temperature-dependent locomotor performance of female lizards (*Lacerta viridis*, *Podarcis taurica*) in different reproductive stages, we measured operative temperature range (T_{min}-T_{max}) and preferred body temperature (T_{pref}), and monitored their locomotor performance on 5 different temperatures throughout their activity range, before and after oviposition, using a nonmotorized running track.

In both species, T_{max} of gravid females were lowest among all groups, and gravid females had lower T_{pref} than post-lay females, suggesting that lizards have to avoid high temperatures during gestation. Egg development *per se* can be hindered by high temperature, or females are more sensitive to overheating when metabolism is more intensive. Interestingly, T_{max} of virgin females was the highest in both species, potentially because gestation has repercussions that hinder the heat-resistance of females, resulting in lower T_{max} temperatures in post-lay females. When comparing gravid vs post-lay performance, peak performance was higher in post-lay state in both species. However, consistency of pre- and post-oviposition performance curves differed: post-lay females of *P. taurica* were able to maintain 80% of their peak performance on a significantly wider temperature range than gravid females, while those of *L. viridis* maintained similarly high performance in both gravid and post-lay state, thus, their performance being more balanced on different temperatures, irrespective of reproductive state. This suggests alternative strategies species can use to cope with changing temperatures, ultimately benefiting a population's short term survival.

Effects of unpalatable plant species on the reproductive success of other pasture plants

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Flowering success of plant species in rangelands highly depends on the effect of grazing and also on the occurrence of unpalatable benefactor species, which can act as biotic refuges protecting neighboring plants from herbivores. Nevertheless, we can assume a competitive trade-off cost for plants that grow in dense populations of unpalatable plants or in the interior of unpalatable shrubs. To disentangle the above mentioned, not well-known effects, we performed two studies. (i) We studied the density dependent effect of an unpalatable herbaceous plant (*Althaea officinalis*) on the flowering success of the understory species. (ii) We assessed the small-scale effects of dwarf shrubs (*Crataegus monogyna* with 30–40 cm diameter) on the flowering success of plants growing together with these shrubs. In this second study, we considered three types of microsites: shrub interior, edge of shrub, and open pasture. The studies were carried out on meadow steppes with medium intensity cattle grazing in the central part of Hungary, in the Great Hungarian Plain. In the first study we found unimodal relationship between the herbaceous Althaea cover and the flowering success of understory species; this phenomenon has not been validated for herbaceous species before. By the demonstration of this effect between herbaceous species we can better forecast the responses of grasslands to changes in management. In the second study the flowering success was significantly higher in shrub interiors and edges than in the open pasture. These results indicate that small-sized shrubs protect other plants from herbivores and that the edge effect plays an important role for the maintenance of small-scale species diversity in pastures. Overall, our results underline the beneficial effect of biotic refuges in pastures and we suggest that retaining a sparse population of them is advantageous from a conservation point of view.

Evolution of parental care in ray-finned fish species

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Ray-finned fish (Actinopterygii) show a diverse pattern of parental care behaviour. Actinopterygii parental behaviour ranges from hiding the eggs in nests and guarding them for up to several months, to carrying the clutch externally, or internally, as well as caring for the young after hatching. Despite the rich forms of parental care in Actinopterygii species, not many studies deal with how parental care evolved across the species, and the distribution of the care patterns is not fully understood. We collected parental care data for more than 9000 species from 47 orders of Actinopterygii species from the literature, which is to our knowledge the largest sample of parental care behaviour in vertebrates. We show here the overall distribution of parental care, as well as forms of pre-fertilisation, post-fertilisation, and sex specific care behaviour across Actinopterygii species. Uncovering the distribution of parental care across the Actinopterygii phylogeny is fundamental to understanding and identifying what drives parental care evolution in ray-finned fish, and the results could be interpreted as how parental care has arisen in vertebrates.

Breeding success and conservation management of Collared Pratincole (*Glareola pratincola*) breeding in aricultural habitats of the Nagykunság region

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The Collared Pratincole (*Glareola pratincola*) is one of the most endangered breeding shorebirds of Hungary. It disappeared from the traditional grassland breeding sites before 2000 and is currently breeding only in three sites in agricultural environments in Hungary. The nests are exposed to considerably higher threat in the agricultural environment and the breeding success is therefore considerably lower when compared to that in natural habitats. Data has been collected since 2008 as part of preparations for the conservation of the largest population, which is found in the Nagykunság. Additionally, we found that colony sizes were substantially smaller during the research period than those found earlier, in the traditional grassland habitats. Highest levels of breeding success were experienced in fallow lands compared with other agricultural fields. We also listed all threats and measures of the conservation for this species. Finally, proposals were given to preserve the species in the long run.

Reproductive performance of the European roller in Southern Hungary

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The European roller (*Coracias garrulus*) is a medium size secondary-cavity nester species, which nowadays highly depends on the availability of artificial nest-boxes in Hungary. In this study we aimed to investigate factors affecting rollers' breeding success in agricultural and their more traditional grassland habitats in Sourthern Hungary. Rollers' egg laying date, clutch size and reproductive success in farmland mosaics and grassland habitats were compared. Prey abundance and diversity estimated by sweep netting and pitfall trappings, as well as feeding rate were evaluated. Their effects on breeding performance were analysed by generalized linear models. In the heterogeneous agricultural habitat Rollers showed an even higher reproductive output than in their traditional habitat of natural grassland. Prey composition showed differences between the two habitats, with the lower abundance of orthopterans in farmland mosaics being substituted by the higher abundance of coleopterans and higher diversity of arthropods. Our results showed that this species can thrive where good quality resources are available, even outside of their typical habitat, where nest-box provisioning schemes may benefit this threatened species.

Cooperation and parental senescence

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Helping by group members is predicted to lead to delayed senescence by affecting the trade-off between current reproduction and future survival for dominant breeders. Here we investigate this prediction in the Seychelles warbler, *Acrocephalus sechellensis*, in which mainly female subordinate helpers often help dominants raise offspring. We find that having female helpers (i) compensates for senescent declines in provisioning rate and offspring survival of dominant females, and (ii) is associated with higher late-life survival and delayed senescence for dominant females. Female dominants with a female helper show reduced telomere attrition, a measure that reflects biological ageing in this and other species. Finally, the probability of having female, but not male, helpers increases with dominant female age. Our results suggest that delayed senescence and improved offspring survival are key benefits of cooperative breeding for elderly dominants and support the idea that sociality and delayed senescence are positively self-reinforcing.

How to define and estimate reproductive synchrony indices for insect populations

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Same-generation individuals of an insect population spend their adult life more or less synchronously, but due to the variance in timing of emergence and lifespan, the synchrony is not perfect. Protandry, when males emerge earlier than females, is also typical. Between-sex asynchrony results in reduced mating opportunities, while within-sex asynchrony reduces mating and resource competition. However, no metrics exist that characterise this (a)synchrony between individuals in a population. We define a reproductive synchrony index (RSi) to gauge individual-level mating opportunities for adult insects. RSi was calculated as a ratio of the number of days overlapping between the i-th imago's lifespan and all opposite-sex individuals' lifespans, to the maximum number of days they could have shared, had they emerged the same day. Similarly, we computed a competitive synchrony index, CSi, to measure within-sex competition for mating, experienced by the i-th individual. Finally, the synchrony of the whole population can be defined between-sex (RSp) to describe how individuals of a population exploit mating opportunities, and within-sex (CSp) to measure the strength of mating competition.

RSi and CSi can be estimated from mark-recapture data that cover the entire reproductive period. We tested these indices on simulated and real mark-recapture data of the Clouded Apollo butterfly *Parnassius mnemosyne*.

In contrast to adult and operational sex ratio, these indices emphasise individual differences in mating opportunities and competition. RSi and CSi declined over the reproductive period and increased with lifespan. RSp and CSp can be used to compare synchronicity across different reproductive periods, populations, or species.

Applications of knowledge on reproductive strategies in conservation biology: historical gaps, present efforts, and future avenues for integration

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Despite several calls for a better integration of methods, results and insights from ethology/behavioural ecology into conservation science and practice, there is still a gap between these two disciplines. In the first part of the talk I will discuss historical reasons for this gap and will continue by highlighting several areas in which progress has been made recently, using case studies on reproductive strategies as examples wherever possible. In the second part of the talk I will briefly summarize studies from our research group that have a bearing on whether and how knowledge of reproductive strategies in animals and plants can be integrated in conservation practice to increase the efficiency of conservation actions. I will start from ecological/perceptual traps influencing habitat choice and reproductive strategies in threatened animal species and end at a macroevolutionary scale, where adaptation of plant reproduction and diversification patterns suggests new avenues for conservation.

Predictors of adult sex ratios in tetrapods: sex determination, mortality, and maturation

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Adult sex ratio (ASR) is an important demographic property of populations influencing reproductive behaviour, productivity and population persistence. We recently showed that variation in ASR across tetrapods is related to the type of genetic sex determination (GSD) system, with typically more male-biased ASRs in ZW than in XY species. This difference can be explained by mechanisms that either distort the sex ratios in embryos, or lead to sex difference in mortality and/or maturation after birth. Here we test these alternatives using comparative methods and data on sex ratios, sex-specific mortality, and age of maturation in more than 400 tetrapods. We show that birth sex ratio is not associated with types of GSD nor with ASR, rejecting a pre-birth origin of ASR difference between XY and ZW species. Males have higher mortalities relative to females in XY than in ZW species both in juveniles and adults, although in juveniles results differ between proxies of mortality. Sex-specific maturation tends to be more male-biased (males maturing later than females) in XY than in ZW species, but its association with GSD is weaker than those between GSD and mortality. These results suggest that mechanisms acting after birth, most likely through juvenile and adult mortalities, generate ASR difference between genetic sex determination systems.

Coevolution of sex ratios and sex-specific parental roles

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The behaviour of male and female parents is often different and numerous evolutionary hypotheses have been put forward to explain the causes of variation. Recent theoretical and empirical studies suggest that sex differences in parental behaviour are related to biases in the sex ratio. However, the causal relationship between parental sex roles and sex ratio bias are often not clear. Moreover, there is considerable debate in the literature on whether the "adult sex ratio" (ASR, the ratio of adult males to adult females) or the "operational sex ratio" (OSR, the ratio of males that are ready to mate to females that are ready to mate) is more relevant for the evolution of parental sex roles. Theoretical arguments are difficult to judge, since they tend to be based on the sophisticated (and error-prone) analysis of an abstract fitness function. In addition, they neglect the possibility of individual variation and the ability of organisms to make their parental behaviour dependent on their own state and on environmental conditions. Here we address these shortfalls by investigating the joint evolution of parental sex roles, ASR and OSR in a suite of individual-based simulation models. When we biased the ASR by sex-differential juvenile mortality, uniparental female-care evolved when the ASR was female-biased, while uniparental male-care evolved under a male-biased ASR. In general, however, neither ASR nor OSR were drivers of a parental care bias but rather co-evolved with care bias in a subtle manner. We show, for example, that in replicate simulations a broad spectrum of care biases and biases in both ASR and OSR can evolve, and that parental care bias can be associated with OSR and ASR in opposite ways.

Do alien plants perform better at endozoochorous dispersal than natives? A case study with mallards

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Alien plants are spreading across the world's aquatic ecosystems, with major impacts on the native biodiversity and huge economic consequences. Field studies have shown that waterbirds, especially members of the Anatidae family, are major vectors of dispersal for a broad range of plants whose propagules can survive gut passage. Migratory waterbirds are likely to have a main role in the spread of many alien aquatic organisms with propagules capable of surviving gut passage. However, at the moment, we have limited information on the effectiveness of this dispersal method in the case of alien plants. We conducted a force-feeding study with mallards (*Anas platyrhynchos*) to see how alien and native plants differ in their dispersal potential. Using six congeneric pairs (overall twelve species) of alien and native wetland plant species, we examined the effect of seed size, shape, hardness and nativeness on the proportion of seeds surviving through mallards, and their retention time within the gut. Intact seeds from all 12 species were egested, but most of the passed seeds belonged to the alien *Juncus tenuis* and *Typha laxmanii*. Most seeds were passed within 4 hours, but eleven species had a maximum retention time over 24 h, facilitating long dispersal. All the species had viable passed seeds, but more native species had higher germination rates. Our study is the first to compare directly alien and native congeneric species survival in the avian gut. Our results highlight the importance of waterbirds in the spread of alien species. They also have a vital role increasing the connectivity between populations of native aquatic organisms, playing a central role in metacommunity dynamics.

Dispersal decisions and the presence of endosymbionts in an inbred social beetle

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Some social species are known to have persistent inbreeding with little deleterious consequences, and outbreeding may even be genetically disadvantageous. In these species, the individual's decision whether to stay in the natal group and inbreed or disperse to outbreed is a consequence of balancing social, genetic and ecological benefits and costs. The haplo-diploid beetle *Coccotrypes dactyliperda* (Scolytidae: Xyloborinae) lives in extended family colonies inside date seeds, where beetles undergo several generations of extreme inbreeding. Yet, outbreeding can occur, involving dispersal away from the maternal seed. We investigated dispersal decisions and fitness consequences in inbred and outbred individuals in relation to colony sex ratio and the abundance of two common endosymbionts. Inbred females dispersed earlier than outbred ones and had a greater relative amount of *Wolbachia*. In behaviour trials, dispersing beetles were more active than ones that remained in the natal seed, but this was unrelated to breeding history. Inbred groups had fewer offspring than outbred ones, and outbred adults that remained in the natal seed were heavier than remaining inbred adults. However, within each breeding system, dispersing and remaining beetles did not differ in body mass. As food was not limiting in this experiment, we suggest that long periods of inbreeding negatively affected female fitness. In order to improve their condition, inbred females should seek outbreeding opportunities through dispersing from the natal seed. Our results suggest that the presence of an increased relative quantity of *Wolbachia* is associated with an increase of activity levels of their host beetles.

Matriliny in China: Using the toolkit from behavioural ecology to study cultural evolution.

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Human social systems are very diverse. Here I will outline how Tinbergen's four questions, 'Four whys', help frame our thinking about understanding the evolutionary basis of human marriage and kinship behaviour. I will argue that this framework is still useful in our study of cultural behaviour. I illustrate the approach with studies of proximate mechanisms, evolutionary dynamics, and phylogenetic comparative methods, to ask why some groups in China are matrilineal (female-centred) and some are patrilineal (male-centred). Comparisons between households, and between different Sino-Tibetan groups, all shed light on the behavioural ecology of the different social systems. I examine, among other things, the role of relatedness, dispersal, sex ratio and witchcraft beliefs in establishing social relationships in these communities.

Extra-pair paternity and intraspecific brood parasitism in the Red-footed Falcon (*Falco vespertinus*) using species-specific and cross-species microsatellite markers

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In the last decades molecular genetic tools brought a revolution and several beliefs were overwritten in studying the avian mating system. However Falco species are considered as socially monogamous, based on some studies and observations it is known that they are also characterized by a low rate of extra-pair fertilization (EPF). Red-footed Falcon (*Falco vespertinus*) is a facultative colonial raptor species and there is no genetic information about its mating system. In our research we wanted to study the extra-pair paternity (EPP) and intraspecific brood-parasitism (IBP) in the Hungarian Red-footed Falcon colonies. In this study, using species-specific (seven) and cross-species (five) microsatellite markers, 210 individuals (45 families) were investigated. The resolving power of the entire marker set of 12 loci was PI=2.2 x 10-15. After genotyping the whole broods and the social parents our results showed a low frequency of EPP. We found two nests (4.44%) from 45 families in which two-two chicks derived from extra-pair fertilizations. The analyses also revealed a higher incidence of IBP. In four nests (8.88%) we found chicks genetically incompatible with the putative parents. All in all 9.4% of the chicks (117 in total) were extra-pair offsprings. Our results show that the EPP rate in the Red-footed Falcon fits into the trend observed among other Falcons, and raising the sample size compared to previous studies does not change this. The frequency of IBP was higher in contrast to the results of other studies and the rate of EPP. To date there is little information about IBP among Falcons, and the Red-footed Falcon as a unique raptor species might play an important role in understanding the constraints and behavioral traits participating in the alternative reproductive strategies.

Does social structure relate to breeding ecology? A case study with an island bird, the Kentish plover

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The breeding success of individuals is shaped by a complex interplay of social and abiotic environmental factors. The social environment may impact individual breeding success by influencing population processes such as the flow of information and diseases, as well as rates of cooperation and conflict. The influence of these factors may vary across multiple stages of reproduction from mating, to incubation and brood care. However, we currently lack a consolidation of what stages of reproduction are mainly influenced by the social environment, and its repercussions for individual breeding success. Here we utilise information on pre-breeding sociality in the ground-nesting shorebird, the Kentish plover (*Charadrius alexandrinus*), in combination with information on mating decisions, nest location and breeding success, to reveal the impact of social structure on breeding ecology across multiple stages of reproduction. Our results suggest that social structure outside of the breeding season may influence patterns of reproductive pairing but its effect on spatial organization of breeding territories and on breeding success is limited. Instead site fidelity and previous breeding experience may be a relatively stronger driver shaping the spatial organization of breeding pairs. In conclusion, our results shed light on the way in which social behavior and social strategies may influence the breeding ecology of a wild bird across multiple stages of reproduction.

Emergence of reproductive isolation in ecological speciation

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Ecological/adaptive speciation is the most parsimonious concept of speciation, which goes back to Darwin's original ideas. It posits that evolutionary diversification is driven by adaptation to different of ecological niches. Emergence of reproductive isolation is assumed to be a consequence, instead of a prerequisite, of diverging adaptation. Evidences for ecological adaptation, as well as for prolonged gene flow, during speciation provide ample empirical support. Two model studies of adaptive emergence of reproductive isolation during ecological speciation are reported in the lecture.
With Ulf Dieckmann we studied an individual-based multilocus model of sympatric speciation, with the aim of deeper understanding of the genetic mechanisms of transition from a single population into a pair of discrete populations. The interlinked evolution of assortativity of mating and the variance of an ecological trait leads to a gradual emergence of reproductive isolation; the process is finalized by sexual selection. Ecological selection may, or may not linked to spatial segregation.

With Benjámin Márkus we compared speciation based on resource- and habitat-segregation in a model context that considers the two types of niche segregation on equal footing. In the case of pure resource segregation, reproductive isolation is purely driven by the disadvantage of the ecological hybrid. In contrast, migration rate becomes an important factor for habitat-related speciation. Reduced migration helps emergence of complete reproductive isolation in some cases, but has an opposite effect in others.

What can movement ecology tell us about reproductive strategies?

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The emerging field of movement ecology largely benefited from the recent development in wildlife tracking technologies, enhanced computation abilities and powerful data analysis tools. Movement ecology studies have utilized those technological advances, along with new conceptual/theoretical frameworks, to elucidate movement patterns, the underlying movement processes and their ecological and evolutionary consequences. Despite these significant advances, some of the key questions on how movement shapes the ecology, behavior and evolution of organisms across multiple spatial and temporal scales remain unresolved. In this talk, I will highlight some of the most exciting developments and challenges in movement ecology, and focus on insights relevant to the study of reproductive strategies of both animals and plants. These include (i) how does variation in various life-history traits determine reproductive phenology and spatial spread of wind-dispersed trees? (ii) how does early-life experience determine flight performance and survival of migrating storks and cranes, and foraging vultures? and (iii) how do diurnal (jackdaws, black-winged kites, kestrels) and nocturnal (barn owls and fruit bats) foragers differ in their movements in relation to sex, age and reproductive state?

Blind date: Insights into the reproductive biology of the Blind mole rats

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The Eurasian Blind mole rats (Rodentia: Spalacinae) are solitary rodents extremely adapted to a subterranean way of life. They spend their entire life underground and are the only rodents on Earth that are completely blind. Because of their very special lifestyle and elusive nature, many aspects of their biology are still unsolved. Among others, many details of their reproductive biology are still puzzling.

A new population of blind mole rats was established by means of translocation of individuals to a potentially suitable site previously lacking any blind mole rat population. In our year-long study, we follow the activity patterns of 13 translocated individuals (4 males and 9 females) every week, by recording the coordinates of the fresh mounds using a sub-meter scale GPS device.

Blind mole rats were found to have several activity periods during the year, interrupted by times of inactivity. We succeeded in identifying activity periods related to mating, nursing of the young and the dispersal of subadults. Activity patterns of the sexes were different throughout the year. Males are more active during late winter and early spring when they are searching for mates, whereas females are more active during the spring, which is most probably the period of nursing. Spatial changes of the tunnel systems were also evident during the year and were connected to such behaviours.

Earlier studies suggested that activity patterns of fossorial mammals are influenced by environmental factors, while others conclude that these factors have no such effect. We found weak connection between the air temperature and the periods of activity, while significant correlation was found between precipitation and the time of activities.

Divided we stand, united we fall? - Fragmentation and clonal reproduction in plants

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The genetic individual (genet) in clonal plants can get fragmented into multiple, physiologically independent subunits (ramets). This capability has appeared multiple times during the evolution of plants, and diverse morphological solutions have evolved for fragmentation. It is interesting to consider a genet as a network consisting of semi-autonomous agents, which can exchange resources and information along the existing links. Spatially adjacent ramets necessarily compete with their root and shoot systems, but this competition can be overwritten by cooperation between those ramets that are linked, even across large distances. When is it adaptive to maintain the links, and when is it more advantageous to split? The question is not easy, as survival versus death of the links can affect the demography of ramets (i.e., of nodes in the network). By these means, the genet can dynamically rearrange itself according to the actual pattern of available resources. I present some frequently occurring strategies of fragmentation, revealed by experiments on various clonal species. We applied spatially explicit population dynamic models for studying the adaptive value of these strategies in various habitat types. The results suggest that the evolutionary transition is relatively easy in both directions, from fragmentation to integration and back. Empirical studies also confirm that fragmentation is a flexible trait both on a micro and macro-evolutionary time scale. Plant clonality thus provides an exciting opportunity for studying hierarchical selection in action, with three levels of organization (ramet, fragment and genet), and to investigate collective behavior in groups in which the links between the members are well-observable.

Community constraints on plant reproductive strategies

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Species exist in communities that shape their reproductive strategies via their interactions. An indirect way to account for this used to be the consideration of density-dependence of the optimal life-history strategies. Subsequently, the theory of adaptive dynamics and eco-evolutionary modeling have provided a more general framework for studying the effect of interactions on life-history traits. Independent of these approaches we developed a classification of primary plant strategies based on four factors characterizing the effects of their community-types. Two-two factors stand for the level of productivity and the level of losses within the given layers of certain communities, respectively. Productivity is characterized by light intensity and the supply rate of soil resources, while we differentiate between loss of biomass without death and average mortality as types of losses. The main factor limiting population growth shapes the primary plant strategy. In this way, 5 primary plant strategies are defined. The sets of the admissible reproductive strategies are constrained by the adopted primary strategies. We shall outline the full argument and provide examples.

Broodmate aggression and life history variation in accipitrid birds of prey

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Aggressive sibling competition for parental food resources is relatively infrequent in animals but highly prevalent and extreme among certain bird families, particularly accipitrid raptors (Accipitriformes). Intense broodmate aggression within this group is associated with a suite of traits including large adult size, small brood, low provisioning rates and slow development. In this study, we apply phylogenetic comparative analyses to assess the relative importance of several behavioural, morphological, life history and ecological variables as predictors of the intensity of broodmate aggression in 65 species of accipitrid raptors. We show that intensity of aggression increases in species with lower parental effort (small clutch size and low provisioning rates), while size effects (adult body mass and length of nestling period) are unimportant. Intense aggression is more closely related to a slow life history pace (high adult survival coupled with a restrained parental effort), rather than a by-product of allometry or food limitation. Consideration of several ecological variables affecting prey abundance and availability reveals that certain lifestyles (e.g. breeding in aseasonal habitats or hunting for more agile prey) may slow a species' life history pace and favour the evolution of intense broodmate aggression.

Sexual selection in contagious pathogens: case studies on parasitic lice (Phthiraptera)

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The evolution of species that live a permanent parasitic way of life may seem to be affected only by a single source of selection pressures, i.e. their host organisms. This view is misleading, however, since parasites are often subjected to strong selection pressures exerted by conspecifics, including sexual selection pressures. Several pathogen species allocate a huge proportion of resources into sexual rivalry and sexual reproduction. Macroparasites, especially parasitic insects, offer an optimal choice to study the evolution of sexually selected traits in pathogens. Their sex ratios and sex allocation patterns are easily quantified because they are easy to count, to sex, and their body proportions (sexual versus vegetative organs) are well defined. I will summarize two recently published studies on the evolution of sexually selected traits in parasitic lice.

First, I will show that sexual size dimorphism in two taxonomic families of lice complies with Rensch's rule, while a third one complies with a reversed Rensch's rule. The reason for this difference is not yet known.

Second, I will show a case study indicating that pathogens are highly sexually selected in the center, but weakly sexually selected (or even asexual) on the peripheries of their geographic distribution, similar to the patterns experienced in several free-living taxa.

Canopy size, conspecific distance and elevation predict insect herbivory in olive plants (*Olea europaea*)

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Plants form the basis of energy flow in an ecosystem. Various organisms are dependent on plants for food; include herbivorous insects, and this dependency harms the plants, which have evolved defensive mechanisms to resist those harms. Herbivorous insects are in turn attacked by other groups; carnivorous, that depend on them for food. Thus, plants are the refuge that many organisms utilize to obtain their food. Consequently, elevation gradient can have significant impacts on both insects and host plants performance. Here, olive plants (*Olea europaea*) were used as focal plants in a study conducted at Almeria, southeast Spain to test 'Dick Root's Resource Concentration Hypothesis'. Our results revealed that elevation significantly limits the number of herbivorous insects and carnivorous species on olive plants. The result also showed that olive plants with small canopy cover experienced higher attack from herbivores and had lower carnivore concentration, whereas those with large canopy cover experienced less attack and had higher carnivore concentration. Our results also revealed that olive plants with small canopy cover and in proximity to conspecific neighbours experienced increased attack from herbivores. Our findings lend to the idea that carnivores, through their obtaining shelter and preying on herbivores, provide protection to the olive plants in exchange. These findings can therefore support steps for biological control methods in olive plantations.

Harem size variation in Przewalski's horses in a European reserve

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Przewalski's horse (*Equus ferus przewalskii*) went extinct in their native habitat in the late 1960s and various breeding programs started to build up populations from a small number of individuals. As a part of breeding programs, the first six horses have been introduced to Hortobágy National Park, Hungary and by 2012 this population reached 198 individuals. Our goal here was to investigate harem size variation in this population between 1998-2012. The study population was slightly female biased over the study period, and approximately half of the males attained his own harem (N= 78 adult males). We show that harem size (number of adult females per group) varies between 1-5 females (mean ± SD = 3.44 ± 2.64, N = 39 harems). As the population grew, the number of harems increased from 3 harems in 1998 to 25 harems in 2012. In our population, changes in harem size were significant but not in linear connection with year. Harem size did not show seasonal changes. Age of the harem stallions was a good and stable predictor of harem size. However, the connection between stallion age and harem size wasn't linear, there is an optimum age between 4 and 10 years when the stallions can tend a harem group. The lack of seasonal changes in harem size in this population can occur because there are no seasonal changes, or may be caused by stable resources. Stallions' age has an effect on the social structure of this species, which is probably an indirect consequence of age- dependent abilities. We should consider this pattern when designing new populations.

A change in the reproductive strategy of the invasive parasitic fly *P. downsi* causes increased mortality in its avian hosts on the Galápagos Islands

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The larvae of the parasitic fly *Philornis downsi* are obligate parasites of bird nestlings. The flies lay their eggs in host nests and the developing larvae drink the blood of the nestlings. This recently introduced parasite has a dramatic impact on the bird community of Galápagos. Our experimental studies show that the parasitic larvae causes high levels of brood loss in arboreal Darwin's finches and the endemic Little Vermillion Flycatcher (*Pyrocephalus nanus*), which contributes to dramatic population declines. Over the last two decades, parasite intensities have increased, while breeding success has decreased in some species and chicks die at an earlier age. Another factor that might influence virulence is the timing of infestation within the breeding cycle. Our data suggests that behavioural changes have evolved in the parasite in this recently established host parasite interaction: while previously it laid its eggs only in nests where chicks had already hatched, it now already lays in incubating nests where the larvae attack incubating females. In an experimental study we compared breeding success, parasite prevalence and intensity during incubation and nestlings phases in the Small Tree-finch (*Camarhynchus parvulus*), the Green Warbler-finch (*Certhidea olivacea*) and the Little Vermillion Flycatcher. Our data indicates that early infestation of nests leads to increased nestling mortality, which contributes to the rapid decline of the host species. Our findings have implications for conservation of the Galápagos avifauna.

The role of plant dispersal and establishment in restoration projects

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A basic challenge of ecology is to understand the mechanisms that generate changes in the composition of communities. Dispersal is a fundamental force affecting community dynamics, as well as the management of species diversity, particularly in patchy and fragmented environments. The neutral theory of biodiversity suggests that ecological drift is also important in structuring communities due to demographic stochasticity. Ecological drift causes species abundances to fluctuate randomly. The neutral theory of biodiversity offers a starting point for understanding the effects of ecological drift among species, and forms the basis of testing the hypothesis that communities are structured by chance demography.

In a manipulative field experiment we opened establishment gaps of $1m^2$, $4m^2$ and $16m^2$ size by tilling in a grass swards of restored grasslands in East-Hungary. In these gaps we sowed high-diversity seed mixtures containing 35 native species in six restored grasslands. The grasslands restored by seed sowing are usually species-poor. Sowing of grass seed mixtures is a feasible and cost-effective method for landscape-scale restoration. However, sowing grass seeds generally leads to the development of a species-poor and dense grass sward, where the establishment of target forbs is hampered by both microsite and propagule limitations. Thus, our experiment was also motivated by the aim to increase diversity, by overcoming these limitations of species-poor restored grasslands. We analyzed the vegetation development of the gaps in the first five years after sowing and also the colonization dynamics of the sown species in four 20-m-long transects around each gap, containing a total of 1440 plots of $1m^2$ size. Our results indicated that most of the sown species were able to establish permanently in the establishment gaps. The highest number of species and individuals dispersed from the $4m^2$-sized gaps, as they had a more stable development than small gaps but experienced lower grazing pressure than large ones.

Sex-specific cellular immunity in wild birds: a meta-analytic approach

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The immune system allows animals to respond to the invasion of the organisms by germs and other microorganisms. In vertebrates, the immune response depends on special cells, proteins, tissues and organs. The study of immunity in vertebrates has been dominated by studies in mammals, where sex-differences seem to appear mainly mediated by the overall immunosuppressive properties of androgens and the immune-enhancing effect of oestrogens. However, in birds, whether males or females differ in immune response still remains obscure. Here we used meta-analytic methods to analyze the cellular immunity (white blood cell counts and immune response to phytohaemagglutinin) in relation to sex, to parasite infection and to seasonality across wild birds. We found that in the absence of disease, only heterophils and lymphocytes presented a female and male bias, respectively. This sex bias disappeared when parasite infection was present. The effect of seasonality showed that during the non-breeding season, heterophils and lymphocytes show a female and male bias, respectively. Whereas during the breeding season, heterophiles reduced their degree of sex bias, while lymphocytes presented no sex bias. Overall, our findings suggest that sexual differences exists in immunity also among birds, however more detailed research is needed to untangle the effect of sex in the different components of the immune system in birds and the fitness consequences of these differences.

Why do frogs have extremely diverse parental care? Phylogenetic analyses of environment, life histories and climatic factors

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Parental care is one of the most complex and striking social behaviours, and anurans (frogs and toads) stand out as having an unusually diverse reproductive behaviour that includes parenting. Here we investigate the parental care evolution using over 1000 frog species that represent all major lineages. We use phylogenetic comparative analyses to test the effects of life histories, climatic and social environment, and sexual selection on parental care. We found that three aspects of parental care, the duration of care, the level of protection, and the level of nourishment, increased when frogs started to reproduce on land. Terrestriality facilitated the emergence of diverse care forms like nest building, attending, and carrying, both by males and females. Also, climatic conditions contributed to care diversification, because adverse (i.e. hot and dry) climates triggered passive protection of the progeny (nest building), while more favourable, mild and humid climates promoted care forms with longer active involvement of the parent(s), such as attendance or trophic egg feeding. Further analyses have uncovered the potential roles of life history traits (clutch size and egg size), and sexually selected traits (eg relative testis size) in care evolution. In conclusion, parental care was a key innovation in amphibians that enabled them to occupy new, terrestrial habitats, and the various challenges posed by different climatic conditions were overcome by adapting diverse caring strategies.

Field biologists as seed dispersers - New aspects of human-mediated seed dispersal

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Due to increased human mobility, cloth-dispersed seeds can be transported over long distances, which would not been bridged otherwise. Thus, human-mediated dispersal can be the starting point of biological invasions in some cases. We studied new aspects of human-mediated seed dispersal in a series of field and greenhouse experiments, focusing on the fate of cloth-dispersed seeds after laundry washing. We asked the following questions: (i) Are cloth-dispersed seeds able to germinate after the laundry cycle? (ii) What are the effects of washing on the fitness of germinated seedlings and on the temporal dynamics of germination? We studied the germination of 18 species, which have morphological adaptations for epizoochory and are commonly dispersed by people. We tested six treatments (washing with water, washnut or detergent, at 30°C or 60°C) compared to an untreated control. Our results showed that washing temperature was the most significant factor affecting germination. Washing at 30°C did not suppress germination of any of the studied species. Washing at 60°C supported the germination of two species, but suppressed six species. The intensive washing treatments at 60°C decreased significantly the synchrony of germination. Our measurements showed that more than 70% of attached seeds remain on our clothes for more than 8 hours and have the chance to enter the laundry cycle. 64% of washed seeds fall down from clothes during drying, thus, they might establish in an urban or rural environment. The remaining 36% of washed seeds can further disperse over a longer distance. Our results showed that people are not purely transporting seeds from one location to another, but via the laundry cycle we also influence the fate of the transported seeds by affecting germination potential, seedling fitness and germination dynamics. These results have new implications for understanding the early stages of biological invasions.

Polyandry and sexual selection in insects

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Polyandry is known in several groups of insects, as well as birds and mammals. I consider the mating here as male investition to female via a spermatophore, since proteins and other nutrients that are available during the larval period are hard to obtain during the adult nectar-feeding stage. It was shown that some nutrients transmitted by copulation have been found in both the eggs and soma of females. Thus, spermatophores function as nuptial gift.

The number of matings for each female can be calculated either by visual observations or by dissection of females and then counting the number of spermatophores they contain. We followed this second way based on a large material of moths collected by different traps. I will show that the level of polyandry is higher in some subfamilies and genera of Noctuid moths than the figures published in review papers.

Based on our data I can re-visit and test some earlier hypotheses. Polyandry in females enables the opportunity for sexually antagonistic selection. It was suggested that this type of selection promotes speciation, therefore monandry likely results in lower speciation rates than would be expected in related polyandric clades. I will show that in our cases all genera are highly diverse and have co-evolved inner genital structures („lock-and-key"). It means that the exactness of spermatophore transfer is a tool of cryptic male competition, in other terms of post-copulatory sexual selection. The changes in external genital appendages serve as a complementary process which results in a pre-copulatory selection. Evolution of the secondary asymmetry of these appendages can enhance the possibility of sexual selection by different allocation of sensory and mechanic structures.

Supposedly, there is an interaction between sex ratio and polyandry. If it is biased for males it implies a higher level of polyandry. Therefore sex-biased sampling, e.g. by light traps should be avoided, and new methods of trapping, e.g. volatile traps should be preferred.

Adult sex ratio affects contest and courtship strategies, but not defence strategies in dung beetles

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Adult sex ratio (proportion of males in adult populations; ASR) is a fundamental concept in evolutionary biology. ASR has been shown to influence breeding systems, as the rarer sex in a population has more potential partners to mate with than the more common sex. Several studies have also shown that ASR influences contest and courtship behavioural strategies of individuals. However, most studies have focused on only a single specific behaviour. Here, we investigate the implications of ASR on contest-, courtship-, and defence behaviours and frequencies in dung beetles (*Onthophagus taurus*). We predict that variation of ASR influences the intensity of contest, courtship and defence behaviours. To do so, we manipulated the ASR of groups (female-biased, unbiased and male-biased) and subsequently monitored the frequencies of the aforementioned behaviours. We found that ASR had indeed a significant positive effect on contest and courtship frequencies in both males and females. ASR had no effect on defence frequencies. Our research contributes to the influences of ASR on behavioural processes, which in turn may influence reproductive strategies.

Body size-related survival in a natural population of Clouded Apollo butterflies, *Parnassius mnemosyne*

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Students of behaviour, ecology, and evolution investigating natural populations aim to estimate fitness by measuring reproductive success (RS). Body size is often related to RS. Various proxies for RS and body size have been routinely measured in many vertebrates. However, in most insects such proxies are unavailable because observation and measurement of live, tiny, fragile organisms is challenging. The mark-recapture method is frequently used to estimate insect survival, and survival is often related to body size and fitness.

We aim to find body size variables that predict individual survival in butterflies. We conducted mark-recapture sampling in a natural population of the Clouded Apollo butterfly in three subsequent years (2016–2018). Body size parameters such as wing and proboscis length, thorax width and body mass were measured for each (re)captured individual. These parameters were used as individual covariates in the Cormack-Jolly-Seber models to estimate survival.

Body mass and thorax width decreased with butterfly age. Female survival related positively to body size in all years, except that females with longer proboscis lived shorter in 2018 and survival decreased with the body mass measured at first capture. Male survival rather changed with time and did not relate strongly to body size in 2016–17, while males heavier at the first capture survived longer in 2018. Survival of both sexes decreased with the rate of body mass decline (2017–18).

Body mass decline rate seems to be a good indicator of aging. Other body size parameters related to survival inconsistently. Annual variation in body size ~ survival relationships imply severe environmental fluctuation impacts. Sex differences in size-dependent survival might be explained by male size relating to mating success rather than survival, whereas female size relates to egg production, and fecundity is also likely positively related to survival.