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ABSTRACT BOOKLET
ORAL & POSTER PRESENTATIONS

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ORAL PRESENTATION ABSTRACTS

(Alphabetical order by presenter's last name)

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Acoustic performance in signalling bush-crickets: Light males adopt lower-frequency signals in competition

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Bush-cricket males signal to attract conspecific females and to repel rivals. Males adjust their acoustic features depending on their energetic status and the surrounding environment. In *Poecilimon*, males compete only through sounds, mainly signalling all night. Little is known about the variation of males' acoustic behaviour during contests of extended duration. We compared the signal's parameters of light and heavy males of *Poecilimon ampliatus*, in both isolation and competitive (playback) conditions, and examined how signals changed during the one-hour recording from the beginning to the end. We found that light males signalled with lower dominant frequency during the competition, while heavy males did not change their dominant frequency. We found no modification over recording time. Furthermore, we found that heavy males signalled in competition with a higher duty cycle than in isolation, independently of the recording time. Light males also signalled with a higher duty cycle in competition than in isolation, but only at the beginning of the recording. When signalling in isolation, all males varied their duty cycles over time, which were higher at the end than at the beginning of the recording. These results suggest that males' signals were affected by both their body mass and the social context. Furthermore, the duty cycle depends on the amount of time males had spent signalling. Surprisingly, only light individuals adjusted their dominant frequency when social conditions changed. Light males' signals, emitted at lower frequencies, might present a reduced attenuation, higher effectiveness and thus be more audible by distanced females.

Peeking through the foliage: Range resolution in echolocating bats

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Many echolocating bats forage close to vegetation - a chaotic arrangement of prey and foliage where multiple targets are positioned behind one another. Bats excel at determining distance: they measure target range by the delay between outgoing call and returning echo. In their auditory cortex, neurons are arranged by the specific delay they respond to, forming a topographic map. This would suggest that bats can resolve echoes of multiple targets along the range axis: a skill crucial for the forage-amongst-foliage scenario. We explicitly tested this hypothesis combining an auditory virtual reality with formal psychophysics: We simulated a prey item embedded in two foliage elements, one in front of and one behind the prey. The simulated spacing between “prey” (target) and “foliage” (maskers) was defined by the inter-masker delay (IMD). We then trained *Phyllostomus discolor* bats to detect the target in the presence of the maskers and systematically varied both loudness and spacing of the maskers. We show that target detection is considerably impaired when maskers are closely spaced (IMD < 1 ms), but remarkably improves when the spacing is increased: the release from masking is about 5 dB for intermediate IMDs (1 - 3 ms) and increases to over 20 dB for large IMDs (≥ 9 ms). These results suggest that prey would enjoy considerable acoustic protection from closely spaced foliage, but also that the range resolution of bats would indeed let them “peek into gaps”. Our study puts target ranging into a meaningful context and highlights the limitations of computational topographic maps.

Sensitivity of bush-crickets to climate change revealed by large-scale acoustic monitoring

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Monitoring biodiversity over large spatial scales is crucial for assessing the impact of growing climate changes. New technologies such as high frequency autonomous recording and machine learning for vocalisation classification unleashed the potential of passive acoustic monitoring schemes intending to track species trends in the long term. Such monitoring schemes have been developed for bats in several countries recently, and bush-crickets (or katydids) have the advantage to be acoustically active in the same frequency range and during the same periods as bats, so species acoustic activity of both groups can be monitored through the very same recordings. French bat monitoring scheme Vigie-Chiro allowed to record bush-cricket activity on 5922 localities during full nights between 2014 and 2018. We used this dataset to track short-term responses of 16 species of bush-crickets to climate change in France. Acoustic data were analysed through a generalised linear mixed model to investigate the interactions between seasonal phenology, seasonal temperature anomalies and species climatic niche (position and width). Seasonal phenologies showed a significant negative interaction with seasonal temperature anomalies, i.e. an average shift of three days°C-1. Results also showed non-linear effects of seasonal temperature anomalies, species with relatively cold climatic niche being negatively affected by anomalies over 1°C whereas species with warm climatic niche took advantage of anomalies over 2°C. These short-term and complex effects demonstrate the value of large-scale acoustic monitoring to study climate change effects on biodiversity, and especially to measure species sensitivity to temperature anomalies, thus highlighting conservation issues.

Multimodal communication in a vocal fish

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Agonistic contests are often mediated by multimodal communication but the way in which visual, acoustic and chemical signals interplay is not yet understood in fish. The cichlid fish *Metriaclima zebra*, like other fish, primarily rely on the use of five sensory channels. They constitute an ideal model for studying the multimodal communication during social interactions. Previous experiments with *M. zebra* have shown that visual signals triggered male aggression but neither acoustic nor chemical signals presented alone were able to induce the same behavioural answer. However, when acoustic signals were combined with visual information, they reduced aggressiveness in this species. Also, in this species sound frequency provides effective information on body size and fish seem to be able to assess the relevance of sensory channels when facing incongruent visual and acoustic body size information. Here we tested how visual, acoustic and chemical signals sent in a multimodal way interplay in a territorial context. Each tested fish received randomly 2 or 3 modalities (acoustic, chemical and visual). The visual stimulus was a live fish and the acoustic signal consisted in the playback of agonistic sounds of a size-matched male. Regarding the chemical stimulus, we used holding water from a dominant male. The behavioural response of the tested individual was measured by counting the agonistic behaviours. As expected the visual stimulus (alone or combined) elicited agonistic behaviour. Surprisingly the combination of acoustic and chemical signals elicited aggressiveness. These results suggest a complex interplay of the three stimuli in shaping agonistic behaviour.

Effects of ecology and mating system on acoustic communication in bark and ambrosia beetles

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Bark and ambrosia beetles (Coleoptera: Curculionidae, Scolytinae and Platypodinae) are two closely related subfamilies of weevils with sound production capabilities. These beetles spend most of their life cycle inside plant tissues and have evolved to display a complex variety of mating systems that are associated with specific acoustic communicatory interactions and stridulatory mechanisms. However, even though bark and ambrosia beetles are some of the few taxa with properly developed acoustic communication in a medium other than air or water, their sound production remains one of the most understudied areas in bioacoustics. Here, we present the most extensive description to date of the types of calls and stridulatory mechanisms in bark and ambrosia beetles. Furthermore, we evaluated the role of environmental and life history features in the variability of their acoustic parameters, and illustrate the importance of acoustic communication in the evolution of mating systems. Sound production in bark and ambrosia beetles can arise in one sex, both sexes, or neither, and the presence of a stridulatory apparatus appears to be associated with the type of mating system. For example, acoustic communication is absent in species that reproduce using inbreeding polygyny. In monogynous species with elytro-abdominal organs, sound production is dominated by males. Both sexes possessing stridulatory capabilities is the norm in Platypodinae, but not in Scolytinae, and females dictate the acoustic interactions in harem polygynous species.

Acts big but squeaks like a mouse: Production of Asian elephant high-frequency vocalisations

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African and Asian elephants demonstrate great vocal flexibility by varying and combining sound sources and vocal tract pathways. Calls range from the commonly used low frequency 'rumble' (fundamental frequency < 20 Hz), produced by flow-induced vocal fold vibration, to high-pitched 'trumpets', produced by a blast of air through the trunk during excitement. Call combinations, sound imitation and invention add variety to the elephants` vocal repertoires which in their complexities are yet far from being completely understood. Recent studies confirm the biological relevance of acoustic information coding in low-frequency rumbles within their complex fission-fusion societies. Only Asian elephants also produce high frequency vocalisations (termed squeaks or chirps) with a fundamental frequency around 1 kHz. We set to study the yet unexplored underlying mechanism and social functions of these particular calls, using sound visualisation (an acoustic camera) along with audio and behavioural recordings in captive Asian elephants. We model and discuss potential sound production mechanisms contrasting probable bio-mechanic vibratory and aerodynamic sources in oral and nasal pathways. We suggest that the variety of sound production mechanisms in elephants allows to overcome the size related limitations of laryngeal sound production to explore a fundamental frequency range spanning seven octaves. This flexibility offers a scope of potential acoustic information coding in order to coordinate complex social interactions in concordance with specific habitat sound propagation properties. Exploring and comparing vocal flexibility across elephant species helps to understand the driving factors of acoustic communication evolution.

The challenges of automatic counting and identification of weak-flying insects using opto-acoustic methods

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In the last five years, there has been an exponential interest in real-time detection of insect threats. Researchers have used electronics to explore the possibilities of detection and have focussed efforts on camera traps with image analysis, radar and lidar all with varying degrees of success. Bioacoustic methods, particularly those using acoustic and optical methods are playing an increasingly important role, often complementing image analysis when identifications are uncertain, as is the case for many insect groups. Here, we discuss the technical challenges of accurately identifying aphid pests to species level using opto-acoustic methods. Aphids migrate just above crop height, producing a wingbeat signal that is an order of magnitude weaker than mosquitoes, making this group hard to detect. Given that there are more than 600 species in the United Kingdom and that these are difficult to differentiate between species even with a microscope, the challenges for automatic detection seem fraught with difficulty. We discuss the technical challenges of accurately identifying aphid pests to species level using opto-acoustic methods. Using fast Fourier transform, a high-pass filter and a detrending step to 'clean' the signal, we plot the frequency spectra generated by a small number of aphid species to indicate the high variability of wingbeat recordings within and between species. Yet, from these we can estimate to reasonable confidence the fundamental frequency, the dominant frequency, the bioacoustic index and the temporal entropy, all of which show some role in aphid species classification.

Song diversity in populations of ultramarine flycatcher across Himalayan gradient

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The present study was conducted to understand the song diversity in the populations of ultrmarine flycatcher (*Ficedula superciliaris*) across the Himalayan gradient (western and eastern Himalayan hills of India). In general, the song of *F. superciliaris* consists of a trill of down-slurred broad bandwidth notes often preceded by a sweet note that differs from the trill note. The initial note was found to vary within a song bout and also within individuals. Five song types based on initial note types were found among which two song types (with high frequency and low frequency initial note types) were present only in western population. Whereas one song type (wide frequency initial note type) was present only in eastern population and two song types (with mid frequency initial note types and song without any initial note type) were present in both the populations. East and west populations differed in song repertoire size; western individuals used 1-3 song types but in the east, individuals repeated only one song type. Thus, the song complexity was found higher in the western population than in the east. Songs in the east were shorter than in the west (east, 0.35 ± SE 0.02 seconds, N = 16; west, 0.50 ± SE 0.02 seconds; N = 34 two sample t-test $p < 0.05$). However, none of the frequency parameters differed significantly between east and west populations.

Vocal fish communities in Mediterranean *Posidonia oceanica* meadows and adjacent areas

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Passive acoustic monitoring (PAM) uses hydrophones to record all components of underwater soundscapes, including fish calls. Several studies have used PAM to investigate different aspects of vocal fish species, such as presence, distribution, relative abundance, diel, lunar and seasonal cycle of activity as well as for delimitating spawning areas and for studying wild fish spawning behaviour. A recent study conducted in Mediterranean rocky reefs has proved that the analysis of vocal fish communities provides high discrimination potential of species assemblages. Aside from this study, most investigations to date have considered fish species in isolation, and there is a general paucity of data addressing acoustic communication of fishes living in natural communities. We present a preliminary characterisation of vocal fish communities over a geographical and environmental gradient in Mediterranean *Posidonia oceanica* meadows and adjacent areas. We compared abundance and diversity of fish sounds recorded during the peak of fish vocal season in *Posidonia oceanica* meadows (-20 m) along a longitudinal axis (Mallorca, Corsica and Crete). In addition, for one site (Corsica), we examined the *Posidonia oceanica* results in the light of the abundance and diversity of fish sounds recorded at the inferior margin of the meadow (-40 m, sandy areas). These results are discussed in a framework that highlights the investment of different vocal fish species in partitioning their active acoustic space (in terms of both frequency and time) over small- and large-scale gradients. Our study supports the potential of PAM to provide high resolution information on fish population dynamics.

Principles of vocal expression of emotions in mammals

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Expression of emotions plays an important role in social species, because it regulates social interactions. Indicators of emotions in human voice have been studied in detail. Similar studies investigating the link between emotions and vocal parameters in non-human animals are increasing. I will illustrate methods to study vocal expression of emotions in non-human mammals using a project that I conducted, aimed at deciphering vocal expression of valence (positive vs negative) in domestic ungulates (horses and pigs) and their closely-related wild species (Przewalski's horses and wild boars). This project combined frameworks adapted from humans to animals to analyse vocalisations (source-filter theory) and emotions (dimensional approach). The results of this project show that ungulates produce different types of calls in situations characterised by positive and negative valence. Additionally, there is some variation and each call type is occasionally produced in the opposite valence. When this is the case, we found that its acoustic structure differs, even after controlling for arousal (bodily activation). Closely related wild and domestic ungulates show both similitude and striking differences in the way valence is conveyed by the call structure. Playback experiments showed that horses and pigs perceive indicators of emotions conveyed by whinnies and grunts, respectively. We additionally performed playbacks of positive and negative vocalisations of conspecifics, closely-related heterospecifics and humans to all four studied species and showed that the animals perceive vocal correlates of emotions across species. These findings lead to a better understanding of the evolution of emotion expression.

Automated species identification of frog choruses in environmental recordings using acoustic indices

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Acoustic monitoring provides exciting opportunities for scaling up bioacoustic study of vocal animals to greater temporal and spatial scales. However, the large amounts of audio that can be easily and efficiently collected necessitates automated methods of analysis to extract useful ecological data. The usual approach to automating analysis of environmental recordings is to develop species call detection software. This is a complex undertaking and has limitations in environments with high background noise and many overlapping calls. We describe an alternative approach to automating acoustic identification of species using acoustic indices. The patterns and acoustic features of many biological sounds can be identified visually in spectrogram images of long-duration recordings composed from acoustic indices. We investigated the efficacy of using acoustic indices as predictors in classification models to identify frog choruses to species level. Several acoustic indices were calculated at a 1-minute scale for a large set of continuous recordings. Random forest classification models were trained for several frog species on samples of the acoustic data, with training minutes validated for the presence or absence of each calling species. The classification accuracy of the models ranged from 94.7% to 98.3% on test data. This presents a promising method of automating the analysis of acoustic recordings to describe and monitor calling phenology in frog communities.

Rhythm measurement: Drum-like beats in bats and whales

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Music is a social phenomenon widespread amongst cultures. Musicality, on the contrary, is a natural and spontaneous trait in any individual: human or otherwise. To gain insight into music's origins, researchers look for musicality in animals. To do so different components of musicality like the temporal structure of animals' vocalisations are investigated. These structures, in other words, these rhythms, are the topic of this talk. How to investigate them in a meaningful, comparable and universal way? Several approaches exist. Here we used three methods to compare the suitability and interpretability for different questions and datasets and test how they support reproducibility of results and bypass biases. Three very different datasets with regards to recording situation, length and context were analysed: isolation calls of the neotropical bats *Saccopteryx bilineata* and *Carollia perspicillata* and click coda of sperm whales. To be able to put the result into perspective, a human drumming sequence was analysed as well. Techniques to be compared included Fourier analysis with a newly developed goodness-of-fit value, a generate-and-test approach where data was overlaid with varying artificial rhythms, and furthermore the analysis of inter-onset-intervals and calculations of a normalised Pairwise Variability Index (nPVI). We show a comparison of the results, different versions for visualisation, and discuss the advantages and disadvantages of all methods. This will enable researchers to decide for a suitable and comparable method on basis of their data and a newly developed decision tree.

Selection of most suitable parameters of vibrational signals of the brown marmorated stink bug, *Halyomorpha halys* Stål (Heteroptera: Pentatomidae) to enhance pest control

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Many groups of insects utilise substrate-borne vibrations for intraspecific communication. This characteristic makes them a suitable model for exploring the vibrations as a tool for pest control, alternative to chemicals. The detailed knowledge of the species communication is prerequisite to select the best signals to use. This study aimed to explore the use of substrate-borne vibrations and further improve existing traps for pest control by using vibrotaxis playback experiments in the brown marmorated stink bug, *Halyomorpha halys Stål* (Heteroptera: Pentatomidae). In order to test signals that improve vibrotaxis, we designed a wooden custom-made T-stand for the trials and gave the males one and two choice tests using signals of conspecific females with varying call parameters (call rate and peak frequency). The arena had a release point, at the base of the T and two stimulation points, one at each lateral end, where the mini-shakers were positioned. All experiments were conducted in the Laboratory of Bioacoustics, of Fondazione Edmund Mach, San Michele all'Adige (Trentino, Italy) inside an acoustically insulated chamber. Insects were exposed to playback experiments and each trial was video recorded in order to analyse the behaviour. The double choice test showed that males of the brown marmorated stink bug were able to identify the best choice and achieve the target. The results show the potential of this system for application to traps and the further use of vibrational signals for pest control.

What can vocal networks tell us about how animals coordinate group behaviour?

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Communication is important for social interactions and sociality. While it is generally accepted that many social species use vocal communication to transmit information (e.g. food source) and maintain contact (e.g. traveling), how vocalisations function to help individuals coordinate group behaviour, with a few exceptions, remains poorly understood. When studying information spread in groups, social network analysis is a powerful and frequently used tool. Often these networks are built from physical interactions such as duration in close proximity. Within groups, however, group behaviour can be mediated through vocal interactions which, unlike many more classical social interactions, are not tied to close spatial proximity. Thus, vocal communication is likely to be important in determining how non-neighbour or distant individuals coordinate collectively within groups. However, despite the potential importance of vocal communication in collective dynamics in groups, our knowledge of the link between vocal communication and fine-scale social behaviours remains almost completely unexplored. This is largely because of the challenge in recording communication and movement at appropriate physical and temporal scales. Using a combination of fine scale localisation of individuals in 3D space (VICON camera system), along with a microphone array that localises all individuals' vocalisations in 3D space, we have collected data on starling foraging movements at appropriate physical and temporal scales to address the role of vocalisations in group behaviour. As vocal communication is likely important to coordination of group behaviour for many organisms across widespread taxonomic groups, understanding how vocalisations are used is increasingly important in our increasingly noisy world.

The beat battle in northern elephant seal males

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The perception of rhythmic pattern has been shown in humans, but seems much rarer in other mammalian species, especially when such ability is not the results of training. Thus, there is no experimental evidence that rhythm perception can have a biological function in non-human mammals. In the northern elephant seals, males produce threat calls during the breeding season to establish and maintain their dominance status. These calls consist of a rhythmic series of pulses with each male having a stereotyped tempo and timbre, found stable over years and across behavioural contexts. Our previous playback experiments have shown that males learn to recognise their rivals individually through the use of such time-stable individual vocal signature. In this study, we tested if northern elephant seal males use this rhythmic pattern and/or the timbre to identify their rivals by performing playback experiments with natural and modified threat calls. We performed two levels of alteration of the rhythmic pattern and the spectral content (from small to substantial changes) to assess how strong males are sensitive to changes in spectral and rhythmic features. We found that males used spectral features to identify individuals as in many mammal species, but this is the first time that a rhythmic pattern is used by a non-human mammal species in a biologically relevant context.

Phenology of tropical acoustic communities in New Caledonia under invasion of the ant *Wasmannia auropunctata*

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In the context of the current biodiversity crisis, ecoacoustics has gained much interest from academics, stakeholders and managers, as it allows studying biodiversity richness, composition and phenology as well as levels of perturbations to ecosystems. In New-Caledonia, soundscapes were collected in shrublands, paraforests and forests, invaded and not invaded by the exotic ant *Wasmannia auropunctata*. Analysis of a first dataset collected during the dry season showed that crickets communities – which dominate the soundscape – are affected by *W. auropunctata* and absent from invaded locations, leaving the tropical soundscapes drastically quieter than non-invaded sites. This is especially true for the night soundscapes of forests, while shrublands and paraforests show milder differences. Raising the interest of park managers in developing acoustic approaches to detect local invasions of *W. auropunctata*, we pursued our research in 2018 to investigate the effect of season on soundscapes phenology and validate the impact of the invasive species on sound-producing taxa – with a focus on crickets and birds communities – during the humid season. Allying analysis at both the species level (by description of each species of crickets singing in the soundscape recordings) and the community level (by description of animal communities using acoustic diversity indices), we compare composition and phenology of acoustic communities at different seasons and evaluate the potential of each season to reveal the presence of the invasive ant. This work contributes to propose fast, global and interpretable tools for conservation actors.

Heterospecific signal recognition in social passerines

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Communication is the interplay of signal production and reception. Generally, in communication, sender transfers information to an intended receiver, but when broadcasted it often becomes 'public information' and is eavesdropped by unintended receivers. A multitude of studies have shown eavesdropping of alarm signal in different model organisms by heterospecifics. On the other hand, not much is known about the eavesdropping of non-alarm signals by heterospecifics. In this study, we examined heterospecific signal recognition between two sympatric congeneric social passerines, Jungle Babbler (*Turdoides striata*) and Large Grey Babbler (*Turdoides malcolmi*). Using non-alarm call of congeneric sympatric species as experimental stimulus, conspecific call as positive control and call of sympatric non-congeneric species as negative control, we conducted a series of playback experiments. Our results indicate that both babbler species show significant response towards their own call as well as to calls of the congeneric heterospecific but not towards the call of non-congeneric heterospecifics. We also demonstrate that the nature of the response towards own call and to that of the heterospecific is dissimilar. To the best of our knowledge this is the first evidence of heterospecific signal recognition of non-alarm signal between two congeneric social passerines which could, through future studies, provide interesting insights into the evolution of signalling system in these birds.

Call combinations in the roaring display of territorial male impala

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Understanding the evolutionary drivers of vocal complexity is a core issue in the study of animal communication. In species with fixed vocal repertoires, such as the majority of terrestrial mammals, complexity is often the product of the combination of single meaningful calls into sequences. The adaptive significance of call combinations has been proposed to reflect either: (i) an increase in the redundancy, and thus in the efficacy, of long-range signals; or (ii) an effective increase in signal repertoire via interactive coding. The vocalisations of male impala offer a unique opportunity to determine the combinatorial properties of mammalian sexual calls. Impala produce nasal snorts as alarm calls, and sequences of snorts followed by guttural grunts as territorial advertisement calls (also known as “roaring displays”). We used field playback experiments to investigate: (i) the redundancy or non-redundancy in the messages conveyed, respectively, by snorts and grunts; and (ii) the potential function of grunting as a contextual modifier of the original information contained in snorting calls. Observed reactions to playback calls in isolation and in combination indicated non-redundant information contents in snorts and grunts. In particular, snorts were associated with alarm responses, while aggressive behaviour was elicited by snort and grunt combinations, and by grunts alone. These patterns suggest that the addition of a grunting call to a snort generates a different signal from the alarm call, with the grunt functioning as a contextual call modifier. In summary, we here provide evidence for combinatorial mechanisms in a complex mammalian sexual call.

Alarming sex: Male superb lyrebirds vocally mimic a mixed- species mobbing flock during prolonged copulation

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Explaining the origin and maintenance of sexual signals is notoriously difficult but essential if we are to account for the diversity of animal signals. The perceptual trap hypothesis provides one explanation. Here, one sex (typically male) evolves a sexual signal that mimics a model that the other sex adaptively responds to in a different context; and while the signal is expected to compromise female fitness, the evolution of female resistance is countered by selection to respond to the model, and so the signal is maintained. Here, we examine a bizarre sexual signal produced by the superb lyrebird, *Menura novaehollandiae*, an oscine passerine with a lek-like mating system. We report that during sexual displays, males create the remarkable acoustic illusion of a mixed-species mobbing flock, a potent cue of a hidden predator. Detailed acoustic analysis revealed high acoustic similarities between the lyrebirds' mobbing flock mimicry and real mobbing flocks, and an in-situ playback experiment further confirmed that the similarities were sufficient to fool avian receivers. Further, males timed this mimicry to coincide with two crucial stages of sexual interactions: (i) when females attempted to exit male display arenas without copulating, and (ii) during the surprisingly long copulation, indicating that this illusion of a predator may prevent females from prematurely terminating sexual interactions. Collectively, our results provide the first evidence of any bird species using deceptive vocal mimicry to bait a perceptual trap, and in so doing, generate a novel, additional explanation for the evolutionary origin, elaboration, and maintenance of 'birdsong'.

Sex-specific vocal development in white-handed gibbons (*Hylobates lar*)

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Great call and coda production in gibbons is sex-specific and plays a role in territory defence. Typically, females produce the great call and males produce the coda. Previous work has revealed vocal flexibility in great call development between mother-daughter pairs. An additional study also revealed an instance of a single, juvenile male gibbon producing a great call. The current study examines another case of a male produced great call, but unlike previous work, this male consistently produces great calls and is an adult. The structure of the male-produced great call is similar to the females in captivity and in the wild; however, the males great call is more likely to be truncated. A total of 127 (63M:65F) great calls were recorded at the Henry Vilas Zoo in Madison, WI, USA and 193 great calls were recorded at the Racine Zoological Society in Racine, WI, USA. The total durations and number of elements per great call differed significantly between these gibbons; however, nine complete great calls were produced by the male at the Vilas Zoo and exhibited acoustic characteristics similar to some wild females. Persistence of female-specific vocal elements in an adult male suggests that maturation alone is not sufficient for normal vocal development of white-handed gibbons. Based on the current data, it is possible that some level of vocal learning is needed for gibbons to differentiate between the use of female-specific elements and male-specific elements. Additional studies focused on the paternal role of vocal development are needed.

Call combination in the indris' song

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Primate communicative abilities have received considerable interest over the years. However, singing primates combinatorial abilities has been frequently investigated only to draw parallels with human speech. Instead, the sequential composition of the different elements constituting the song may be relevant in understanding how a species-specific communication process evolved. In primate songs, units are organised in phrases of variable length, and understanding to what extent animals are flexible in combining different elements in phrases and different phrases within a song can indicate the potential for song complexity. The indris, the only singing lemurs, emit a song containing three major phases: long notes, single notes, and phrases. Phrases are usually termed descending phrases because they consist of a series of modulated notes with a descending frequency pattern. We analysed the combinatorics at both unit- and phrase-level. We labelled each note according to its position in the phrase and measured spectro-temporal parameters of 12992 notes given by 23 individuals. We then performed a cluster analysis which indicated the presence of 9 groups. At a phrase-level, we considered how phrases of different length were concatenated and submitted this structure to a Levenshtein distance analysis. We found that many individuals shared particular combinations, where the most common were mostly occurring between males. At a phrase level, males emitted sequences overall more stereotyped when compared to females. These findings are in agreement with previous studies, showing that indri male's song has a more fixed pattern and transmit information about relatedness more consistently than females' one.

Multitrack recordings of grey seal pup interactive vocal behaviour

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Grey seal pups (*Halichoerus grypus*) are usually born and weaned in large breeding colonies on land, making puppyhood one of the most social and vocally active periods in their lives. During this period, pups call for the attention of their mothers. These vocal signals play an important role in mother-pup recognition, and both spectral and temporal aspects of the pups' calling behaviour are in turn shaped through socio-ecological pressures for individual conspicuousness and distinguishability. Although earlier studies have investigated vocal development in individual seal pups, studying pup groups in interactive settings provides insight into the acoustic variability and rhythmic timing of calls between conspecifics.
Here we study the spontaneous interactive vocal behaviour of wild-born grey seal pups. The pups were temporarily housed in groups of varying compositions at a rehabilitation centre, where multitrack audio recordings were collected daily over the course of two months. Separate semi-directional microphones were installed above each individual's pool, providing one audio track for each seal pup in the chorus. We analysed a manually annotated subset of evenly spread recordings throughout this dataset, examining the acoustic variability between individuals and the timing of vocalisations made in multiple-pup interactions. Most interestingly, our preliminary results indicate that grey seal pups in groups vocalise antisynchronously to their nearby conspecifics, resulting in an alternating chorus. This work presents some useful first steps in analysing multitrack recordings of spontaneous seal pup vocal behaviour, and contributes to our understanding of pinniped rhythmic cognition and vocal flexibility in interactive social environments.

Vocal ontogeny in Eastern Atlantic harbour seal pups

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Vocal communication is a highly developed ability among pinnipeds. Different call types are often produced in specific behavioural contexts. In harbour seals (*Phoca vitulina*), young pups produce mother attraction calls (MAC) which play an important role in parent-offspring recognition. Findings from previous studies conducted on harbour seal MAC's report that these calls are individually distinctive, that mothers can recognise the calls of their offspring shortly after birth and that the calls show a change in acoustic structure over time. The latter finding suggests that mothers must adapt to the calls of their pups as they grow. This begs the question of which acoustic parameters are used by mothers to identify their offspring. Studying parameters that remain constant within and between individuals during the lactation period could help us understand more about individuality, but also learning. The following research is the first longitudinal study that analysed daily recordings in order to provide a better scientific understanding of harbour seal call ontogeny. The subjects were 64 pups of the Eastern Atlantic subspecies (*Phoca vitulina vitulina*) that were born in the wild and brought in for rehabilitation. Preliminary analysis of 10 individuals shows that, as pups grow older, calls become less harmonic, more frequent and longer in duration. This study supports previous findings that calls are affected by age and sex, but it does not report an effect of body size. Initial conclusions highlight that call structure varies between captive and wild individuals, and across populations inhabiting different geographical locations.

Patterns of sound production associated with the reproductive activity of dusky grouper, *E. marginatus*, at its spawning sites

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Groupers are fish of key ecological and economic value. The most iconic Mediterranean grouper is the dusky grouper, *Epinephelus marginatus*. Fishing caused dramatic population declines across the Mediterranean Sea, where the species is listed as endangered. This species is abundant only in effective Marine Protected Areas (MPAs) but knowledge on its reproduction is still limited. Passive acoustic surveys are valuable tools for studying and monitoring reproductive sites of soniferous species. The dusky grouper is known to emit at least two types of sounds, one of which is associated with courtship displays. Nonetheless, no observation of direct co-occurrence between sound production and reproductive behaviours has ever been made in the wild. In this study, conducted in the "Tavolara-Punta Coda Cavallo" MPA (Sardinia, Italy), we assessed if and how Dusky grouper acoustic activity was linked to its reproductive behaviours, and compared sound production patterns at two spawning sites over one month, during the peak reproductive season. By coupling underwater direct visual observations to simultaneous passive acoustic recordings, we could attribute Dusky grouper sound production to its courtship behaviours. The courtship call was found five-times more often when courtship was observed than when it was not, being significantly linked to the documented courtship displays. Both sites showed similar diel sound production with one site, falling in the MPA no-take and no-access zone, showing a more pronounced acoustic activity. The study consolidates the value of passive acoustics within monitoring programs aiming at protecting this endangered species during a vital phase of its life cycle.

Freshwater ecoacoustics: Temperature, lateral connectivity, and macroinvertebrate communities shape acoustic communities in a riverine floodplain

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The emerging discipline of ecoacoustics aims to investigate ecological attributes of the environment using sounds emanating from animal communities. In freshwater environments, animal communities are shaped by key ecological factors which can be abiotic such as habitat connectivity and temperature or biotic such as species interactions (e.g. competition or predation). We predict that those ecological factors also shape acoustic communities formed by the collection of sounds emitted underwater. We deployed a passive acoustic monitoring during 15 days in six floodplain channels of the river Rhône (France). The channels differed in temperature and lateral connectivity to the main river. In parallel, we assessed the macroinvertebrate communities of these six channels using classical net sampling methods. A total of 128 sound types and 142 animal taxa were inventoried revealing an important underwater diversity. This diversity, instead of being randomly distributed among the six floodplain channels, was site-specific. We found a strong effect of both temperature and lateral connectivity on acoustic community composition. These results, congruent with macroinvertebrate community composition, suggest that acoustic communities reflect the interactions between animal communities and their environment. Additionally, with random community simulations, we revealed that the temporal and frequency characteristics of sound types in acoustic communities were more divergent between sites but more convergent within site than expected by chance. These results reveal that acoustic communities similarly to biological communities are shaped by biotic and abiotic factors. Additionally, our study strongly supports the perspectives offered by acoustic monitoring to describe and understand ecological patterns in freshwater environments.

Phonology and syntax in an insect? Combinatorial processing in *Enchenopa binotata* treehoppers (Hemiptera: Membracidae)

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Mating choice involves processing signals that can reach high levels of complexity and feature multiple components, even in small animals with tiny brains. This raises the question of how such organisms deal with this complexity. One solution involves combinatorial processing: signals with different elements are processed by receivers as single units. Combinatorial processing has been described in several mammals and birds, and recently in *Enchenopa binotata* treehoppers. Combinatorial processing involves arbitrary rules about acceptable combinations of signals (e.g. phonological and syntactic rules). We ask about the relationship between combinatorial rules and typical mating preferences and whether there are higher order combinatorial processing homologous to syntax. *Enchenopa binotata* male signals are composed of two elements: a “whine”, and pulses. Those signals are typically emitted in bouts of four increasing in amplitude. Females show preferences for frequency and element order of the signals. Here, we played back synthetic male signals varying in signal element order, frequency and bout structure to females and recorded their preferences. The wrong combination of signal elements resulted in a fixed decrease in attractivity of the signals conserving the shape of the preference for frequency. This suggests that the relationship between phonological rule and mating preference is additive. Females responded less to decreasing amplitude bouts than to normal and staggered bouts. This may indicate that treehoppers process higher order element combinations. Overall combinatorial processing may be more widespread than currently appreciated, and may represent a convergent solution to the cognitive challenges of communication with complex signals.

Using hierarchical Bayesian models to analyse acoustic data

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Acoustic data provide numerous challenges for statistical modelling and analysis. Such challenges include data that are multivariate, spatially and temporally correlated, non-Gaussian, and non-stationary. Passive acoustic monitoring studies often result in high-dimensional time series that are both statistically and computationally difficult to analyse. The hierarchical Bayesian framework is a statistical modelling framework applicable to a wide range of ecological problems that can account for the complexities of acoustic data in a logical and computationally efficient manner. The Bayesian structure enables the incorporation of previous research into models, and allows for parameter estimates, fitted values, and predictions to be obtained within the same algorithm. The hierarchical framework enables thinking about modelling in an ecologically relevant manner. Here, we describe the general framework and its broad applicability to the fields of bioacoustics and ecoacoustics and use it to analyse a soundscape data set from western New York to predict the soundscape over a sample region in western New York from public road data. We build soundscape maps over the sample region, along with estimated uncertainty maps, to display the power of such a modelling framework. Wide adoption of such a framework in the fields of bioacoustics and ecoacoustics could enhance collaboration between researchers, increase our understanding of the acoustic environment, and improve our ability to answer ecologically-important questions using acoustic data.

Chestnut-crowned babbler calls are composed of meaningless shared building blocks

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A core component of human language is its combinatorial sound system: meaningful signals are built from different combinations of meaningless sounds. Investigating whether non-human communication systems are also combinatorial is hampered by difficulties in identifying the extent to which vocalisations are constructed from shared, meaningless building blocks. Here we present a novel approach to circumvent this difficulty and show that a pair of functionally distinct chestnut-crowned babbler (*Pomatostomus ruficeps*) vocalisations can be decomposed into perceptibly distinct, meaningless entities that are shared across the two calls. Specifically, by focusing on the acoustic distinctiveness of sound elements using a habituation-discrimination paradigm on wild-caught babblers under standardised aviary conditions, we show that two multi-element calls are composed of perceptibly distinct sounds that are reused in different arrangements across the two calls. Furthermore, and critically, we show that none of the five constituent elements elicits functionally relevant responses in receivers, indicating that the constituent sounds do not carry the meaning of the call; so are contextually meaningless. Our work, which allows combinatorial systems in animals to be more easily identified, suggests that animals can produce functionally distinct calls that are built in a way superficially reminiscent of the way that humans produce morphemes and words. The results reported lend credence to the recent idea that language's combinatorial system may have been preceded by a 'superficial' stage, where signallers neither needed to be cognitively aware of the combinatorial strategy in place, nor of its building blocks.

Humans assess negative emotional state of dogs using vocal indicators of separation stress in whines

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During vocal communication, individuals' inner state affects their calls' acoustic features. Listeners can use these cues to assess the emotional state of the caller. Besides high pitch, irregularities in vocal fold vibration resulting in low tonality and nonlinear phenomena might act as honest cues of high arousal. Separation anxiety is a common problem in dogs, described by excessive vocalisation among other signs. Earlier, we found that dogs with separation problems have harsher whines and this might have a role in the assessment of the dogs' stress level by the owners. We built a database from 216 separation whine bouts from 60 dogs with different level of anxiety and known separation behaviour. Using an online questionnaire, we asked 720 participants to rate these on seven emotional scales. On each scale, we tested which acoustic features affect the ratings and their relationship with actual separation behaviour. We found that harsher sounding whines were rated higher on stress and aroused-negative emotions. Higher pitch resulted in higher ratings on all scales except urging. Presence of biphonation affected positively sadness, worry and despair ratings. Furthermore, whines of dogs that actively tried to escape from separation were rated to be more hysterical and urging, but less sad and worried. In line with earlier findings, pitch affects humans' general arousal state perception, while harshness facilitates assessment of higher stress level and frustration linked negative emotions. Moreover, the ratings reflected the actual separation behaviour, suggesting honest signalling of inner state in dog whines.

Sound production mechanisms in banded penguins: From structures to functions

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Banded penguins (*Spheniscus spp.*) are colonial seabirds where vocal communication mediate individual recognition, mate choice, and territorial defence. The recent application of the source-filter theory of vocal production to penguin calls has demonstrated that both fundamental frequency and formants (resonant frequencies of the vocal tract) encode acoustic cues to species and individual identity of the emitter. However, contrary to what the source-filter predicts for mammals, previous work showed that formants do not correlate with skeletal size and body weight, and thus cannot be used for body size communication. To investigate the anatomical basis of such lack of correlation, we dissected the vocal apparatus of several African penguin carcasses from zoos and at the Southern African Foundation for the Conservation of Coastal Birds. At first, we showed that the tracheal length is free from skeletal constraints. In particular, we found that the trachea is formed by imbricated cartilaginous rings, which allow changing its length through contraction of the longitudinal musculature of the trachea. Subsequently, we built computational models of the vocal tracts derived from the anatomical data. The models supported our prediction that variations in tracheal length affect the formant spacing, explaining while filter-related parameters are unreliable cues to the body size of the emitter in this species. Our results have broad implications for the use of the source-filter approach to study size communication in seabirds. We also underline the importance of combining anatomical and modelling approaches to link the anatomy of the vocal apparatus with the spectral features of vocalisations.

Identification of potential signature whistles from free-ranging common dolphins (*Delphinus delphis*) in South Africa

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Conveying identity is important for social animals to maintain individually based relationships. Communication of identity information relies on both signal encoding and perception. Several delphinid species use individually distinctive signature whistles to transmit identity information, best described for the common bottlenose dolphin (*Tursiops truncatus*). In this study, we investigate signature whistle use in wild common dolphins (*Delphinus delphis*). Acoustic recordings were analysed from 11 encounters from three locations in South Africa (Hout Bay, False Bay, and Plettenberg Bay) between 2009 and 2017. The frequency contours of whistles were visually categorised, with 29 signature whistle types (SWTs) identified through contour categorisation and a bout analysis approach developed specifically to identify signature whistles in bottlenose dolphins (SIGID). Categorisation verification was conducted using an unsupervised neural network (ARTwarp) at both a 91% and 96% vigilance parameter. For this, individual SWTs were analysed type by type and then in a 'global' analysis whereby all 497 whistle contours were categorised simultaneously. Overall the analysis demonstrated high stereotypy in the whistle structure and temporal production of common dolphins, consistent with signature whistle use. We suggest that individual identity information may be encoded in these whistle contours. However, the large group sizes and high degree of vocal activity characteristic of this dolphin species generate a cluttered acoustic environment with high potential for masking from con-specific vocalisations. Therefore, further investigation into the mechanisms of identity perception in such acoustically cluttered environments is required to demonstrate the function of these stereotyped whistle types in common dolphins.

Babbling in bat pups and human infants: A key element during vocal development

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Canonical babbling in infants is a conspicuous behaviour and together with the ability of vocal production learning a key element in spoken language acquisition. Infants acquire the phonological repertoire of language by imitation of speech sound subunits produced in reduplicated sequences. To shed light on the mechanisms necessary for the evolution of spoken language, comparative studies on species which are vocal production learners and babble during ontogeny are especially promising. This study introduces a new non-human mammalian species as a promising candidate for comparative research in biolinguistics. The bat species *Saccopteryx bilineata* is a vocal production learner and exhibits a conspicuous phase of intense vocal practice during ontogeny (i.e. daily production of multisyllabic vocal sequence bouts, with durations of up to 30 minutes) that is highly reminiscent of infant canonical babbling. We investigated the entire pup vocal ontogeny (i.e. 12 - 14 weeks each) of 20 pups belonging to two genetically different populations. We found that features defining canonical babbling in infants are likewise characteristic of pup babbling in *Saccopteryx bilineata*; early babbling onset (I), babbling sequences composed of non-adult syllable types and simultaneously emergence of adult-like ones (II), vocal overproduction (III), subset acquisition of the adult repertoire (IV), non-linear repertoire acquisition pattern (V), repetitiveness (VI), universality (VII), and meaninglessness (VIII). These findings suggest that a distinctive vocal practice phase is characterised by similar features across species, probably arising from similar underlying mechanisms in order to acquire adult social communication.

Auditory responsiveness of male and female mosquitoes in the vicinity of mating swarms

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Many mosquito species mate in swarms consisting mainly of males and lab studies show that males and females respond to species-specific flight tones of the opposite sex, indicating that sound might guide mosquitoes to con-specific swarms. We tested this hypothesis in the laboratory with two species in the *Anopheles gambiae* complex. Previous studies analysed auditory responses of only 1- to-1 opposite-sex interactions, with inconsistent results. We investigated the acoustic behaviour of single mosquitoes close to a swarm of mosquitoes. The responses of single females to male swarm sounds and single males to female swarm sounds, were investigated for *An. coluzzii* and *An. gambiae* s.s. (i.e. testing sex x species) at sound levels typical within ~ 10 cm of a swarm. We tested the effect of two swarm sound levels; 36 dB (close to a typical swarm) and 48 dB. The responses of individual mosquitoes were measured by analysing flight-tone data and 3D flight paths of individual mosquitoes. Both sexes responded to sound stimuli of both species by increasing their wing-beat frequencies, albeit with sex-specific patterns of response. Whereas, for females there were no differences in their responses to *An. coluzzii* or *An. gambiae* males, males responded significantly more quickly to the sound of females of their own species than to conspecific sound at 36 dB. The findings indicate that both sexes detect swarm sounds within close range of a swarm, but only males are likely to differentiate between swarms of their own vs another species as they approach a swarm.

Emotional voice intonation as a biological code: A comparative approach to the emergence of language

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In the descent of man, Darwin hypothesised that the ability to modulate the voice to express emotions, which is shared across animal species, might have evolved into the ability to express emotional content in words. This would have, thus, started the path of language evolution. Yet, our understanding of the role of vocal expression of emotions in language evolution remains the same today as when Darwin first tackled it in 1871. In this talk, I describe recent findings that advance our understanding of this issue. In a recent study, we found that humans use information related to the fundamental frequency of vocalisations to identify emotional content across all classes of animals. Based on this data, I argue that adaptive mechanisms of vocal emotional expression are widely shared among vocalising vertebrates and might represent a biologically universal signalling system. The question then remains as to whether these biological mechanisms for emotion expression paved the way to the evolution of language. One way of addressing this question empirically is to explore the relative salience of emotional voice modulation and lexical information in emotional word processing, as an indicator of the biological role of voice modulation in the emergence of language. To support this, I present recent empirical data on the cognitive prominence of voice modulation over lexical information in emotional word meaning identification tasks. Finally, within this research framework, I emphasise the role of emotional voice within social interactions in the emergence of linguistic communication.

Mapping the genomic response to incubation calls in embryonic zebra finches

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Growing evidence suggests that developing birds sense acoustic cues from the environment, even while in the egg. Zebra finches provide a striking new example: at high ambient temperatures and in the presence of eggs, nesting parents produce an 'incubation call', and embryos exposed in the egg to this call later develop with better adaptation to hot weather. This implies that embryos somehow receive acoustic cues from parents — but auditory capacities of songbird embryos have never been demonstrated. Here, we report on ongoing experiments to test the hypothesis that incubation calls trigger a genomic response in the embryo, ultimately leading to adaptive developmental reprogramming. In a first experiment, eggs (n=28) reared in an incubator were exposed to playback of either incubation calls, other control calls, or silence. Using qPCR, we compared expression levels for several Immediate Early genes including egr1 (ZENK) but found no evidence of a treatment effect when averaged across the whole brain. In a second experiment, eggs (n = 29) were collected following the same playback protocol and egr1 expression mapped using in situ hybridisation. Initial results identify several regions in the embryo brain where egr1 is expressed at a high level, with very preliminary evidence for a potential treatment effect. In a further analysis (ongoing), we are using RNAseq to look for other genes that may respond to incubation call exposure. These data potentially address whether altricial nestlings have prehatch acoustic sensitivity and carry implications of such sensory perception for adaptive development.

Male Mongolian gazelle: Displaying an oversized, retractable larynx

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Mongolian gazelle (*Procapra gutturosa*) is a sexually dimorphic bovid species of Asia. During the December rut, males defend harems of females against rival males. Male rutting behaviour involves the emission of rutting barks, herding and chasing females, and ferocious fights between males. We investigated Mongolian gazelle in the steppe area of the Daursky Nature Reserve, the only site in Russia, where Mongolian gazelles occur. The larynx of male Mongolian gazelles is large, permanently descended, imposingly bulges the ventral neck region and is further accented by colours of the winter coat. The larynx is visibly retracted for emission of the rutting barks. The anatomy of the male larynx involves several derived features. The hyoid-larynx connection is established by a resilient ligament. Pharynx and soft palate are elongated. Retrolingually, the soft palate expands ventrally into an unpaired palatinal pharyngeal pouch. The intra-pharyngeal ostium is large to accommodate the huge epiglottis, which is about half the length of the remaining larynx. The thyroid cartilage is ventrally folded into a broad keel. Novel paired, double-chambered ventricles open rostrally into the laryngeal vestibulum. Laterally, they subdivide the thyroarytenoid muscle into two portions. The ventral ends of the pharyngotympanic tubes expand to form paired tympanic pharyngeal pouches. The very large vocal folds lack any flexible part and are supported by a tough vocal pad. Apparently, the oversized, retractable larynx of male Mongolian gazelles evolved under sexual selection for displaying visual and acoustical traits of male quality. This research was supported by a grant (19-04-00133) from the Russian Foundation for Basic Research.

Vocal communication during the breeding cycle of zebra finches

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Call interactions and dynamics remain largely unexplored in groups of birds and mammals as their relation to different species-relevant contexts or life-history stages is difficult to study with individual-level resolution. Similar to many vocal vertebrates, zebra finches (*Taeniopygia guttata*) interact using multiple, functionally distinct calls. Both sexes are able to recognise individuals of the other sex by means of various call types. Using microphone telemetry, we recorded the vocalisations of individual zebra finches behaving freely in social groups, while females and males previously unknown to each other passed through different breeding stages. As birds formed pairs and shifted their reproductive status, their call repertoire composition changed. The timing revealed that calls occurred non-randomly in fine-tuned vocal interactions, decreasing within groups while pair-specific patterns emerged. Call-type combinations of vocal interactions changed within pairs, and were associated with successful egg-laying, highlighting the evolutionary importance of calling dynamics in communication systems. We discuss potential mechanisms underlying the change of call usage during the breeding cycle.

Rhythmic variation in the song of the indris

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The emission of a series of loud elements organised in phrases is shared among humans and some nonhuman primate species. These utterances are usually termed songs and often occur as duets or group choral displays. The way the emitters combine their contribution has been considered relatively rigid and investigated for specific, subspecific, and sex differences. Only recently our understanding of nonhuman primate rhythmic abilities has increased. Indris are pair-living lemurs who sing a group chorus with their offspring. Songs are emitted regularly and play a role in advertising territorial occupancy and inter-group spacing. We examined whether chorus size may affect individuals' contribution to the song, its total duration of the song, and the inter-onset intervals within a phrase and between phrases. We found that females have significantly higher variation in the rhythm of their contribution, both within a phrase and between phrases. Female singing also changes according to chorus size. We suggest that female indris sustain a higher cost of singing than males when the number of singers increases. These results indicate that cross-species investigations will be crucial to our understanding of the evolutionary frame in which such sexually dimorphic traits occurred.

Vocal predisposition in mammals: Insight from meerkat and primate vocal repertoires

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Vocal diversity in mammals has been a long-standing research focus in bioacoustics. A wide range of studies has investigated this question by attempting to quantify such diversity into categories, i.e. by defining species vocal repertoires. However, methods for this are far from being standardised and often prone to a varying degree of subjectivity. Vocal repertoires often overlook the fact that call types can grade into one another and as such, do not provide much insight into how vocally flexible a species' communication system can be. Here we emphasise how vocal anatomy can shape vocalisations in a pre-determined manner ('vocal predisposition'). We provide a detailed description of particular acoustic features of meerkat vocalisations in parallel with anatomical examination of the meerkat vocal apparatus. We thus highlight the potential anatomical constraints pre-determining sound production in this species. We complement our reasoning based on empirical data obtained from primate excised larynx experimentation. Finally, we discuss the implications of taking vocal predisposition into account when compiling species vocal repertoires, and broaden our perspective to research investigating vocal flexibility and vocal production learning, an ability highly debated within mammals but which seems to lack adequate experimental testing.

Tapping into woodpeckers' species-specific codes: Drumming is not all about rhythm

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The effect of sexual selection on the elaboration of oscines' song has received considerable attention, potentially because vocal displays are quite conspicuous in species sharing this ability. Typically, males produce songs during the breeding season, serving both as territorial and as mate attraction signals. This process can lead to the reproductive isolation of related species, whereby signals not only are selected by conspecifics, but prevail at a higher level as they are also selected against (or at least discriminated) by heterospecifics. Despite being non-vocal by nature, Woodpeckers' drumming (a repetitive striking of the bill on a substrate, usually wood) holds the same functions as songbirds' songs, both allowing inter-specific discrimination and intra-specific mitigation of sexual competition and attraction. Because of the mechanical constraints applying on drumming's production, the amount of species-specific information encoded in this signal is potentially more restricted than songbirds' songs. Here we investigate this question by first assessing the ability of great-spotted woodpeckers (*Dendrocopos major*) to discriminate between conspecific and heterospecific drums; we then investigate in more depths which features (rhythmic, spectral and intensity-related) constitutive of drumming patterns matter when it comes to recognising their own species' drum. Our results highlight a strong historical contingency on drumming's structure and a sub-optimal species information encoding system. We conclude by framing our results within a more ecology-based perspective and provide insight into how this system can prove efficient at the community level.

Burrowing petrels' calls carry information about individual identity and physical characteristics of the caller

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The Blue Petrel (*Halobaena caerulea*) is a monogamous seabird which lives in crowded colonies at night and does not display a sexual dimorphism. In this context, acoustic and olfactory communications may play a major role in information exchange. While recent studies investigated the function of olfaction, the vocalisations remain poorly studied in this species. Calling in the breeding colony exposes petrels to increased predation risks and thus should provide an important benefits, possibly in sexual selection. Indeed, during the pair formation period, bachelor males call from their burrow, likely to stimulate and/or attract females flying and calling over the colony. Males also call from their burrow when vocally challenged by other males. Here, we investigated the informative content of males' calls by assessing if they (i) bear an individual vocal signature (ii) reflect phenotypic characteristics. To do so, we recorded males' calls from Blue Petrels on their breeding site (Verte Island, Kerguelen). We first calculated the Potential of Individuality Coding, i.e. the ratio between intra- and inter-individual variabilities, for acoustic features in both spectral and temporal domains. Second, we tested the relationships between seven morphometric measurements and 12 acoustic features by performing multivariate analyses. The results support the idea that both spectral and temporal features carry an individual vocal signature and provide information about the caller's phenotypic characteristics. This stable information may play a crucial role in social interactions, such as burrow defence (e.g. neighbour-stranger discrimination) and/or female mate choice.

Evolution of advertisement calls in closely related frog species occurring in sympatry

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Because advertisement calls are sexual signals used by anurans for the recognition of conspecifics during mate pairing, sympatric populations of closely related species may display diverging calls (reproductive character displacement) in order to minimise signal interference and/or the probability of hybridisation between the two species. Reproductive character displacement may be mediated by plasticity in signal production, diverging mate preference or ecological character displacement. In addition, horizontal social transmission of mate preference or preferred sexual signals may occur and increase the divergence between populations. The grass frogs of the genus *Ptychadena* in the Ethiopian highlands represent a radiation of 12 species that produce loud advertisement calls from roadside puddles, flooded fields and slow-moving streams. Although several species can be found in syntopy (i.e. calling and mating in the same locality) and are morphologically very similar, only a few cases of hybridisation have been found between species of this group, suggesting the existence of a behavioural mechanism preventing mixed-species pairings.
We studied the advertisement calls of populations of Ethiopian *Ptychadena* and compared them in a phylogenetic and biogeographic context. We found that sexual signal divergence far exceeds morphological divergence in this group, and is increased between co-occurring species, which is congruent with reproductive character displacement. We further examined the potential behavioural mechanisms leading to highly divergent sexual signals in this morphologically conserved group, in order to better understand the processes initiating reproductive character displacement.

Vocal individuality of Holstein-Friesian dairy heifers is maintained across positively and negatively valenced farming contexts

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While previous research has shown cattle contact-call individuality, whether cattle maintain this individuality when vocalising across highly stressful, positively and negatively valenced farming contexts is unknown. We recorded 333 high-frequency vocalisations from 13 Holstein-Friesian dairy heifers during oestrus (putatively positive), anticipation of feed (putatively positive), denied feed access (putatively negative) and upon physical and physical + visual isolation from conspecifics (putatively negative). These vocalisations were analysed in Praat software using narrow-band spectrograms with 21 temporal, spectral and nonlinear vocal parameters measured. Stepwise discriminant function analyses (DFA) were performed in SPSS including 1) the 170 positively valenced calls used as a 'training set', to classify the 163 negatively valenced calls in the 'test set'; and 2) the 163 negatively valenced calls used as a 'training set' to classify the 170 positively valenced calls in the 'test set'. The potential for individual coding (PIC) was also determined for each of the vocal parameters, with values > 1 interpreted as good predictors of individuality. The cross-validated DFA correctly classified 52.1% of the negatively valenced calls to the correct individual using 10 vocal parameters from the positively valenced test set. Additionally, the cross-validated DFA correctly classified 49.4% of the positively valenced calls using nine vocal parameters from the negatively valenced test set. Across valences, 18 of the 21 vocal parameters had PIC values above 1 indicating their inter-heifer variability was greater than their intra-heifer variability. This study shows that cattle vocal individuality is maintained for high-frequency calls across positively and negatively valenced farming contexts.

Acacia-Ants' acoustic aposematic warning signal

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The common name of the whistling thorn acacia originates from the whistling noise that is audible if it is windy. The whistling sound is linked to the presence of Crematogaster ants that defend the tree against mammalian browsers. It is emitted when the wind strikes the tree's bulbous thorns in which the ants have drilled holes. The typical whistling sounds characterising acacia trees could be an information source to mammalian browsers: a whistling tree is protected by ants and a strong defence must be expected. Mammalian browsers, such as elephants can have devasting effects on the survival of trees and consequently on the ants' survival. The whistling has a good potential of shortening the time needed to teach browsers about the upcoming defence. As an auditory warning signal, the whistling could add to the visual clarity of thorns and to the aggressive attacks by Crematogaster ants. We conducted this study in the Tsavo ecosystem (Kenya) and combined experiments in the field and laboratory to investigate various aspects of the whistling of *Acacia zanzibarica* thorns. Due to the entrance hole drilled by the ants the acacia thorns function like a Helmholtz oscillator that whistles when the wind speed exceeds about 4 ms-1. The ants drill the holes in the thorns in a way, that they are optimal exposed relative to the wind direction. In doing so, the ants maximise the whistles' sound emission. We provide strong evidence that the whistling sound is a warning signal addressed to mammalian browsers.

Agonistic "Tsak" call: A non-invasive tool for species diagnosis in a cryptic smallest-bodied primate, the mouse lemur?

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Bioacoustics uses digital technology to record and analyse animal vocalisations to enhance our understanding of animal communication, distribution as well as biodiversity. Mouse lemurs represent the smallest-bodied extant primate radiation, are nocturnal and live in diverse Malagasy forests. This primate radiation comprises 24 genetically defined, phenotypically similar species. The conservation status of most species is barely known, but the often small geographical distribution makes them highly vulnerable to anthropogenically caused habitat disturbances. The aim of this study was to explore by a comparative and integrative bioacoustic, behavioural and genetic approach, whether the most frequently used mouse lemur calls bear species-specific signatures allowing on the long run to establish bioacoustic rapid assessment tools for surveying and monitoring species diversity in nature. We will present bioacoustic data from mouse lemurs, originating from seven different study sites in north-western and eastern Madagascar ("Bombetoka", "Ampijoroa", "Marosely" and "Anjiamangirana" with dry deciduous forest and "Lokobe National Park", "Ankaramibe" and "Mantadia" with rain forest). The variation in vocalisation and its use in signalling were determined by standardised bioacoustic methods using a social encounter paradigm (N = 12 dyads/study site). Comparative data on agonistic calls between eight genetically different cryptic species: *Microcebus myoxinus, M. ravelobensis, M. bongolavensis, M. danfossi, M. mamiratra, M. margotmarshae, M.murinus,* and *M.lehilahytsara* revealed a uniform acoustic contour, but species-specific statistical distinctiveness in acoustic structure. Acoustic divergence between species is predicted by genetic distance. The studied calls do not display habitat-specific differences. Thus, findings support an acoustic diversification caused by genetic drift.

Towards the standardisation of ecoacoustic indices for cross-comparison of audio datasets

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Ecoacoustics offers alternative techniques to direct observations for ecologists and conservation biologists. Ecoacoustics is at the crossroads of ecology, acoustics and computer science, taking advantage of the broadening of affordable and easy-to-use passive acoustic recording devices. The tremendous amount of fast-growing data collected all around the world, all year-long makes manual annotation by experts impossible. The common global approach consists in reducing full audio recordings into acoustic indices, that are mathematical functions designed to describe the complexity and the diversity enclosed in each audio fragment by single numbers. However, ecoacoustics is actually facing a lack of standardisation that prevents direct comparison of indices computed from different audio datasets. This severe limitation has a substantial impact on the reliability of acoustic indices to describe acoustic richness and diversity among various habitats. To address this issue, we propose to standardise the computation of acoustic indices by 1) calibrating audio recordings, and 2) taking into account the variation of time/frequency resolution based on a multiscale approach. The standardisation workflow has been validated on two audio subsets of long-term surveys in tropical rain forest (dB@Nouragues project, French Guiana, France) and cold mountain forest (dB@Risoux project, Jura, France). Preliminary results show that standardisation allows cross-comparison of acoustic indices from different audio data set opening new opportunities in ecoacoustics.

Impact of lossy acoustic compression on soundscape identification

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It has been shown that environmental soundscapes can be grouped and classified depending on a variety of spectral and temporal features, into categories including but not limited to time of day and forest type. This has the potential to be used as a means of continuously monitoring ecosystems remotely. The benefits of analysing ecosystems remotely are numerous, however the volume of data collected can become an issue, mostly due to constraints on data storage and transmission. A viable solution is to compress the raw audio data from large PCM files into smaller compressed formats. Lossy compression techniques (e.g. MP3, AAC) achieve a smaller file by disregarding information considered irrelevant to a 'cochlear model' based around human sound perception. While this will allegedly not affect the human listening experience, it has the potential to be impactful when analysing natural soundscapes. This study quantifies the impact of applying these methods of lossy compression, at different levels, on a classifiers ability to differentiate between day and night rainforest soundscapes (recorded at the SAFE project in Borneo). Our findings assess the effectiveness of current continuous audio monitoring in the area as well as discuss the potential for further compression.

Numerical simulation of elastic wave propagation in the skull of dolphins

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Compared to other mammals, dolphins are known to have a striking ability in localising a sound source with equal sensitivity to changes in the elevation or azimuth. Considering the fact that these animals have lost their pinnae during evolution, their localisation methods are presumably different from those of other mammals and the role of their anatomy in sound localisation remains an open question. This study aims at investigating the contribution of soft tissues and the skull of dolphins in sound localisation. We study wave propagation in dolphin heads via a numerical approach. Our first objective is to validate the results of a previously performed laboratory experiment (Reinwald et al., 2018) on the skull of a short-beaked common dolphin and expand them to a broader frequency band. Our simulations are implemented based on 3D tomographic scans of the skull used in the experiment. We convert grey-scale values of the images into elastic/acoustic parameters. We explored different tools for running the simulations, eventually focusing on two options: the simsonic and kwave packages. We eventually determined that kwave was overall a more adequate tool for our goals. We model the incident waves in the form of plane waves, corresponding to a relatively far source and well-defined direction of propagation. We will present a detailed comparison between the two numerical tools, discuss the various issues related to plane-wave modelling in a finite 3D domain, and present the strategy for the conversion of skull grey-scale images to an elastodynamic model for the simulation of wave propagation.

Duets in the wild: Inter-individually coordinated motor control enables cooperative behaviour

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Investigating the neural mechanisms that underlie an animal's natural behaviour is the fundamental aim of neuroethology. Neurophysiological experiments are, however, usually performed in animals that are kept alone in cages inside laboratories, which clearly limits their ability to behave naturally. Here we present the first extracellular neural data that has been synchronously recorded from pairs of socially interacting animals ranging completely free in their natural habitat. We exploited a newly developed radio-telemetric recording technique to investigate the neural basis of a rhythmic cooperative behaviour: duet singing. Avian duets show a high diversity in the precision of coordination between the partners' vocal emissions. While the spectro-temporal structure and ecological function of duet singing has already been described for several bird species, the neural mechanisms that mediate the inter-individual coordination of vocal activity during duetting is so far not known. We simultaneously recorded individual vocalisations and multiunit vocal premotor activity in pairs of duetting songbirds (*Plocepasser mahali*) in the South African Kalahari. In nucleus HVC, the highest level of the descending motor pathway that controls birdsong, we found that the onset of the partner's contribution to the duet triggered a change in rhythm in the periodic neural discharges of the bird initiating the duet. The resulting inter-individually synchronised pattern of neural activity elicited vocalisations that perfectly alternated between partners in the ongoing song. We conclude that rhythmic cooperative behaviour requires exact inter-individual coordination of premotor neural activity, which might be achieved by integration of sensory information originating from the interacting partner.

Tackling all acoustic taxa inventories in the neotropics

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South American forests comprise some of the most diverse hotspots of biodiversity in the world. While managing such places require integration from diverse specialists and policy makers, knowledge on species distribution and acoustic behaviour is still incipient. We will explore the ABC (Arquivo Bioacústico Catarinense/ECZ/UFSC) endeavour of annotating all acoustic taxa in the Serra do Tabuleiro State Park, the most bio-diverse region of South Brazil, and the efforts of sharing finds and information with scientific and professional communities. Although bird and anuran repertoires are fairly known, the overwhelming activity of insects is still poorly understood, revealing a clear need for a deeper understanding of their vocalisations and further acoustic research.

Using networks of EMT2 pro bat detectors to identify key points on linear features used by Daubenton's Bat (*Myotis daubentonii*)

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Part of a PhD study into the assemblages and movements of bats in green belt / urban fringe areas, this study examines the use of canals and railway verges by bats, by utilising acoustic monitoring to investigate habitat permeability in urban fringe environments: at what points and under what circumstances will M. daubentonii leave a dark corridor and cross an area of conurbation in order to get to feeding grounds more directly? In order to investigate such behaviour, access and egress points used by bats on linear features must be located. To locate these key points, the researcher used a series of EchoMeter Touch 2 Pro units and teams of volunteer surveyors to record the passes of *M. daubentonii* along linear features. Using the average speed of the species and distance between survey points, the researcher anticipated time between triggers and could then follow the movements of individual bats along the feature using the timestamp and geolocation of the acoustic recordings. Repeated sampling provided information about regularly-used access and egress points. Preliminary field surveys and method/equipment tests have been promising. The presentation will detail the method, show the preliminary results from the pilot study, and discuss future developments for statistical analysis and development of a standard survey protocol for this novel method of acoustic monitoring of bats along linear features.

Exploring vocal plasticity in zebra finch social networks

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The relative simplicity and temporal precision of the adult male zebra finch's crystallised song have made it a fruitful model system for studying behavioural and neurobiological mechanisms of vocal learning. However, beyond the core sequence of song elements copied from a tutor during development, zebra finch song bouts exhibit within-individual diversity in both sequence and timing, as well as variability between individuals in the degree of this structural diversity. How such performance-level plasticity is acquired and whether it serves any social function is not known. Zebra finches are group-living, and males sing abundantly in general social as well as female-directed settings. Here we report an initial exploration into how song plasticity is expressed in zebra finch vocal culture. We phenotyped individual birds within an established social group according to the sequential stereotypy and temporal jitter in their solo bout repertoires. We then tested the social salience and potential mutability of these phenotypic differences by systematically pairing individuals and quantifying singing amount and expressed bout repertoire in each bird. In addition to stable individual phenotypic differences, we found pair-specific time-sharing patterns, from which a vocal interaction network for the original group was constructed. This work paves the way for future studies relating dyadic interactions to the singing behaviour of individuals in zebra finch groups.

Startle and avoidance reactions of Cuvier's beaked whales to sudden onset sounds

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The Cuvier's beaked whale (*Ziphius cavirostris*) is a species that has repeatedly been found stranded in association with naval sonar operations. Apart from received level, the sudden onset of sounds has been identified as a potentially aversive feature that could contribute to strong avoidance responses. In all tested mammal species, sounds with rapid onset times elicit a startle reflex which can lead to a sensitisation of avoidance responses with repeated exposure. Here, we tested the reactions of Cuvier's beaked whales at the surface to repeated startle sounds to investigate whether animals show evidence of sensitisation to such stimuli. We exposed individuals to sequences of bandwidth-limited startle sounds with a 20 dB bandwidth from 3.5 to 9 kHz. We monitored the animals' muscle contractions using 3D accelerometry recorded with DTAGs and analysed their avoidance behaviour focusing on swim speed, vocalisation behaviour and distance covered after exposures. We found that Cuvier's beaked whales have a clear startle response that is consistent with descriptions for other terrestrial and marine mammals. All whales ceased vocalising, increased swim speed and left the playback site when hearing startle stimuli with a rms received level between 135 and 160 dB re 1 µPa. In a second exposure bout, one animal showed avoidance to a received level of only 104 dB re 1 µPa rms, suggesting conditioned sensitisation may be taking place. We conclude that rise time is a significant component of a noise stimulus that has the potential to amplify avoidance reactions shown by beaked whales.

Interview with a rhino: Functionality and directionality of communication calls in the captive Southern white rhinoceros

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Acoustic communication is a complex model that is most essential in social animals. Since vocalisations are considered to be indicators for social interactions, it is inevitable to be able to identify the functionality and social relevance as well as the directionality of communication calls in order to facilitate monitoring of socio-sexual behaviour and group dynamics. This study aims to examine these fundamental parameters in the white rhinoceros (WR). For this purpose, behaviour and vocalisations of 32 Southern WR (*Ceratotherium simum simum*) were video- and audio recorded in seven zoos using focal animal sampling. Vocal analysis focused on three call types: pants, threats and snorts. The behavioural context in which each call type was uttered and the nearest neighbours were determined. Moreover, communication networks were generated for each call type in order to analyse directionality and structure of vocal interactions. The results emphasise distinct call functions: Pants are uttered in affiliative and neutral interactions between sexes. Threats are uttered by females towards males during agonistic interactions. Snorts are uttered by all individuals equally during various relaxed contexts. Furthermore, vocal interactions proved to be unidirectional and depending on the proximity of specific group members, indicating that individuals adapt their vocalisations according to surrounding conspecifics. In conclusion, the three call types have distinct functions and social relevance in WR. The animals vocalise at a non-random level and direct the calls to specific group members. Therefore, the analysis of acoustic communication is a useful tool for illustrating group composition as well as social interactions.

Hierarchical linear dynamical system for classifying bird notes

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In order to aid understanding of avian vocal complexity in Family Paridae, and its relationship to environmental and social phenomena, we seek to develop automated classification of specific notes for two species that co-occur in N America, Carolina chickadee (*Poecile carolinensis*) and tufted titmouse (*Baeolophus bicolor*). These two species have been classified as `community informants' whose vocal production encodes situationally specific information used by other species to mitigate predation risks. To automate classifying bird notes from recorded audio, we worked with hierarchical linear dynamical system (HLDS), a recently proposed architecture for modelling time series. HLDS can be employed in two ways: 1) simultaneous segmentation and clustering for exploring the data i.e. finding unknown notes, 2) simultaneous segmentation and classification in the presence of outliers for finding the notes of interest. We utilised HLDS for the second purpose since it is an easier task and still a challenging problem in the field. Each test clip has the same recorded notes as in the training clip, but it is different from the training clip in the order of the recordings and also the level of degradation. After the training, the classes of the interest are defined to be the notes that HLDS can model nicely during validation. At test, it is automatically decided to which of the classes of interest a note belongs to if any. Unlike discriminatory classification algorithms, HLDS can find outliers at the test time i.e. without resorting to anomaly detection as a pre-processing step.

Convergent character displacement of acoustic signals revealed by range-wide spatial mapping

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Classical theory in ecology and evolutionary biology predicts that when related species come together into coexistence, characters such as communication signals will diverge, thus reducing the potential costs of competing for resources or of interbreeding amongst themselves. An alternative possibility is that signals of dominance or aggression may instead converge to facilitate coexistence among ecological competitors. Such convergence in signals may seem a counter-intuitive process, but it is supported by recent theoretical and empirical studies. However, the extent to which this process drives spatial patterns of acoustic trait evolution at continental scales remains unclear. By modelling variation in song structure of two ecologically similar species of *Hypocnemis* antbird across Western Amazonia, we show that their territorial signals converge such that trait similarity peaks in the contact zone, where intense interspecific territoriality between these taxa has previously been demonstrated. Based on analysis using remote sensing data, we show that signal convergence is not explained by environmental gradients and is thus unlikely to evolve by sensory drive (i.e. acoustic adaptation to the sound transmission properties of habitats). Our results suggest that character displacement driven by interspecific competition can generate spatial patterns opposite to those predicted by classic character displacement theory and highlight the potential role of social selection in shaping geographical variation in signal phenotypes of ecological competitors.

Emotionally expressive artificial sounds based on biological rules

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Humans can assess the intensity and emotional valence of animal vocalisations based on simple acoustic features, such as the call length and fundamental frequency of the sounds. These simple encoding rules are suggested to be general across terrestrial vertebrates. To test the degree of this generalisability, our aim was to synthesise a set of artificial sounds by systematically changing these acoustic features, and examine how emotional valence and intensity is attributed to them by humans. Starting from sine wave sounds, we generated almost 600 sound samples with Praat in seven categories, across three levels of complexity and incorporated added parameters that are characteristic of animal vocalisations. We used a two-dimensional model of emotions to measure the perceived emotional valence and intensity of the sounds, applying an interactive online questionnaire. The answers of more than 230 participants were analysed using Generalised Linear Mixed Models. The results show that in case of valence both the fundamental frequency and the call length of the sounds affected the ratings; sounds with low fundamental frequency and shorter call lengths were considered more positive. The fundamental frequency of the sounds also affected the intensity ratings, as samples with high fundamental frequency were rated as more intense across all categories. Thus, we can conclude that the basic rules of vocal emotion encoding apply not just to biological but artificial sounds too. The application of such rules to generate artificial emotion expressions can be a good starting point for the development of novel non-verbal vocalisations for social robots.

Evolution of song developmental trajectories in island populations.

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Some species of songbirds learn songs with high precision, while others don't. This diversity in developmental processes provides us with a unique opportunity to explore the evolution of cultural behaviour. In the case of chaffinches (*Fringilla coelebs*), Atlantic Island subspecies learn with lower precision than European subspecies, suggesting that the process of song development has evolved over a relatively short time period. In this study, we intensively recorded yearling chaffinches from European and Tenerife populations of the common chaffinch in situ during song development, from shortly after they began defending territories. We recorded more than 500 songs from each of 16 individuals and computationally compared songs using a dynamic time warping analysis. We found that for Tenerife common chaffinches, the rate of song development was much slower than in mainland populations. In particular, while syllable sequences became stereotyped over a matter of two weeks in the UK, this process was still continuing after two months of development on Tenerife. We used these results to develop a conceptual model of song development that suggests an unexpected connection between perceptual predispositions, song learning precision, and developmental trajectories.

A forked relationship: Understanding acoustic communication strategies in sympatric Drongos

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The primary function of acoustic signals is to communicate information over optimal distances to their intended receiver, for various contexts. This is subjected to changes and distortions imposed by the physical structure of the habitat, as well as masking interference from co-occurring signals of other vocal species, especially from congeners. Passerine birds in particular, owing to vocal learning and mimicry, are highly vocally plastic, and have been relatively little studied in this regard. However, they pose interesting possibilities because of this, as this plasticity expands the range of possible behavioural and physics-based strategies they may employ to "get the message across" in an acoustically crowded environment. Drongos (Dicruridae) are a group of highly vocal passerines known for their vocal plasticity. In this (ongoing) comparative study of four sympatric drongo species, we aim to understand the breadth of communication strategies used by these birds in presence of other congeners. Carried out in a lowland tropical evergreen forest in Assam, India, we use active recording of focal drongo individuals. Perch heights of both calling and non-calling individuals were recorded. Passive acoustic recorders were used to estimate diel activity patterns. Spatial information was collected along with abundance estimation. Through preliminary analysis, we present evidence of difference in song perch heights in the drongo species, with *Dicrurus hottentottus* occupying the highest perch and *Dicrurus paradiseus* the lowest. There is high overlap in vocal activity time suggesting no temporal partitioning. Further analysis will provide interesting insights into how sympatric drongos coexist in a similar habitat.

Vocal complexity of the pale spear-nosed bat, *Phyllostomus discolor*

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Vocal communication can be studied as a window into the complex behaviours and social interactions of virtually all vertebrates. The recording, analysis, categorisation, and finally the understanding of vocalisations allows us to draw conclusions about a species' ecology, its social system, and even the internal state of individuals. This is particularly relevant for bats, which are often highly social and vocal, and for which acoustic analyses permit unprecedented insights into their complex behaviours. One obstacle in the acoustic investigation of such gregarious, group living animals is the discrete assignment of vocalisations to the emitting individual. We combined high-resolution infrared video recordings with a 16-channel ultrasonic-microphone array to generate an acoustic camera. This allowed the synchronous recording of audio and video streams, while additionally enabling us to detect the origin of the recorded vocalisations. This individual assignment of vocalisations to its source permits us to analyse social behaviours on a completely new scale. With this setup, we recorded the vocal repertoire of the pale spear-nosed bat, *Phyllostomus discolor* in a social roosting context. In addition, we documented the emission of higher-order syllable combinations, and the corresponding social behaviours. This recording procedure afforded us exceptional insights into the behaviour and social structure of *P. discolor.*

Cross species effect of distress calls on dogs: Comparison of reactions toward pup-, baby-, kitten- and artificial cries

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In the absence of the caregiver, offspring of different species emit separation calls. These cries have highly conserved acoustic structure and function across mammals. Therefore, adult individuals might react similarly even to heterospecific separation calls as to their own species' ones. Although in the wild such interactions must be rare, they are rife in case of dogs. Through domestication, they became especially sensitive toward humans' communicative signals, including baby crying. Our aim was to examine dogs' reactions toward conspecific, human or kitten separation calls. We also tested how they react to synthetised cries to explore the effect of specific acoustic features. After testing 154 dogs with pup cries in a previous study, we tested 116 further dogs in three groups based on the presented species. Four different 7 s long separation call bouts of the same species were played for the dogs from a hidden speaker. Latencies of attention and owner orientation were measured. We tested the effects of the species, call length, pitch, jitter and entropy of the calls. Dogs reacted toward pup and artificial cries the fastest, and baby cries the slowest, while responses to kitten sounds were intermediate. From the acoustical parameters, independently from the species, jitter and entropy affected their reaction extensively: higher entropy caused faster owner orientation, while higher entropy and jitter caused slower speaker orientation, suggesting a stress reaction and avoidance or comfort seeking when hearing noisier calls. However, species-specific cues seem to have a stronger effect on the attention of the dogs.

Of whistles and squeaks: Selection for ultrasonic calls in rat pups leads to changes in larynx mineralisation and F0 in adults

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Selection on one trait can lead to changes in other, unselected traits as a by-product. These by-products may occur simultaneously and/or across developmental stages. Current knowledge is limited concerning how acoustic traits dependent on the laryngeal structure influence other traits associated with the larynx throughout development. We investigate how long-term selection for increased rat pup call rate affected the laryngeal morphology and vocal repertoire in adults. We recorded the vocal output of two rat lines. The “high line” was bred to produce a high rate of ultrasonic vocalisations (USVs) as pups, while the “low line” was bred to produce low USV rates. We analysed vocal output and µCT scanned the larynges of adults from both lines. We found that selection for higher USV whistling rates in pups decreased the fundamental frequency of human audible squeaks (high line adults). Further, adult rats of the high line had a more mineralised thyroid and arytenoid cartilage compared to the low line. Our results support the idea that selection for USV rate at an early developmental stage leads to unselected by-product effects on the vocal apparatus and vocal communication at later developmental stages.

Onset of vocal recognition of filial pups by female northern elephant seals

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Allo-nursing is more common in phocid than in otariid pinnipeds and thus mother-pup vocal recognition has been suggested to be less well developed. The northern elephant seal is a colonial breeding species with a 27 -day nursing period on shore and an abrupt weaning when females return to sea. Allo-nursing rates reach 18% within some rookeries, and breeding females can be aggressive towards non-filial pups, leading to increased mortality. These observations question the occurrence and onset of vocal recognition, as misguided maternal care could be a consequence of a mother's failure to recognise her dependent pup. Playback experiments were conducted with 22 adult females to examine behavioural responses to calls of their own pup and responses elicited by vocalisations from unknown pups. Playback tests were performed weekly on focal females from birth to weaning to determine when vocal discrimination of pups by their mothers emerges. Females demonstrated vocal recognition of their pups from the first week. To further resolve the onset of vocal recognition, eight additional females were tested 1 - 2 days after parturition. These playbacks showed that some females are able to recognise their pup's call within one day of birth. Our findings indicate that female northern elephant seals learn to recognise their pup's voice as early as do some otariid species, and that factors other than lack of vocal recognition may explain the occurrence of allo-nursing behaviour in this species.

Monitoring acoustic labels to determine individual movement of coastal bottlenose dolphins, *Tursiops truncatus*

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50 years of research into the use and long-term stability of signature whistles (SW) indicate their use in monitoring individuals acoustically. Mark-recapture is commonly used for studying abundance, survival and movements of animals. For cetaceans, photographs are often used which must be obtained during daytime in good weather, involve significant costs and human effort and can disturb focal animals. Fixed hydrophones offer a less-invasive alternative to capture individuals using unique acoustic labels. We investigated the potential to use static acoustic monitoring (SAM) to detect individual bottlenose dolphins and analysed the data within a mark-recapture framework. Data were collected from four moored hydrophones in Walvis Bay, Namibia. To test the influence of recording location and duration, we analysed data from four sites collected over 22 days; and 124 days of data from one high-use site. SW were identified from the recordings using a bout analysis approach. Between-site comparisons revealed high variability in SW capture, with between 0 and 13 SW detected at different sites. Different noise backgrounds and/or individual differences in habitat use may explain this variability. At the high-use site, 31 SW were captured – detection initially increased, approaching asymptote around day 105. This study indicates the potential use of acoustic labels as proxies for individual occurrence and highlights potential sources of bias that may influence study design. These findings indicate that SAM of SW offers a viable alternative to photo-identification and could be applied when investigating habitat range, social structure or generating density estimates.

Listening from the egg: Songbird embryos alter their development based on prenatal acoustic cues

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In many species, ranging from crocodiles and birds to humans, embryos can perceive, learn and even produce sounds before birth. Surprisingly however, the role of prenatal acoustic communication in shaping developmental trajectories has been only recently realised. In wild-derived zebra finches (*Taeniopygia guttata*), we demonstrated that parents produce a peculiar high-pitched rhythmic call, when incubating at high ambient temperatures. In a large playback experiment in artificial incubators, we showed that exposure to this specific call alone alters nestling begging and growth in a temperature-dependent manner, with life-long positive effects on reproductive success. Here, we investigated whether zebra finch embryos discriminate between different biologically relevant rhythmic acoustic signals and adjust their development accordingly. Specifically, using playbacks to artificially incubated eggs, we tested whether exposure to sibling begging calls or parental heat-calls accelerates hatching, compared to control parental calls. Whilst hatching success was unaffected by prenatal acoustic experience, we found that embryos exposed to begging calls tended to hatch earlier than controls, particularly when they were early in the laying sequence. By contrast, exposure to parental heat-calls had no effect on hatching time. Furthermore, these two acoustic signals appeared to have contrasting effects on post-hatching feeding and growth. These findings demonstrate that embryos are capable of obtaining relevant information about the external environment by eavesdropping on acoustic signals. Overall, our data therefore suggest that the effect of prenatal acoustic environment on development is considerably greater than currently acknowledged, and warrant further research in both birds and other taxa.

Long-term acoustic recordings: A solution for the rock ptarmigan?

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The rock ptarmigan (*Lagopus muta*) is a bird living in high altitudes in France and considered as a sentinel species of the alpine environment. The ever-changing weather of mountains and the low call rate of the bird makes it a challenge to monitor. The current monitoring of the species is based on localisations of males during the mating season by acoustic cues of males during point count protocol. The inconsistency between counting days and localisations problems due to sound propagation in alpine environments question the protocol validation. According to these problems, long-term acoustic monitoring might be an appealing solution. Indeed, numerous studies showed that acoustic signals convey individual information about the emitters. Bioacousticians can exploit this information obtained over long periods of time to estimate the number of individuals in an area, and furthermore monitor population dynamics but present two drawbacks: (1) The weather might corrupt the recordings and mask the calls and reduce individuals identification. (2) The acoustic availability of the animals: individuals might not be identified if they don't vocalise enough. Despite these strong constraints, our study covering three consecutive years of long-term recordings shows that bioacoustics is relevant as a monitoring tool for this species. Moreover, the temporal scale covered by our study allow to obtain finer information than by point count such as the number and time of presence of individuals in the area of interest. Hence, the precision of the data obtained by acoustic monitoring is dependent of its duration, especially for secretive species.

Effects of underwater noise on the vocalisations of bottlenose dolphins in an urbanised estuary

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In coastal marine environments, vessel traffic is the most ubiquitous anthropogenic activity with the potential to disturb marine wildlife. This is of particular concern to acoustically specialised species, such as dolphins. The Fremantle Inner Harbour in Western Australia forms part of an industrial port; however, it is also frequently used by a resident community of Indo-Pacific bottlenose dolphins (*Tursiops aduncus*), which are consequently exposed to high levels of vessel traffic. To investigate whether acoustical responses could be occurring, a non-invasive combination of acoustic and visual monitoring was conducted using an autonomous acoustic logger and a land-based theodolite station. Dolphin whistles were measured using 11 characteristics: duration, minimum frequency, maximum frequency, delta frequency, start frequency, end frequency, inflections, extrema, steps, saddles, and harmonics. Separate Generalised Additive Models (GAMs) with contextual covariates were fitted for each of these whistle characteristics. The explanatory variables included broadband noise levels, as well as information on dolphin activity state, group size, and calf presence obtained from visual monitoring. Noise levels over the whole recording period were approximately 110 dB re 1 µPa rms (10 Hz – 48 kHz). All 11 whistle characteristics significantly varied in association with increasing levels of broadband noise. Despite being acoustically specialised for higher frequencies, dolphins displayed the strongest acoustic variation during low-frequency noise. However, whistle characteristics also varied to a lesser degree according to other contextual variables. This highlights the need to consider acoustic behaviour alongside appropriate contextual data in disturbance studies.

The acoustic space of pain: Coding and decoding distress in human babies' cries

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Crying is the primary signalling strategy available to the human newborn for eliciting parental care. Yet, we only have superficial understanding of the information carried by cries, and of how this information modulates parents' interpretation and response to cries. Using modern tools of sound processing and playback experiments coupled with brain imaging, we are currently investigating both the information content of cries and the factors influencing the behavioural and the brain responses of adults to cries elicited by different levels of stress. We used dedicated sound analysis tools to compare the structure of cries of healthy babies recorded in controlled conditions differing by the degree of elicited stress (i.e. bath or vaccinations). We identified vocal 'roughness', a composite acoustic factor characterising the level of aperiodicity of the cries, that differs between different levels of discomfort or pain. On the receiver's side, while adults are able to use acoustic features of cries to discriminate broad differences in distress levels, they fail to discriminate between different levels of pain. During this talk, we will also demonstrate the importance of familiarisation, emphasising that the ability to recognise newborns by their cries is independent of sex and parenthood status.

New perspectives of calibrated bioacoustics detectors

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The use of calibrated microphones on the field has been considered until now as a costly and time-consuming burden for bioacoustic research. However, since the absolute level of the pressure wave is missing, crucial information about acoustic energy devoted to echolocation/communication prevent doing complete systemic studies including propagation physics. Historical data set are thus untrackable for new research focused on individual and environmental perception/interaction analysis. Moreover, for multi-sensor spatial sound analysis, it is mandatory to use homogeneous and possibly absolutely calibrated microphones. We present in this paper a new low-cost and “open hardware” instrumentation concept suitable for deploying large set of calibrated microphones in the field. For this purpose, we use connected instrumentation and MIMO (Multiple Input Multiple Ouput) transmitter/receiver principles. A prototyped-instrumentation, built with on-the-shelf electronics is detailed. We finally conclude this presentation by making the analogy between our concept and the auditory system of animals. In the latter, the permanent production of sound seems to be a fundamental requirement for spatialisation.

Mitigating the impacts of motorboat noise on nest defence in tropical damselfish

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Coastal waters are polluted by noise from vessel traffic worldwide, calling for a greater understanding of the potential impacts of anthropogenic noise to inform management. Currently, there are around 12.5 million registered recreational motorboats in the USA and there are expected to be 0.5 million using the Great Barrier Reef by 2040. Because of the wide prevalence of recreational boat traffic, consequent scientific evidence now demonstrates the clear negative biological impacts of vessel noise on marine life. However, the issue is becoming clearer and investigation should also consider ways of reducing these damaging biological effects. For example, exacerbated responses following exposure to louder motorboat engines compared to newer, quieter engines has been demonstrated in tropical damselfishes. Similarly, our study explored the influence of motorboat noise on important territorial behaviours and nest defence of Ambon damselfish males. Furthermore, our group explored the potential for responses to be altered via mitigated boat-driving strategies. Animals that defend territories use a diverse suite of behavioural strategies to repel intruders. Therefore, any disturbing stressors that may influence important territorial behaviours have the potential to directly affect defence against opportunistic predation by invaders or indirectly alter energy budgeting and parental care. This research aims to explore the influence of noise disturbance on these biological processes and provide a potential solution supported by scientific evidence to help address this multifaceted problem.

Acoustic stress tolerance in native and invasive fish species

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Biological invasions are one of the main drivers of biodiversity loss, impacting native species through competition, predation or disease transmission. Invasive populations are often found to be tolerant to environmental stressors like salinity, rising temperature or oxygen depletion, which may contribute to their success. Anthropogenic noise represents a pervasive environmental stressor whose ecological implications are attracting a growing interest. However, differences in acoustic stress tolerance between invasive and native species and consequences in terms of invasion success and impact have not been investigated so far. In the lab, fish were habituated to either ambient noise (control group) or to ambient noise supplemented with boat noise (noise-habituated group). We then derived the functional response (FR, the relationship between resource use and resource density) of the fish feeding on live invertebrate prey under the two noise conditions and for both groups. Interestingly, the shape and magnitude of FR curves are powerful indicators of how the predator exploits its prey population. We also recorded the mobility, spatial distribution and sociality of fish to link changes in behaviour with changes in foraging. Under the assumption of a greater tolerance for invasive species, we expected no difference in FR between the two noise conditions compared to a reduced FR with boat noise for native fish. If fish get habituated to noise, then alterations in FR should be observed in the control group only. We expected stressed fish to behave as if they were under predation risk.

Condition dependent lifetime signalling in the tree cricket, *Oecanthus henryi*

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In the tree cricket, *Oecanthus henryi*, males invest in long distance acoustic signals which the females use to identify and localise conspecific mates. Males that live and call longer are expected to have higher mate attraction opportunities. Since calling is an energy demanding behaviour, we would expect males to adopt different signalling strategies over their lifetime depending on their body condition. Nutrition and age can contribute to male body condition. Therefore, in this study we investigated the effect of diet on male longevity and the interaction of diet and age in determining lifetime male calling propensity & calling duration in a semi-natural setup. We tracked daily calling behaviour of the study males over their lifetime. In concordance with our expectation, males on high nutrition lived longer, had higher lifetime signalling and had longer within-night calling duration. Within-night calling propensity, however, was not affected by diet. We, additionally, studied diet-dependent phenotypic senescence of male acoustic signals. Both within-night calling propensity and calling duration showed senescence with age. Interestingly, males on high dietary condition sustained their high signalling activity over a longer period while males on poor dietary condition suffered a sharp decline in signalling. Our results suggest condition-dependence of male acoustic signals in *O. henryi.*

Biotic and abiotic sounds affect calling activity but not plasma testosterone levels in male frogs (*Batrachyla taeniata*)

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In animals, the expression of diverse reproductive behaviours is hormonally regulated. In particular, vocalising during courtship has been related to circulating androgen levels, and reciprocally, conspecific vocalisations are known to modulate androgen secretion in vertebrates. The effect of natural sounds of abiotic origin on hormonal status has virtually not received attention. Therefore, we evaluated the vocal responses of male *Batrachyla taeniata* frogs to conspecific chorus and rainfall sounds in natural and controlled laboratory settings, measuring the testosterone levels of exposed individuals. In field and laboratory conditions, testosterone levels of frogs exposed to 31.5 min of chorus and rain sounds and non-exposed individuals were similar. In the field, frogs increased their call rate in response to playbacks of chorus and rain sound, but the evoked calling activity was unrelated to plasma testosterone. In contrast to the field, frogs showed limited responsiveness to 31.5-min acoustic exposures in the laboratory. In spite of the limited vocal activity, the overall calling activity and plasma testosterone levels were positively correlated in the laboratory. Additionally, in this group, testosterone levels were higher in vocally active males as compared to non-calling individuals. Overall, these results indicate that in *B. taeniata* testosterone levels are not altered following a short-term exposure to conspecific biotic and to abiotic sounds. The positive relationship between the calling activity and testosterone levels of frogs tested in the laboratory may indicate that under controlled conditions relationships between androgens and behaviour are more accurately unveiled than amid the environmental and social complexity of natural settings.

Quantifying timing in animal vocal sequences

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Timing in animal vocalisations can indicate context, emotional states and can even correlate with the genes. Although correlations between timing and biological characteristics have been reported for numerous species, to date, there are few objective methods for capturing temporal structure in animal vocalisations. In this talk, I will present and compare quantitative techniques for characterising temporal structure including Fourier analysis, phase portraits and distributions of silence gaps. These techniques are applied to artificial and animal sequences and evaluated in terms of their insight power. Investigating temporal structure in animal vocalisations in an objective and reproducible way can further our understanding of animal vocal communication, contribute to taxonomy, support conservation efforts by helping monitor animals in the wild.

Finding a sound-producing fish in a water-filled tank with few hydrophones

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In this contribution, we present a recently developed algorithm for localisation of sound-producing fish in a small rectangular tank. The algorithm is based on a theoretical acoustic model of the fish tank and can be used for behavioural bioacoustical studies to determine which fish in a group is sound producing. We use four hydrophones placed in the tank together with a group of fish under study (six sparkling gouramis). To show the accuracy of the localisation, we compare the results with a localisation based on image processing technique and with video recordings acquired synchronously with the acoustic recordings.

Songs in the wild and in domestication: Relaxed selection of song complexity in Bengalese finches

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The Bengalese finch is a domesticated strain of the wild White-rumped Munia. The process of domestication ranged over 270 years during which about 500 generations have passed. Songs of Bengalese finches are complex both in acoustics and in sequence, and about 10 dB louder than those of Munias'. Cross-fostering experiments showed at least some of these differences are due to genetic preparations. Nevertheless, auditory dependency in real-time song maintenance is equally high both in Bengalese and in Munias. Field study of Munias found that simple songs tended to occur in the populations where there was the high ratio of sympatric, closely related species. Laboratory study of both Munias and Bengalese found that song sequential complexity stimulate reproductive behaviour of females. These two set of studies suggest that song is maintained rather simple in the wild to avoid infertile hybridisation. In other line of experiments, song complexity in the wild and domesticated strains were related with the degree of basal ganglia expression of androgen receptors. Furthermore, the degree of receptor expressions was related with de-methylation at the androgen receptor coding site. This study suggests that there may be experience-related modulation of song complexity in these two strains. Taken together, song complexity in Bengalese finches might be shaped both by relaxed selection in domestication and by indirect sexual selection under domestication. Furthermore, rearing environment might affect song complexity via epigenetic modulation. This research was supported by a MEXT grant (number 4903, JP17H06380 to KO).

Acoustic communication network of duetting Yellow-breasted boubou (*Laniarius atroflavus*) from W Africa montane forest

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The Yellow-breasted boubou is an endemic bird to W Africa montane forests. Sexes are monomorphic and pairs produce simple calls as solos and duets. Calls produced by males (three whistle types) and females (four atonal sounds) have strikingly different structures. We analysed circadian vocal activity based on recordings from synchronised SM3 recorders working continuously in territories of 18 pairs. Males were much vocally active than females. Duets accounted for 24.7% and solos for 75.3% of all calling events (N = 4470), 65.2% of solo cases were male and 36.8% were female. Activity was started before sunrise usually by males producing solo a specific type of call Whee-whee. Then, females joined mates in duets and for 2-3 morning hours birds produced many calls both together or as solos. Later the vocalisation rate decreased but was regular during the day. Around dusk, females became more active and often finished the day with series of alarming Kecks. Despite the small repertoire of calls birds combined them into 45 different call sequence types, with the most common 14 types comprised 97% of all cases. Male solos and typical duets initiated by males, were more likely used to overlap calls of neighbours and, more likely were overlapped by them. Female calls were less than expected overlapped by neighbours. The faster birds responded to neighbours the more likely their signal match the type used in preceding call event. The communication system described is likely stabilized by individual recognition and conventional costs. This research was financially supported by the National Science Centre, Poland (UMO-2015/17/B/NZ8/02347).

Bottlenose dolphin whistle repertoires: Size and stability over time

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Bottlenose dolphins are well known for their vocal learning abilities that influence the development of individually distinctive signature whistles. While signature whistles have been studied in detail, little is known about other whistle types in bottlenose dolphin communication. These other whistle types account for an average of 50% of whistles emitted in the wild. We collected 24-hour acoustic recordings for two months from a group of 13 bottlenose dolphins at L'Oceanogràfic in Valencia, Spain to determine the whistle repertoire size of this group and investigate change in learned whistle types over time. Signature whistles were identified using the SIGID method. We then analysed 50 randomly chosen whistles per day (n = 2,660 whistles) and categorised them using ARTWARP (96% vigilance level). The cumulative whistle type discovery curve from these data showed that while the curve began to level off over time and reached 342 whistle types after two months, new whistle-types were still being discovered at a rate of one whistle type per day over the last ten days of the study. However, the pattern of appearance and disappearance of whistle types from our data did not differ from a pattern expected by chance (exact randomisation test: n.s.) when using subsampling. This demonstrates that while the whistle repertoire was large, whistle types were retained and did not change over the time of two months. Future studies on group and species specificity of whistle types are needed to assess whether stable repertoires of non-signature whistles can improve passive acoustic monitoring of delphinids.

Assessing biodiversity with sound: Do acoustic diversity indices reflect diversities of bird communities in grassland habitats?

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Measuring biodiversity is a challenging task for research in ecology and conservation. Acoustic indices calculated from soundscape has been suggested as a solution for biodiversity assessment. However, the relationship between on-the-ground truth and acoustic indices still needs to be investigated. This study applied the emerging tools of ecoacoustics to examine the avian diversity of the Prairies in the US. In this study, we investigated the suitability of five acoustic indices: Entropy, Acoustic Complexity Index (ACI), Acoustic Diversity Index (ADI), Biodiversity Index (BIO) and Normalised Difference Soundscape Index (NDSI) to measure the avian richness of Prairies at different level of degradation. Twenty-one 24-hour long recordings were made at nine sites of remnant, restored, and degraded prairies each in northwest Arkansas (US) between May-July 2018. Using “soundecology” package in R, the five acoustic indices were calculated for randomly selected one-minute recordings. A linear mixed-effect model highlighted a significant correlation between the ACI values and the number of bird vocalisations composing the soundscape. A comparison of ACI value for prairies with different degradation scale, showed that remnant and restored prairies had significantly higher ACI values than degraded grasslands. This was in agreement with avian richness estimated using traditional point count surveys. Acoustic indices offer new opportunities to monitor grassland bird communities faced with the challenge of human-induced disturbances and other proxies like climate and land use changes.

How do crocodiles localise a sound source?

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As top predators, crocodilians are well equipped to probe their environment: excellent vision in air, highly developed smell, extraordinary use of mechanoreceptors, and an acute sense of hearing. Besides being useful to localise and identify their prey, these sensory abilities also sustain social interactions between sexual partners and between parents and young. To evaluate crocodiles' sound localisation abilities at the complex air-water interface where they spend most of their active time, we firstly measured crocodilians' external cues such as Head-Related Transfer Functions (HRTF) and Interaural Time- and Level Differences (ITD and ILD). We found the presence of external sound localisation cues in crocodilians, even when the animal is at the air-water interface with most of its body underwater. We then conducted behavioural experiments on both conditioned and naive Nile crocodiles, *Crocodylus niloticus*, at the lab and in semi-captivity. Our main objective was to quantify crocodiles' sound localisation performances and to describe their behavioural strategies when approaching a sound source of interest. We paid a particular attention to the use of external cues during sound localization tasks. We found that crocodiles show strong acoustic localisation abilities with a low error when estimating the sound source position, and that crocodiles can rely on both ITDs and ILDs.

Communicative complexity in wild primates: Comparing sociality and communicative systems in two lemur species

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Animals exhibit an astonishing diversity of communicative systems, with substantial variation in both the nature and the number of signals they produce. Variation in communicative complexity has been conceptually and empirically attributed to social complexity, with animals living in more complex social environments exhibiting more signals and/or more complex signals than animals living in simpler social environments. Within the scope of this "social-complexity hypothesis for communicative complexity," we propose a comprehensive comparison of the communicative systems of two closely related species of Eulemur with similar morphology and habitats, but different social systems. We carried out focal behavioural observations and focal acoustic recording of 33 wild *E. rufifrons* (5 groups) and 10 wild *E. mongoz* (3 groups) in Madagascar, respectively in Kirindy and Ankatsabe forests. Based on these 449 hours of focal behavioural observations and 284 hours of recordings, we adopt a comprehensive approach of communicative complexity parameters by assessing the number of signals or signalling units and the uncertainty (combinations and gradation of signals) at both signal and system levels. Integrating these measurements in a network approach, we discuss the role of the different components of the social system on the evolution of communicative flexibility.

Social settings and vocal communication from the perspective of the human communication niche

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The human language capacity provides a quite interesting case study of a vocal communication system ubiquitous across one species and nevertheless highly diverse, as reflected by the thousands of distinct languages spoken around the world. Each one of these languages endows its speakers with a communication system flexible enough to adapt to various communication situations and still fulfil one of its most important function: information transmission. In this presentation, I will review recent studies showing regulation mechanisms between speakers and their language structure at different social scales (from online adaptation between interlocutors in everyday conversation to the larger scale of the global speaker population). I will also address the issue of interactions between social network and linguistic system complexity in human communication. Finally, I will discuss these results in the general context of a multi-scale bio-cultural niche construction.

Sound production in the Meagre(*Argyrosomus regius*): Intraspecific variability associated with size, gender and context

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Many fish taxa produce sound in social and in alarm contexts but knowledge on the full acoustic repertoire is lacking for most species. Yet, this knowledge is critical to enable monitoring of fish populations in nature through acoustic monitoring. In this study we characterised the sounds emitted in alarm and social contexts by captive juvenile and adult meagre, *Argyrosomus regius*. In the case of adults, the acoustic activity and characteristics of sounds produced during social contexts in relation with and spawning events (monitored by the collection of eggs from the tanks) were also characterised. For comparison, we also registered meagre sounds in the Tagus estuary from unseen fish during the breeding season. The present dataset demonstrates for the first time that in this species dominant frequency is inversely related to fish size, and that sounds vary according to gender, context and throughout ontogeny. Sounds produced by captive meagre during the breading season showed a richer repertoire than previously observed. Sounds from captive breeding adults were comparable to sounds recorded in the field.

Yellowhammers with Kiwi accent: Evolution of birdsong dialects in an alien population

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While biological invasions threaten both the native ecosystems and economy, they also allow to study various biological phenomena, including the cultural evolution of birdsong. We grasped this golden opportunity to explore how the initial bottleneck, followed by a rapid spread through unoccupied territory affected the dialect diversity and distribution in the exotic population of yellowhammers (*Emberiza citrinella*). 140 years ago, several hundred of these Eurasian passerines were introduced to New Zealand from Great Britain, and after successful establishment colonised most of the territory. Using recordings collected by citizen-scientists or by our team, supplemented by those from various sources, including online repositories and library archives, we mapped the geographical variability of the yellowhammer song both in native source range and in exotic range. Surprisingly, the diversity of dialects was not impoverished in alien range despite an initial bottleneck and even exceeded the diversity in native range; we recorded one exclusive dialect in Great Britain and five in New Zealand, two (BC and XB) were shared. Those that were unshared by British and New Zealand yellowhammers were repeatedly recorded in several countries from European mainland. New Zealand yellowhammers thus either re-invented the wheel, or more likely, retained the dialects that have been lost in mother country due to a population decline.

Can my dinner hear me? The perception of bats' echolocation signals by Orthoptera insects

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Predation is one of the strongest factors in natural selection. Under this biological interaction, prey have developed a number of defence mechanisms (passive and active), of which the most common are behavioural. Some predators specialise in eavesdropping the courtship songs of their prey, leading to a trade-off being developed during the mating period that balances sexual selection and the pressures of predation. *Tettigoniids* comprise the main part of the diet of the *M. blythii*, one of the two European species of bat who apply this "eavesdropping" strategy to foraging. In turn, Orthoptera species of insect are sensitive to ultrasound, which induces reactions such as pausing or stopping their mating songs, curtailing flight, and flying away from the source of the sound, actions that are indicative of defence strategies developed against insectivorous bats. We tested the responses of several tree species – *Gryllus campestris, Tettigonia cantans* and *T. viridissima* – to echolocation calls of the *Myotis blythii* (who feed on Orthoptera) and *Eptesicus serotinus* (who do not feed on Orthoptera), using playback experiments. Research was conducted under natural conditions in regions where both species of bats naturally occur (Poland and Romania). The results found no reaction to the *M. blythii* feeding sequences (predator), yet reactions from all three Orthoptera species (stopping or pausing vocalisation) to the feeding sequences of *E. serotinus* (not a predator). These results demonstrate that defence strategies to avoid echolocation predators is, to a certain extent, dependent on the range of prey audibility, in this case Orthoptera insects.

Chorusing seal pups and their interactive vocal rhythms

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A key feature of animal vocalisations is their temporal and rhythmic structure. In particular, understanding vocal timing and rhythm in a few specific mammals (e.g. pinnipeds, elephants, bats) drives a cross-species hypothesis in evolutionary neuroscience: vocal learning and rhythm perception and synchronisation go hand in hand. Harbour (*Phoca vitulina)* and grey seals (*Halichoerus grypus*) are among these mammals, and their puppyhood is possibly the most active vocal period in their lives. In these species, timing vocalisations precisely can have an adaptive function during the nursing period, namely being heard by the mother in a chorus of other pups. Here we present data from two species in four different setups: recordings of semi-natural vocal interactions in 1) individual and 2) group settings, 3) playback experiments to elicit vocal responses and 4) perceptual listening experiments to measure behavioural responses. We complement empirical data with mathematical and agent-based computational modelling. Our data suggest that harbour and grey seal pups have a sense of rhythm, but this is quite different from that of other species. Pups of both species show rhythmic interactivity and antisynchronous coordination in their vocal interactions. Evidence for antisynchrony, rather than synchrony, in these two vocal learners has several implications. In particular, it suggests that the rhythm-vocal learning link across species may be more complex than previously surmised.

From song libraries to corpora: A case study on extracting Orthoptera songs from environmental recordings

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Orthoptera are a major component of soundscapes, particularly in tropical and subtropical forests, but also temperate grasslands. However, most acoustic monitoring projects still focus on vertebrates, particularly birds, frogs or bats. Fortunately, many of these recordings are publicly available or are readily shared by the authors, which facilitates re-use for Orthoptera assessments based on song identification. Using ecoacoustic recordings from North- and South America, Malaysia and Greece I demonstrate their usability for Orthoptera monitoring. The stereotyped temporal structure and well-defined frequency ranges (which reach far into ultrasound for many katydid species) facilitate the development of automatic species recognition algorithms. However, rapid development of algorithmic Orthoptera species recognition is hampered by a lack of labelled reference recordings and incomplete song libraries. The Orthoptera Species File (http://orthoptera.speciesfile.org/) could serve as a reference song repository, providing a carefully curated taxonomic backbone, while sound libraries such as Bio.acousti.ca (http://bio.acousti.ca/) could serve as a repository for large labelled corpora, needed for development of automatised song recognition.

Multi-scale ecoacoustic analysis of natural soundscapes within the INR of Sasso Fratino (Italy)

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Ecoacoustics is an increasingly emerging interdisciplinary science that investigates natural and anthropogenic sounds and their relationship with the environment. But if on the one hand, it allows a great opportunity to monitor a habitat because, by the placement of many sensing devices it is possible to record continuously and simultaneously different locations, on the other hand, it is generated a huge quantity of data that needs to be archived and analysed. The new challenge is to draw up a scaled analysis methodology to optimise resources both in the field (saving memory cards and batteries) both in the lab, reducing time and effort of analyses, while maintaining high the accuracy of the information. This work focuses on the testing of scaled multi-view analyses that are both qualitative, based on visual screening of compact daily spectrograms, and quantitative, by the estimation of the acoustics indices and the analysis of spectrum energy for each 1000 Hz range (from 0 to 24 kHz). A further level of analysis is the identification of species by listening to the sounds and observing high-resolution real-time spectrograms, possibly driven by automatic detection tools. On a five-year archive of acoustic data collected in the Integral Natural Reserve of Sasso Fratino (Italy), we operated cross-section (horizontal) and time series (vertical) analyses to explore its soundscapes' spatial-temporal dynamics across different scales.

Designing an acoustic observatory

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The Australian Acoustic Observatory will have 400 continuously recording sensors deployed around Australia that will produce over a terabyte of compressed audio each day for five years. We share insights gained through addressing the challenges of designing this system, including site selection, ensuring sensor hardware is robust to harsh conditions for long durations, protocols for deployment and retrieval of recordings, maintaining data provenance, and development of a public repository capable of making the audio discoverable and navigable.

Evidence for vocal control in a domestic dog?

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Vocal control is a fundamental skill involved in human speech production. Although vocal control has been observed in birds, and some cetaceans, evidence of vocal control in non-human mammals is in its infancy. This study tests for the first time whether dogs (*Canis familiaris*) have vocal control, by comparing the structure of howls produced by a domesticated dog in response to different musical stimuli. The dog was elicited to howl to familiar music from three television programmes, both in their original versions and with the music manipulated in frequency or tempo etc. (e.g. 25% lower in frequency or 25% slower). Recordings were made in 10 playback sessions across more than 4 years (n= 240 howl sequences). The resulting F0 contours were extracted and dynamic time warping was applied. Discriminant function analysis showed that the dog produced distinctive howl sequences in response to the different musical stimuli but did not directly follow the tune. When stimuli frequency or tempo was reduced, his response rate fell and time gaps between howls increased, resulting in more fragmented responses. The elicited howl contours remained stable over time only if the dog was regularly exposed to the musical stimuli, but changed if he was not. Our preliminary results suggest that dogs are one of the few species capable of vocal control.

Recognising Wolf Howls

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Study of population ecology is imperative in wildlife conservation studies. The conservation status of any species is dependent on its population size, the smaller the size of the population, the more vulnerable it is to extinction. The population size and distribution of endangered Indian wolves (*Canis lupus pallipes*) are entirely unknown due to lack of standardised population estimation methods for this cryptic long-ranged species. Mark-capture-recapture based population estimation method falls short in estimating the population of wolf as they lack identifiable coat patterns. Our acoustics based survey method offers a potential method for detecting vocal animals like wolves from as far as three kilometres away. To standardise individual identification from wolf howls, we collected data from three captive wolves as known samples and howls of nine pack of free-ranging wolves. Twelve parameters were measured from the fundamental frequency of each howls. DFA showed 100% accuracy in identifying 44 known howls from eight individuals. The same function (DF1 and DF2) was applied over 52 howls from eight known individual and classified using Centroid Clustering with Minkowski 2nd order function. 64.7% howls were identified correctly. The primary aim of this study was to check the feasibility of wolf pack census through howling. We are still working to improve the accuracy and reliability of this protocol. Estimating the wolf population can be achieved scientifically by further improvement of this technique and systematic sampling, which in turn will help us to get a proper status of wolves in India and continuous population monitoring.

Comparison of the call repertoires of killer whales (*Orcinus orca*) between Iceland and Norway

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Killer whale (*Orcinus orca*) pulsed call repertoires can provide information on the relatedness of social groups or populations and thus can be used as population markers. Killer whales in Iceland and Norway are presumed to belong to the same ecotype and to have been in contact prior to the collapse of the Atlanto-Scandian herring stock in the 1960s but the actual level of contact between the two populations is unknown. Using data collected between 2005 and 2016 this study provides a detailed description of the call repertoire of killer whales in Iceland and updates existing catalogues of the Norwegian population. 43 call types and 31 subtypes are described in Iceland and 32 call types and 21 subtypes in Norway. Measurements of time and frequency parameters of 5752 calls (Iceland n = 4,037, Norway n = 1,715) showed significant differences for most parameters but a high overlap between the populations. A discriminant function analysis classified 57% of calls correctly, thus performing only slightly better than a by-chance classification. However, a visual and aural comparison of all call types did not yield any matches between Icelandic and Norwegian calls, indicating the two populations have different call repertoires. This stands in contrast with expectations of similarities in the repertoires due to the presumed past contact between the populations. The consistent difference in repertoires suggests that if the populations have been in contact before they were likely not one totally mixed population.

An exploration of high dimensional acoustic features applied to a real-time monitoring network in Borneo

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Automated acoustic monitoring of ecosystems provides a cost-effective way to track changes in natural system's dynamics across temporal and spatial scales. Current methods of analysing soundscapes in a holistic manner typically reduce chunks of audio data to a single index (or a few indices), broadly based on the entropy of the signal. We find that by adopting a deep convolutional neural net used for general purpose audio classification, we are able to embed the audio in a more descriptive, high dimensional feature space. We apply this technique to a real-time passive acoustic monitoring network based in the tropical forests of Sabah, Borneo. We are able to accurately predict metrics of habitat quality from audio alone using this feature embedding, and show how this is not possible using existing approaches. Additionally, we explore potential applications of this approach to general acoustic anomaly detection.

Measuring vocal consistency in birdsong: Validation and comparison of methods

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The neuro-motor skills involved in birdsong demand a fine coordination of respiratory and syrinx muscles as well as the two independent sound sources from each bronchus. If the bird's vocal system is finely tuned, we expect the sound output to be highly consistent when repeating the same type of note. There are a number of ways to test consistency in delivery of acoustic signals and all of them involve two steps. Firstly, the sound can be described by individual parameters (duration, peak frequency), a bi-dimensional matrix (dominant frequency, power-spectrum) or the three-dimensional matrix (spectrogram). Then, there are at least 3 widely used methods to compare them, namely the variation coefficient of each parameter, dynamic time warping (DTW) or spectrogram cross-correlation (SPCC). There is currently no standardised methodology, and this hinders the evaluation of vocal consistency across studies. Here, we use a novel approach to validate these methods by using synthetic sounds with controlled variation. We synthesised 20 pure tone and 20 multi-harmonic notes similar to those found in birdsong. For each model note, we synthesised 100 copies with controlled variation in only one parameter: duration, frequency, spectrographic shape and amplitude envelope. We found that the sensitivity to variation is different between methods and between different aspects of sound. We show that only spectrogram cross-correlation responded to variation in all acoustic domains. Hence, we propose spectrogram cross-correlation as the best method to measure vocal consistency in birdsong, although we advise using the minimal temporal sliding.

Fifty-kHz ultrasonic vocalisations as a tool for measuring emotional states and effects of psychoactive drugs in rats

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Adolescent and adult rats emit 50 kHz ultrasonic vocalisations (USVs) to communicate appetitive arousal and positive emotional states to conspecifics. Based on its communicative function, emission of 50 kHz USVs is increasingly being evaluated in preclinical studies of affective behaviour, motivation and social behaviour. Emission of 50 kHz USVs is initiated by the activation of dopamine receptors in the shell subregion of the nucleus accumbens. However, it has now become evident that non-dopaminergic receptors may influence the numbers of 50 kHz USVs that are emitted, as well as the acoustic parameters of calls (i.e., bandwidth, duration, maximum frequency). Emission of 50 kHz USVs is a non-invasive method that may be used to study reward and motivation without the need for complex animal manipulations. Moreover, emission of 50 kHz USVs can be used alone or combined with other well-standardised behavioural paradigms used to study reward and motivation at the preclinical level. On this basis, rat 50 kHz USVs appear as a useful experimental tool to investigate how different neurotransmitter systems regulate the manifestations of positive emotional states.

How colour realistic imagery, virtual reality and robotics can help to understand vocal learning in zebra finches

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Understanding animal behaviour through psychophysical experimentation is often limited by insufficient stimulus representation. For example, important signals and cues can be difficult to standardise, to control, or match species-specific sensory specialisations. Realistic and independent stimulus control becomes even more important when multimodal signals are involved. New techniques like colour realistic imagery and virtual reality can be very potent tools in the quest of gaining new insights in sensory world of animals, in particular in interactive setups where animals can interact with presented stimuli from multiple angles and the stimuli can be adjusted in real time. Moreover, robots can be used as models of specific animal systems to test hypotheses regarding the control of behaviour. We demonstrate how these techniques can be applied to study vocal learning in zebra finches. Our results show that these novel stimuli are well accepted by the birds and that these approaches can help to uncover general principles of multimodal sensory integration.

Dealing with noisy neighbours: Conspecific acoustic masking avoidance in a field cricket

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Many acoustically active animals call in choruses. Such simultaneous signalling of conspecifics often results in acoustic masking interference. In this study, we investigated the problem of conspecific acoustic masking interference in male field crickets (*Acanthogryllus asiaticus*) and the strategies they use to solve it. We calculated active space overlap by spatially mapping every calling male in a chorus and calculating its broadcast areas from transmission experiments. We calculated the number of potential maskers for every focal male across 10 different choruses. Playback experiments were conducted to examine whether a given focal male adjusts its signalling pattern (temporally) in response to a natural masking neighbour in both field and laboratory conditions. We also examined if they modulate their sound pressure level (SPL) with respect to the loudness of a neighbour. We found that males call from spatial aggregations and their nearest neighbour is on an average 3 m away. The calls transmit over 3 m on an average, thus there is significant overlap of calls with at least one masker. Field and playback experiments show that males call in alternation with their nearest neighbour, thereby largely escaping masking from the nearest masker. We also found that in presence of either a softer or louder neighbour, focal males modulate their call SPL. This study demonstrates that males employ multiple techniques to avoid conspecific acoustic masking by spatial partitioning, temporal partitioning and modulation. The study also provides insights into the potential for a female to sample two or more males in the field.

Better songs sung by middle and old age: A longitudinal study of the Java sparrow

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As close-end (age-limited) song learners sing stereotyped songs throughout their lives, it remains controversial how much acoustic features of such crystallised songs reflect singer's present physical conditions to serve as an honest indicator. Accumulating evidence has revealed that crystallised songs show subtle changes depending on nutritional conditions or social contexts. In addition, young adults (1-2 years) are shown to improve song performance in early adulthood. However, lifelong song changes in close-end learners have not been well documented so far. Therefore, in this study, we examined within-individual changes of the songs of captive male Java sparrows (*Lonchura oryzivora*), by comparing songs recorded when they were young (1-2 years) and old (4-8 years) (the average life-span of the species is around 5 years). We found that aged birds showed better song performance. Specifically, they sang longer songs, comprised of longer trills and unchanged non-trill parts than when they were young. Based on the fact that Java sparrows sing longer trills when they were courting females (directed singing) than when alone (undirected singing), we assume that aged birds are better at singing appealing songs. Though we also considered quadratic models, linear models showed the better fit, meaning that age-related song changes did not have a clear peak. Our finding is rather surprising because we could not find any sign of senescence in songs while a few previous studies reported on age-related decline in song motor performance.

The role of song convergence in two species of nightingales: Singing mixed songs to mediate territorial conflicts?

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The Common Nightingale (*Luscinia megarhynchos*) and Thrush Nightingale (*Luscinia luscinia*) are two closely related songbird species, sharing a recent sympatric zone across central Europe. Both species are well known for their capacity to develop complex songs, composing large song repertoires and playing a central role in both intra- and intersexual communication. Interestingly, Thrush Nightingale males in sympatry often develop a “mixed singing” strategy involving the unilateral copying of part or sequences of songs from its related species. In our study, we explored the potential functions of such behaviour by testing the hypothesis of a role of mixed-singing strategies in the regulation of interspecific competition. Over one breeding season in Poland, we tested the territorial reaction of Common Nightingale males to the display of pure songs of the two species, as well as mixed-songs from copying Thrush Nightingales. Each male’s response to the three different stimuli was quantified at both vocal and physical levels, confirming a more aggressive reaction to conspecific songs compared to the heterospecific ones. Moreover, if the non-vocal response to mixed singing did not differ from the heterospecific one, vocal response revealed a higher level of aggressiveness, comparable to the conspecific stimulus. The copied Common Nightingale might thus adjust its level of vocal communication to establish clearer territorial boundaries, while avoiding unnecessary risks of direct physical confrontation with the larger and likely dominant Thrush Nightingale. Overall, these results suggest a territorial role in interspecific interactions and open new questions on the adaptive meaning of mixed-singing strategies.

Estimating Density and Abundance of Willow Tit (*Poecile montanus kleinschmidti*) populations from Acoustic data using Distance Sampling and N-Mixture Models

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Autonomous recording units are used for surveys of many vocal taxa with success in surveying avian populations. Often compared to more established methods as means to obtain species abundance/density its validity as a method of estimating species richness remains questioned. Both N-Mixture models and Distance Sampling have become popular and reliable estimates of abundance and density. However, little has been done to apply these existing population models to bioacoustic data. Previous studies have found evidence for application of distance sampling to acoustic data through training observers using recorded data at set distance. Here this method is tested using pre-recorded vocalisations accessed on Xeno Canto (xeno-canto.org), of Willow Tits (*Poecile montanus kleinschmidti*). Willow Tits are one of the UK's fastest declining bird species. This species is poorly studied with effective monitoring techniques questionable. Its decline of 92% since 1970, brings urgency to finding appropriate methods for monitoring populations and providing suitable management plans. Using acoustic data collected in wet woodland habitat in Cheshire, legitimacy is shown for both N-mixture models and distance sampling protocols in estimating population size of Willow Tits. Furthermore, evidence that training observers through playback trials, greatly improves distance estimation and in turn reliability of distance sampling density estimates is found. These results demonstrate how acoustic recording units can be applied to estimate population density and/or abundance of similar declining passerine species, providing implications for future population monitoring studies. The findings of this study offer suggestions for improving use of bioacoustics in avifaunal populations and their continued use to calculate reliable population abundance and density estimates.

Visual Attention Dynamics Entrain to an Auditory Beat: The Palimpsest Paradigm

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We investigated how rhythmic auditory cues influence visual perception of dynamically presented, partially masked words. It has long been argued that both the period and phase of dynamic auditory attention can be entrained by periodic stimuli. Even more so, an endogenous attentional oscillator can exhibit stable, periodic persistence even after exogenous rhythmic cueing has ceased. In this study, participants were presented with an ever-changing array of multiple overlapping, semi-transparent five-letter words, in a stimulus we dubbed a "palimpsest". These letter arrays mostly consisted of nonsense strings, but every two seconds, two actual words briefly appeared consecutively (and typically subliminally), superimposed upon the nonsense letter array. Participants were asked to name all words that they recognised. One group of participants observed only visual stimuli, while a second group additionally received an acoustic stimulus: a drum beat that was timed to co-occur with some, but not all, of the words in the array. Participants provided with this additional synchronised auditory information were able to detect more words from the array, and the words that they recognised were typically those that coincided with the dominant acoustic beat. This shows that when visually presented words are difficult to detect, acoustic cues can improve word recognition by dynamically focusing participants' attention upon specific moments in time. We also found that the auditory rhythm continued to affect visual perception after the sound fade fades away. A third group heard the drum beat only for the first four seconds, after which it faded away for the remaining 76 seconds of a trial. Like the continuous beat in condition two, the transient acoustic rhythm continued to influence participants' perception of the written words, even after its cessation. These results are consistent with the hypothesis that dynamic, temporal aspects of visual perception can be strongly influenced by periodic auditory input, and that this results from the entrainment of an endogenous multi-modal attentive process, even in such culturally created media as the written word.

The gentlemen's club: Vocal communication in male African savannah elephants

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The prevailing theory about male elephants (*Loxodonta africana* and *Elephas maximus*) was that, once sexually mature, males are solitary and mainly targeted at finding oestrous females. While this might be true during the competitive state of 'musth', male elephants generally are companionable animals exhibiting social relationships and long-distance communication. Our current results on male vocal behaviour of African elephants reveal that similar to females living in matriarchal family groups, individuality and context is transferred via bull vocalisations and that acoustic cues to size are particularly pronounced. Further, male elephants have a distinct network of vocal recognition discriminating and preferentially moving towards the vocalisations of unfamiliar females. Males might use acoustic cues to assess mating opportunities, which may involve selection to identify individuals or kin in order to avoid inbreeding. Social knowledge, companionship, hierarchy, reproductive competition and the need to communicate over long distances are the aspects that drive male elephant vocal behaviour. Recent examples of vocal learning and sound invention (in both, African and Asian elephants) that occur particularly often in male individuals further highlight their extraordinary vocal plasticity and complexity. By increasing our knowledge on male vocal abilities, we might finally achieve a more complete picture of elephant vocal behaviour and how it relates to the specific life history of these iconic species.

State of the art in computational bioacoustics and machine learning: How far have we come?

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Terrestrial bioacoustics, like many other domains, has recently witnessed some transformative results from the application of deep learning and big data. Generalising over specific projects, which bioacoustic tasks can we consider "solved"? What can we expect in the near future, and what remains hard to do? What does a bioacoustician need to understand about deep learning? This contribution will address these questions, giving the audience a concise summary of recent developments and ways forward. It builds on recent projects and evaluation campaigns led by the author, as well as broader developments in signal processing, machine learning and bioacoustic applications of these.

Aerial and underwater vocalisations in penguins during foraging activities

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Penguins are known to be very vocal when breeding in colonies, where they are accessible to researchers on land. Vocalisations in this context are essential for partners and kin recognition, and some species have developed very complex acoustic signals. However, penguins like all seabirds spend most of their life at sea and rely on marine resources to survive. Penguins in particular have lost their flying abilities and have developed extreme diving techniques (down to 240 m depth for the King penguins), to forage on various marine prey (fish and crustaceans, in a pelagic or benthic habitat). Their vocalisations and use of acoustic signals in the marine environment are barely known, due to the difficulties of recording animal emitted sound at sea. We deployed video-cameras with built in microphones on three species of penguins, the King penguin *Aptenodytes patagonicus*, the Macaroni penguin *Eudyptes chrysolophus* and the Gentoo penguin *Pygoscelis papua*, to study their vocal activities when foraging at sea. We recorded vocalisations emitted at the sea surface by the three species, and also vocalisations emitted under water during foraging dives. While aerial vocalisations were most probably related to contact and grouping with conspecifics, underwater vocalisations were always associated with hunting activity and prey capture attempts. We compare the acoustic structure of the different vocalisations, among the three species and the different marine environments (sea surface and under water, pelagic and benthic).

Acoustic development of wild porpoise (*Phocoena phocoena*) calves

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Toothed whales use sounds for communication and echolocation. Here we studied the development in echolocation clicks in wild neonate harbour porpoises (*Phocoena phocoena*) using underwater acoustic recordings synchronised with video observations from a drone. The neonate sound recordings were extracted when its distance to the SoundTrap was shorter than 50 m and the mother was not present. We calculated the inter-click intervals, and the duration, source level and frequency content of the clicks. We found that, similarly to previous studies in captive harbour porpoises, there are some differences between adult and neonate clicks. This methodology has allowed us to link sound and visually observed behaviour in wild porpoises for the first time. Future studies using this method may enable us to estimate the neonate's age based on the development of their clicks and their size, and then, be able to correlate their behaviour with different age stages. The difference between neonate and adult clicks can also be used to acoustically monitoring the presence of harbour porpoise calves and thereby help defining protective areas for this species.

Using bioacoustics to examine how blue whale migration changes with environmental conditions: Implications for climate change

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The blue whale is the largest animal on the planet and is also listed as endangered by the IUCN. Blue whales, like many other baleen whales, undergo an annual migration between high latitude feeding grounds and low latitude wintering areas. This migration is important for these endangered populations as it influences their recruitment success. To date, very few studies have examined long-term migration patterns of blue whales due to logistical constraints, and limitations with studies that rely on visual observations. Here we use a network of hydrophones in the Southern Hemisphere established in 2001 by the Nuclear Test Ban Treaty Organisation to detect Antarctic blue whale vocalisations. We analysed hydroacoustic data, spanning from 2001 to 2017, to find Antarctic blue whale Z-calls across four sites located in the three major oceans. To model whale call detections, we analysed long-term environmental variables. The El Nino Southern Oscillation (ENSO), Southern Annular mode and yearly Antarctic sea ice coverage was found to be correlated with the number of whale detections. These patterns are likely the result of changes in krill productivity in Antarctica, as sea ice conditions are influenced heavily by these large-scale environmental phenomena. Climate change is predicted to influence the frequency and intensity of ENSO events as well as the amount of sea ice surrounding Antarctica and therefore will likely affect whale migration patterns. Our relatively long-term study provides one of the first links between whale migration patterns and variability in environmental conditions.

One, no one or one hundred thousand? An objective quantification of *Indri indri* vocal repertoire

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Despite the rising amount of studies focusing on acoustic communication, this field of research suffers from the lack of shared methodical techniques, leading to inconsistency among studies and, therefore, to the unfeasibility of performing comparative analyses. We used the t-Distributed Stochastic Neighbour Embedding (t-SNE), a recent, promising method that has been successfully employed in several studies investigating a wide range of acoustic aspects, to analyse the vocal repertoire of *Indri indri*, the large of extant lemurs, a forest-dwelling primate especially known for its particular song. Still, beside this unique choral display, the species also shows an interesting vocal repertoire. We sampled 18 groups of indris, from 2005 to 2018, and recorded 3360 spontaneous vocalisations that were visually inspected using spectrograms. We assigned the sounds to 10 putative categories on the basis of the acoustic similarity among them: clacsons (n = 622), grunts (n = 1145), hums (n = 418), kisses (n = 296), long tonal calls (n = 31), roars (n = 62), short tonal calls (n = 44), wheezes (n = 150), wheezing grunts (n = 297), songbits (n = 295). We extracted frequency (spectral coefficients) and duration parameters using a custom-made script in Praat and then submitted the dataset first to the t-SNE algorithm, then to a clustering procedure using a hard-clustering approach. We expected to find an easier grouping of discrete calls than graded ones and, in fact, although the analyses revealed a good classification performance with respect to the a priori categories for most call types, vocalisations showing aspects of similarities one another were grouped together.

Seeing voices: Does multimodal exposure to a vocal model enhance vocal learning?

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Like many signals in animal communication, birdsong is multimodal: sound production is accompanied by beak and body movements. We here investigate the hypothesis that the visual information enhances vocal learning and might explain the difference in learning success after song tutoring only with audio playback versus life social tutoring. This difference is usually thought to stem from the lack of a social component but not assigned to the lack of multimodality. We carried out an experiment in which cohorts of young birds were exposed to a same tutor in one of three conditions: one juvenile could only hear the tutor, one could both hear and see the tutor (through a one-way mirror), and one was housed together with the tutor, being able to hear and see it, as well as socially interact with it. Our results suggest that visual exposure to a tutor has a positive influence on song learning, suggesting that multimodal stimulation per se, independent of, or in addition to, social factors, enhances vocal learning.

Automatic recognition system to study effect of ferryboat passages on meagre (*Argyrosomus regius*) chorusing

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Anthropogenic noise has been increasing during the last decades, especially along the routes of freighter liners and in harbours areas, likely augmenting the pressure on aquatic animals' acoustic communication and causing enhanced stress on populations inhabiting such regions. One of such areas, the Tagus estuary, holds important maritime harbours and a network of ferryboat connections, and is used as breeding grounds for several fish species, including the meagre (*Argyrosomus regius*). This valuable sciaenid species enters the estuary for breeding and produces loud drums often in aggregation chorusing, thus being susceptible of masking by anthropogenic noise. To study the effect of ferry boat passages on the meagre´s vocal activity we used continuous Passive Acoustic Monitoring (PAM) to record underwater soundscape during the meagre breeding season (April to August) in the Tagus estuary. Automatic methods are invaluable tools to extract the relevant biological information from such long recordings. Here we adapted automatic recognition methodologies based on the Hidden Markov Model to recognise meagre choruses and ferry boat noise. Coupling the automatic recognition systems with power spectral density computations, we found that the effect of boat passages on adult meagre choruses was variable. Nevertheless, there was usually a reduction in the chorus energy related to ferryboat passages. In this talk, we will discuss the use of PAM to study the impact of anthropogenic noise on vocal fishes and debate about difficulties arising during the analysis of a large acoustic datasets.

Vocal expression of emotions in pigs during anticipation of positive social contexts: Impact of human animal relationship.

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'Emotions' have long been considered as a human specificity. We now know that animals have emotional states characterised by their valence and arousal. Vocal signals carry emotional information and they provide a way to assess the origin and evolution of emotions. We thus studied vocal expression of emotions in domestic pigs, which use several call types in various contexts and are known to be able to anticipate events. We chose to focus on anticipation, which is supposed to trigger more intense emotions than the situations itself. Using a two-way associative learning assay, 60 pigs were trained to learn to anticipate a reunion with either their conspecifics (positive event) or a human. Half of the pigs were habituated to human repetitive positive interactions and were expected to form a positive relationship with the caretaker. The other half were expected to express fear of the caretaker and then get used to this neutral event. This paradigm allowed us to assess how pigs do express anticipatory emotions differing in their valence and arousal. Behaviours, heart rate and vocal expression were monitored. By decoding vocal flexibility in pigs, we provide perspectives for assessing positive emotions in pigs, which may have application to assessing pig welfare.

Investigating the nature and number of human nonverbal vocalisations

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Human nonverbal vocalisations remain poorly characterised despite their ubiquity in communication. While there is a growing body of evidence that emotional motivation effects nonverbal vocalisation, the nature and function of these vocalisations is yet to be determined. This study aimed to identify how many different nonverbal vocal signals can be elicited by affective stimuli. It hypothesised that nonverbal vocalisations are ethological signals related to a listener's response, and therefore that there are many distinct vocal signals motivated by emotion. A pilot experiment examined 13 participants responses to 69 affective prompts designed to evoke a target emotion (31 positive valence). Their vocalisations were analysed in Praat for F0 modulation, formant frequencies, intensity, and perceptual correlates of roughness. The prompts were successful in generating varied responses, as membership patterns of hierarchical clusters based on the acoustic analysis had a significant relationship to the prompts. Experiment 1 presented 71 revised affective prompts (31 positive) to 36 participants to determine which prompts reliably elicited acoustically distinct vocal signals. Thirty prompts (13 positive) were identified that were associated with different clusters and also had significantly different cluster membership patterns. Experiment 2 presented these 30 prompts to 15 participants. Their vocalisations acoustic features were described and discussed with respect to motivational-structure rules. This study identified a far larger number of distinct human affective nonverbal vocalisations than have previously been reported. This suggests that their contradictory descriptions in the literature may have been caused by collapsing across too few emotion categories.

Rapid and independent cultural evolution of male and female NZ bellbird song across an island archipelago

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Cultural evolution is the gene-like transmission of cultural units or memes through populations. A prime example is birdsong, which in songbirds is learnt (culturally transmitted) rather than innate. The song profile of a songbird population changes as new syllables are introduced through immigration, copying errors, and innovation, while other syllables fall out of use. This leads to a diversification of the syllable repertoire across the species, much like the diversification of human language. How cultural evolution of female song compares to that of conspecific males remains completely unknown. Here we reveal the first ever comparison of male and female song culture in birds, the results of a five-year study of New Zealand bellbirds (*Anthornis melanura*) spanning an archipelago meta-population of six islands. We classified over 21,000 syllables and used new bioacoustics software Koe, to analyse and compare population syllable repertoires and assess repertoire overlap between sites and sexes. In the first study of its kind, we show that males and females, with complex song structure, have distinct song cultures, sharing 6 – 30% of syllable types within each site. Furthermore, sex-neutral syllables can be statistically discriminated from sex-specific types based on acoustic properties. Patterns of sharing between sites are sexually dimorphic; despite females moving between sites more frequently, it is males who have greater site-site repertoire overlap, suggesting that female song undergoes more intensive diversification. These results provide the first evidence for decoupled cultural evolution of male and female song, and we discuss the implications for future research on female culture.

Snorting crescendo: A reflection of increasing arousal in rock hyrax songs?

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Understanding the roles of acoustic and rhythmic temporal patterns which appear both in animal vocalisations and in human music, may shed light on the evolutionary basis of musical perception. Male rock hyraxes (*Procavia capensis*) advertise their quality by singing a long complex song. Past research has revealed that the temporal structure of hyrax songs demonstrates a similarity to a musical crescendo as it includes a gradual increase in both acoustic and structural parameters throughout the song. In western culture, a similar progression is used to increase listener tension, thus preventing habituation. In hyrax songs, the snort is a relatively rare, low and harsh vocal element, which increases in number along the song progression. We have previously shown that snort harshness is positively linked to both the singer's social status and testosterone levels, possibly reflecting inner arousal. Here, we measured the changes in snort harshness along natural hyrax songs. Our results indicate that in mature males, harshness, quantified by shimmer and jitter, increases as the song progresses (although for jitter this trend is opposite in the songs of young males). We suggest that increasing snort harshness may either: a) indicate the progression of inner excitation or aggression throughout the song; or b) that the harshness may reflect the difficulty of vocal control following increasing effort or the physical fatigue of the vocal cords. Thus, explaining the natural development and progression of challenging elements within natural communication systems may reveal a key fundamental root of modern musical structure.

Winners and losers in a noisy neighbourhood: Do motorboats alter coral reef fish communities?

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Anthropogenic noise is an internationally recognised 21st century pollutant, contaminating the natural marine soundscape and masking vocal communication and acoustic cues. Research has demonstrated that anthropogenic noise can impact a range of physiological and behavioural processes in fishes within single species and interspecific interactions. However, there has never been an ecological study that has investigated the influence of anthropogenic noise on entire wild fish assemblages, exploring how species level impacts translate to a community scale. Our research is the first to measure the response of coral reef fish communities to long-term exposures of motorboat disturbance. In French Polynesia, established boat channels carve through coral reefs providing a valuable study system. We conducted fish surveys on reef near and far to boat channels to compare communities that have either been subjected to long-term ambient or noise-polluted conditions. The presence of motorboat noise has not altered the overall abundance, species richness or diversity of coral reef fish communities. Yet the surveys revealed a significant shift in the abundances of a subset of reef fish species in response to long term motorboat disturbance. Additionally, we exposed a historically undisturbed reef to a month-long motorboat manipulation. The population shifts found in particular species at the boat channels were also observed after our motorboat manipulation. Considering community-wide implications will help bridge the gap between our current knowledge of the impacts of anthropogenic noise on individual species to understanding its influence on wild marine ecosystems.

Identifying potential selection on vocal individuality: An example in the cooperatively breeding meerkat

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Individual distinctiveness and recognition are important elements of communication systems in many social animals. These signals can be used in a wide variety of interactions from social bonding, kin recognition, parental care, and cooperative behaviours to dominance hierarchies, territoriality, and social control. The production and use of such information within signals can be selected for if net fitness benefits exists for both senders and receivers. However, variation in the adaptive benefits may occur depending on the social context and the characteristics or previous interactions of the sender or receivers. Within vocal signals, this can lead to varying levels of individuality across a species' call repertoire, with some call types being more individually distinct than others. We examined vocal individuality in two functionally different call types in meerkats (*Suricata suricatta*), a cooperatively breeding mongoose. Meerkats organise social behaviours using an elaborate vocal system, including close contact calls used during foraging to facilitate group cohesion and movement, and sentinel calming calls emitted by guards to coordinate vigilance behaviour. Both call types were recorded from free-living adult meerkats in the Kalahari Desert, South Africa. Individual distinctiveness of acoustic parameters was compared between call types and between caller classes based on dominance status, age, and sex. Vocal distinctiveness was present in both call types, but the level differed between call type depending on caller class. These findings indicate how selection pressures for individuality within caller class can vary depending on differing fitness benefits and the relative need to be recognised within different social contexts.

Exploiting fear of hawk-like calls: How the female cuckoo manipulates host behaviour

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Imperfect resemblance between species is common in the natural world, yet the persistence of imperfection presents a challenge for mimicry theory. Here, we examine whether the hawk-like call of the brood parasitic female common cuckoo (*Cuculus canorus*) misdirects reed warbler (*Acrocephalus scirpaceus*) host defences via mimicry or perceptual exploitation. First, we test whether imperfect resemblance between the female cuckoo call and that of the most likely model (Eurasian sparrowhawk, *Accipiter nisus*) is driven by the benefit of occupying an intermediate position between the similar calls of other small predatory raptors. Second, we use field playback experiments and video analysis to examine host responses to the calls of threatening and non-threatening species that have similar acoustic characteristics to the female cuckoo and sparrowhawk call, to test whether there are multiple models feared by hosts and, given that mistakes could be fatal, whether responses are error-prone. Finally, we use field playback experiments of natural and modified calls to uncover which characteristics of the call are important in provoking host responses. Together, these analyses reveal how an imperfect acoustic resemblance can manipulate the behaviour of another species by exploiting fear of predators.

Analysing song similarity from a birds' perspective.

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The study of bird song largely relies on our ability to measure the similarity between songs using sound spectrograms. While most of these comparisons use computational methods, even these sophisticated methods have been validated only by comparing their output with human judgements of spectrographic similarity. Moreover, differences between spectrographic representation and auditory perception make this method inherently flawed. Therefore, a more reliable quantification of song similarity is needed. Here we present how song comparison methods can be validated by generalising from birds' own perception of song similarity, rather than by human judgements. Using behavioural operant conditioning with a 2-alternative-forced-choice paradigm, we have experimentally tested how captive zebra finches perceive the similarity between different song syllables. By developing an operant conditioning device in combination with a radio-frequency identification (RFID) system we were able to individually train and test the different birds, while being housed in social groups in their home cage. This unique operant approach enabled us to collect a large database of avian judgements of song similarity. This method was subsequently used to optimise a DTW comparison algorithm. Using this unique database, it is for the first time possible to validate song comparison methods from an avian perspective, thereby providing a solid foundation for future bird song research.

Sequential organisation of bird song: Time-scale dependent encoding, individual quality and fitness traits

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Many animal species produce their acoustic signals in sequential order, however, we know little about the significance of the general ordering of signals in sexual selection. To examine this, we have to characterise the within-individual and between-individual variances of sequential organisation of signals and reveal its relationships with the individual quality and fitness traits. In this study, we investigated the significance of the syllable sequence structure in the song of collared flycatcher based on a large number of individuals. By using network analysis, we studied the potential encoding capacity of signal sequences on different time scales (within-day, between-days, between years), and the relationship with the already proved fitness related age, condition and arrival date of males, and with the males' pairing success, pairing speed and survival. We found general, non-random tendencies for syllable sequential organisation rules at the population level, large between-individual differences and time-scale dependent potential encoding capacity of sequences at the individual level. We found strong relationships between sequence organisation and the age of the individuals, however, our results showed no direct relationship with the fitness traits.

POSTER PRESENTATION ABSTRACTS

(Alphabetical order by presenter's last name)

Refer to conference programme for schedule

Eco sound systems

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d-Eco sound systems is a concept to bring dark ecology in musical and artistic applications. We aim to develop discussions and solutions for fourth spheres of sound production: materials and resources, operational sound structures, performative practical applications and pondering directions of streaming and proposes. Our goal is to create tools for an ideal artistic concert, where specifications are consciously planned and respect the delimitations and the sensibilities of space/being. We are using concepts of bioacoustics (echolocation, sonar, bioacoustics filters, genetics/biologic algorithms for sound structure/design, neural oscillation), diffusion, sonification, dark ecology, aural tectonics and binaural sound recording to develop analysis tools or mobile products in artistic proposals aiming the improvement the balance of the world.

Impact of noise exposure on development, physiological stress and behaviour of larval zebrafish

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Noise pollution is widely present in most aquatic soundscapes, however, very limited information is known on how this environmental stressor impacts fish populations especially during early ontogeny. Zebrafish (*Danio rerio*) is an important vertebrate model system for high-throughput screening of stressing agents, hearing research and to investigate genetic modulators of embryonic development. In this study, we performed a split-brood experiment to test the effects of increasing moderate noise levels in the environment (c. 105/control, 130 and 150 dB re 1 µPa, white noise playback) and noise temporal patterns (continuous versus intermittent with different silent intervals) on survivability, development, physiological stress, and behaviour in larval zebrafish. Recently laid eggs were randomly selected and split into custom-made net-boxes suspended above underwater speakers within the treatment tanks. We found that exposure to increased amplitude levels of continuous noise led to a significant increase in cardiac rate and a decrease in the size of the yolk sac at both three and five days post fertilisation without affecting morphological development. These results were complemented by whole body cortisol quantification, which revealed a significant increase in the noise-treated groups. Exposure to intermittent noise regimes caused comparatively fewer differences. Testing for anxiety-related behaviour revealed scotophobia displayed by noise treated individuals. We provide first evidence of higher physiological and behavioural stress in larval zebrafish due to exposure to moderate noise levels (140-150 dB). Continuous noise exposure seemed to elicit the highest effects. Current work focuses on assessing the effects of noise on hearing sensitivity and inner ear development.

Characterisation of burst pulsed sounds produced by *Sotalia guianensis* in Rio de Janeiro, Southeastern Brazil

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The spectral structure of burst pulsed sounds produced by delphinids is still poorly understood. The goal of this work was to characterise the acoustic parameters of different categories of burst pulsed sounds produced by Guiana dolphins. Recordings occurred in coastal bays in Rio de Janeiro state. The recording system consisted of a Fostex digital recorder (192 kHz sampling rate) and a C54XRS hydrophone (-155.8 dBV, 5Hz - 48 kHz). Five parameters were extracted through the software SoundRuler: peak frequency (kHz), minimum frequency (kHz), duration (ms), interclick interval (ms), and number of clicks. Each analysed sound was visually classified into four categories (C1, C2, C3, C4). A discriminant analysis was performed to evaluate if the parameters corroborated the visual categories. Mean and standard deviation were calculated for all variables: peak frequency (C1 = 36.82 ± 6.67; C2 = 37.26 ± 4.40; C3 = 36.02 ± 7.64; C4 = 33.87 ± 10.95), minimum frequency (C1= 9.22 ± 4.93; C2 = 17.56 ± 6.06; C3 = 5.53 ± 5.20; C4 = 6.74 ± 6.45), duration (C1 = 59.50 ± 49.15; C2 = 285.11 ± 201.19; C3 = 78.70 ± 51.49; C4 = 57.89 ± 59.61), ICI (C1 = 3.43 ± 1.36; C2 = 3.68 ± 1.77; C3 = 0.73 ± 0.27; C4 = 1.43 ± 0.41), number of pulses (C1 = 18.18 ± 15.32; C2 = 82.62 ± 57.13; C3 = 94.32 ± 73.21; C4 = 38.32 ± 42.64). The discriminant analysis was significant ($p < 0.05$) and 67% of the signals analysed were correctly classified into the four categories. The different burst pulse categories could indicate different functions in this species' social communication.

Effect of mouth opening, larynx position and nasalisation on formant frequencies in the calls of Holstein-Friesian cows and fallow deer

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Information encoded in vocal signals is constrained by the anatomy of the caller's vocal apparatus. According to the source-filter theory, vocal signals of terrestrial mammal species are produced by two independent parts of the vocal apparatus: the vocal folds (the source), which produce the fundamental frequency; and the vocal tract (the filter), which produces the formant frequencies. The anatomy of the vocal tract, which is highly variable across species (e.g. vocal tract length, larynx position), can be modulated by the caller using different kinds of movements, such as the movement of the tongue and the larynx or variation in mouth opening. To understand how information encoded in vocal signals can be modulated by such articulatory movements, we studied two ungulate species presenting different vocal tract anatomies: Holstein-Friesian (HF) cows, having a non-descended larynx and fallow deer bucks, having an enlarged, descended and mobile larynx. We CT-scanned the head and neck region of several HF cow and fallow deer buck specimens and we measured the cross-sectional areas along the vocal tract. These data were used to model the vocal tract and predict the resonances produced by a) the oral tract only, b) the nasal tract only, or c) both oral and nasal tracts. For both species, we extracted formants from several vocalisations for which animals show different patterns of mouth opening and/or laryngeal descent. The calculated resonances produced by a specific vocal tract model are compared with the formants produced in a specific anatomical pattern.

A method for automatic segmentation and parameter estimation for bird vocalisation

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Animal vocalisations are ubiquitous, produced by various taxa and represented in all habitats. Tracking and quantifying animal vocalisations is a basic necessity in various biological disciplines such as nature conservation and biomonitoring. With the advancement of digital recording technology, a huge amount of audio recordings is accumulated. Since manual annotation and analysis of the relevant acoustic features is impractical, development of reliable algorithms for automatic analysis of birdsong is highly required. One of the first challenges in birdsong analysis is that of segmentation of the acoustic signal, i.e. detection and demarcation of its basic elements or syllables prior to further analysis. In this study we present two simple unsupervised algorithms for automatic birdsong segmentation and parameter estimation. The algorithms are based on a smoothed envelope of the short-time energy of the signal, and on parameters derived from the fundamental frequency and the short-time Fourier transform (STFT). The methods were evaluated using a small database of trill vocalisations recorded with high background noise. The algorithms output was compared to a manual segmentation carried out by a human expert and to ground truth values obtained by using synthetic signals, and produced highly similar results. In summary, the methods are shown to segment accurately birdsong signals with high background noise levels, are simple to implement, and thus could be of great benefit to bioacoustic researchers.

Non-invasive acoustic monitoring of swarming bats

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Temperate zone bats gather at underground sites during autumn for an activity called swarming. Presumably, the main functions of swarming are mating and information transfer. I recorded echolocation calls in multiple nights during the swarming period from August to November in front of the biggest hibernation site in Northern Germany, which is predominantly inhabited by Natterer's bats and Daubenton's bats. Over the swarming season the assemblage of species changes. The conglomeration of echolocation calls at this popular swarming site makes it almost impossible to identify species composition through standard bioacoustic monitoring. Since the echolocation signals of different bats overlap considerably, it is not possible to extract classical acoustic parameters from recorded calls. Therefore, I extracted acoustic features based on linear-frequency cepstral coefficients (LFCC). LFCCs are spectral-based representations of entire signals, thus making the need to analyse single calls obsolete. With the computed LFCCs, I performed a cluster analysis to investigate how they group together. Preliminary results showed that the extracted features differ based on time of recording; therefore, it should be possible to differentiate between times with a majority of swarming Natterer's bats compared to a majority of Daubenton's bats. Bats tend to swarm where they hibernate, so the relative abundance of species correlates between the swarming and the hibernating season. This non-invasive technique for monitoring species abundance during autumn swarming can provide an important tool to describe species assemblage during swarming and can lead to predictions for species assemblage during hibernation without directly influencing the bats.

Nocturnal occurrence of delphinids registered through passive acoustic monitoring

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Rio de Janeiro coastal area is known to be used by more than one species of delphinid, but records are restricted to visual observations during daytime hours. Passive acoustic monitoring was conducted during one month in the austral summer by deploying one SM2M+ device during a complete lunar cycle. The equipment recorded at a 66% duty cycle with sample rate of 96 kHz and 36 dB gain. In order to search for delphinid presence, a band limited energy detector was employed using Raven 1.5 software in a 512 Hann window, 50% overlap. Detections were manually checked and validated before they were quantified and separated in acoustic encounters. Detections within a time interval lesser than one hour were considered as part of the same acoustic encounter. Delphinids were registered in 78% of recorded days. A total of 1808 delphinid sound emissions were detected throughout 38 acoustic encounters. There was a mean of 31 detections/hour in encounters, varying from 2 to 202 detections/hour. Acoustic encounters usually lasted one hour or less, but there were longer encounters. The majority of acoustic encounters occurred during dark hours, with only five happening during the daytime. The full moon period had five acoustic encounters with an average of 15 detections per encounter, while the new moon and first and last quarters periods had eleven encounters each and all with more than 25 detections per encounter on average. These results indicate a strong nocturnal use of the area, which was only possible to observe through autonomous monitoring.

Acoustic characteristics of the golden jackal howls (*Canis aureus*) in Samos island, Greece

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The European population of the golden jackal (*Canis aureus*) is mainly distributed along the Mediterranean and Black Sea coasts of the Balkan Peninsula. Samos is the only Greek island inhabited by *C. aureus*, whose population has been found to be genetically different from those found on the Balkan Peninsula. As with other Canidae species, such as wolves and coyotes, golden jackals are predominantly nocturnal and use species-specific howls and barks to communicate. The acoustic characteristics of *C. aureus* have remained understudied and the geographically isolated population of Samos island can be acknowledged as a model to fill this data deficiency. Data collection begun in October 2018 and remains ongoing. Jackal communication sounds were recorded using AudioMoth 1.0.0. devices adopting two methodologies: stationary monitoring stations and playback surveys. In the latter case, this required using a Vonix MEG050 megaphone to broadcast recorded conspecifics' howls in order to stimulate the jackals' response. Howls were analysed using Raven V 1.5 to measure the following parameters: duration; low and high Frequency; peak frequency; number of inflections; number of harmonics. Environmental data was also collected during each survey. This research aims to define for the first time the acoustic characteristics of the golden jackal howls in Samos Island and compare these to other populations. In addition, acoustic characteristics are being studied to determine the correlation between environmental and behavioural factors. This methodology will set a guideline for defining the characteristics of the howls using an insular canid population as a model.

Daily and seasonal changes in intensity of solo, duet and chorus singing in a tropical songbird - the Chubb's cisticola

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Many bird species produce coordinated acoustic signals, like duets and choruses. Several non-mutually exclusive hypotheses have been proposed for the function of these coordinated vocalisations, including joint resource defence, mate defence, signal of partner commitment, maintaining social bonds within the group or maintaining social hierarchies within a group. However, to correctly understand the function of duets and choruses it is important to know how the intensity of singing these vocalisation types is changing, both daily and seasonally. In our study we focused on the Chubb's cisticola - a tropical, sedentary songbird, distributed in Nigerian and Cameroonian mountains, living in a pairs or small groups. We collected whole-year recordings of Chubb's cisticola vocalisations by using autonomous sound recorders. Six recorders recorded soundscape every seven day in a static points. Then, we classified each recorded syllable as singing: solo, duet or chorus. We examined (1) whether proportion of solo, duet and chorus syllables is changing daily, (2) how proportion between solo male and solo female syllables is changing daily and seasonally, and (3) whether the number of produced solo, duet and chorus syllables has any seasonal-dependent pattern, correlated for example with a stage of the breeding season. The results of our study will enable to better understanding the function of duets and choruses in birds.

Anthropogenic vibrations affect anuran calling activity

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Anthropogenic disturbance is one of the major causes of the biodiversity crisis. Nevertheless, the threat of substrate vibrations caused by anthropogenic activities in animal behavior has been underestimated. Amphibians are the terrestrial vertebrates most sensitive to vibrations, and since communication is crucial to their survival and reproduction, they are a suitable model for investigating this timely subject. Using playback tests, we assessed the effect of vibrations produced by two sources of anthropogenic activity- road traffic and wind turbines- on the calling activity of a naïve population of terrestrial toads. Traffic and wind turbine vibrations were recorded *ex situ* and synthetic copies of these signals were generated digitally. In their natural habitat, we used a buried tactile sound transducer to simulate the following seismic sources: (a) traffic, (b) wind turbine, (c) synthetic traffic, (d) synthetic wind turbine, and (e) no-stimulus as a control. We analyzed the toads' acoustic response by measuring important parameters for reproductive success: call rate, call duration and dominant frequency. Our results showed a negative effect of both seismic sources on the call rate of *Alytes obstetricans*, while call duration and frequency remained stable. Furthermore, call rate was more affected by the original traffic and wind turbine recordings than by the synthetic stimuli. Since anurans use calls to attract reproductive partners, defend territories, etc., our results suggest that anthropogenically derived substrate-borne vibrations could reduce individual reproductive success. Our study demonstrates the effect of anthropogenic vibrations on anuran communication and the urgent need for further investigation in this area.

Sounds from the deep: Fish sound diversity and temporal patterns in Azores

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Due to the many threats oceans are facing, such as habitat loss, overfishing or marine pollution, assessing biodiversity and habitat health is paramount. Passive Acoustic Monitoring (PAM) is a cost-effective non-impact method that can be used for long term surveys, even under adverse conditions and is especially relevant in deep-sea studies. It can be an important complementary method in biodiversity surveys as it registers sounds emanating from aquatic organisms. Using PAM, we evaluated seasonal and diel patterns of putative fish sounds identified in a deep-sea Azorean protected seamount, the Condor, and compared the abundance and diversity of sounds before and after the establishment of the protected area. We further compared deep-water demersal fish assemblages surveyed by longline fishing and the sound types found in Condor using biodiversity and acoustic indices. We found a higher number of sounds in winter compared to the rest of the year. There was a decrease in the mean abundance of sounds from 2008 to 2012 while the number of sound types kept stable even after the reserve establishment in 2010 (a higher diversity was only observed in 2010). Although we expected an increase in fish sound type abundance and diversity, the observed trends were in line with the variations in fish assemblages estimated by fishing. Consistently, the biodiversity indices (Species richness; Shannon; Simpson; Equitability of Simpson and Equitability of Shannon) presented similar annual trends for both the fish assemblages and the sound types, validating the acoustic sampling for monitoring biodiversity.

Physiological and perceptual correlates of masculinity in children's voices

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Low frequency components (i.e. a low pitch (F0) and low formant spacing (ΔF)) signal high salivary testosterone and height in adult male voices and are associated with high masculinity attributions by unfamiliar listeners (in both men and women). However, the relationship between the physiological, acoustic and perceptual dimensions of speakers' masculinity prior to puberty remains unknown. In this study, 110 pre-pubertal children (58 girls), aged 3 to 10, were recorded as they described a cartoon picture. 315 adults (182 women) rated children's perceived masculinity from the voice only after listening to the speakers' audio recordings. On the basis of their voices alone, boys who had higher salivary testosterone levels were rated as more masculine and the relation between testosterone and perceived masculinity was partially mediated by F0. The voices of taller boys were also rated as more masculine, but the relation between height and perceived masculinity was not mediated by the considered acoustic parameters, indicating that acoustic cues other than F0 and ΔF may signal stature. Both boys and girls who had lower F0, were also rated as more masculine, while ΔF did not affect ratings. These findings highlight the interdependence of physiological, acoustic and perceptual dimensions, and suggest that inter-individual variation in male voices, particularly F0, may advertise hormonal masculinity from a very early age.

Audiolog: A low-cost, versatile, field-ready tool for large-scale acoustic surveys

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Passive acoustic monitoring (PAM) can dramatically facilitate behavioural studies or biodiversity surveys, especially at large, i.e. landscape, scale. The panel of PAM tools available to researchers however remain small, and power-consumption and costs still often limit the spatial and temporal scales of surveys. Here we present our solution, the Audiolog. The Audiolog is a low-cost, small and low-power acoustic recorder. The user has control over the sampling frequency as well as over the timing of recording, programmable through user-defined schedules. All interactions with the Audiolog are through a dedicated software. Most importantly, the Audiolog has been designed with field studies in mind, and is able to withstand rough conditions as it comes fully packaged in a weather-proof enclosure. Access to the logger for uploads/downloads and battery charging is made through a unique USB port. The poster presents details about the Audiolog specifications, as well as examples of spectograms. Overall, the Audiolog offers a low-cost, versatile, field-ready tool for large-scale acoustic surveys that extends the toolbox of ecologists studying behaviour or biodiversity.

Effects of acoustic stimuli on shark behaviour

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The effect of sound on the behaviour of sharks has not been investigated since the 1970s. Sound is, however, an important sensory stimulus underwater, as it can spread in all directions quickly and propagate further than any other sensory cue. We used a baited underwater camera rig to record the behavioural responses of eight species of sharks (seven reef and coastal shark species and the white shark, *Carcharodon carcharias*) to the playback of two distinct sound stimuli in the wild: an orca call sequence and an artificially generated sound. When sounds were playing, reef and coastal sharks were less numerous in the area, were responsible for fewer interactions with the baited test rigs, and displayed less 'inquisitive' behaviour, compared to during silent control trials. White sharks spent less time around the baited camera rig when the artificial sound was presented, but showed no significant difference in behaviour in response to orca calls. The use of the presented acoustic stimuli alone is not an effective deterrent for *C. carcharias*. The behavioural response of reef sharks to sound raises concern about the effects of anthropogenic noise on these taxa.

Male vocalisations convey information on kinship and inbreeding in a lekking bird

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Kinship and inbreeding are two major components involved in sexual selection and mating system evolution. However, the mechanisms underlying recognition and discrimination of genetically related or inbred individuals remain unclear. We investigated whether kinship and inbreeding information is related to low-frequency vocalisations, “booms,” produced by males during their courtship in the lekking houbara bustard (*Chlamydotis undulata undulata*). Based on a captive breeding program where the pedigree of all males is known, we investigated the similarity of booms’ acoustic parameters among captive males more or less individually inbred and therefore genetically related with each other. We found (a) a relationship between the individual inbreeding level of captive males and their vocalisation parameters; (b) that kin share similar frequency and temporal characteristics of their vocalisations. Overall, our results indicate that genetic information potentially related to both the identity and quality of males is contained in their vocalisations.

Human baby crying, a universal distress signal?

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Crying is an essential survival mechanism used by human preverbal infants to communicate distress and elicit care. Although adults can discriminate broad differences in distress or pain from babies' cries, these ratings are influenced by unreliable acoustic markers (e.g. pitch) and biases (e.g., sex stereotypes). Research on the communicative functions of babies' cries has also been largely limited to nuclear families in Western countries. Here, we investigated whether adults' perceptions of babies' cries differ cross-culturally. We hypothesised that the capacity to perceive distress in cries may be universal, however, experience (i.e., frequent exposure to crying) may sharpen this ability and cultural differences influence stereotypical biases. To test this, we conducted playback tests on parents in remote villages in the Democratic Republic of Congo and compared these results to French mothers and fathers. We firstly tested which acoustic parameters the Congolese listeners (28 fathers, 28 mothers) relied on to assess distress levels in the natural cries of unknown Congolese babies, recorded during a bath and vaccine. Second, we artificially manipulated the mean fundamental frequency (pitch) of these cries, and tested whether cry pitch positively predicted the perceived level of distress as judged by Congolese parents (28 fathers, 28 mothers). Lastly, we tested if distress ratings of Congolese parents (30 fathers, 30 mothers) were influenced by stereotypical biases, by randomly assigning a gender to each natural cry in a counter-balanced experimental design. Our cross-cultural comparisons emphasise the influence of experience and culture on the perception of distress levels in babies' cries, and have both theoretical and clinical implications.

Recording slugs to improve slug pellets

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Gastropod damage to crop plants has a significant economic impact on agriculture and horticultural industries worldwide, with the grey field slug (*Deroceras reticulatum*) considered as the main mollusc pest in the United Kingdom. The prevailing form of crop protection are pellets containing the active ingredient, metaldehyde. Metaldehyde is known to cause paralysis and ultimately death after threshold amounts are ingested. The paralysing effects were suggested to result in inadequate pellet consumption; greater understanding of the interaction between consumption and the paralysing effects of metaldehyde could reveal an area of potential manipulation to be targeted by novel molluscicide formulations. An audio sensor was used to record individual slugs feeding on a variety of pellet types, including commercially available pellets and novel metaldehyde formulations. A graphical.mlapp application was used to quantify the time each bite was taken; the length of each bite and the total number of bites. There was significant individual variation in number of bites on a non-toxic pellet, but this was not observed on metaldehyde formulations. Slugs took significantly fewer bites from metaldehyde pellets than from non-toxic pellets. There was no significant difference in the length of the bites between non-toxic and metaldehyde pellets.

Macro-geographic variation in song dialects of common hawk-cuckoos (*Hierococcyx varius varius*) across the Indian subcontinent

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Variations in habitats can lead to divergence in bird vocalisations. Common hawk-cuckoo (*Hierococcyx varius varius*) occupies a variety of habitats ranging from rainforest to semi-arid scrub forests, and from pine forests in Himalayan mountain ranges to coastal forests over its entire range in India, southern Nepal, Bhutan, eastern Burma, and Sri Lanka. I quantified the dialects of the hawk-cuckoos recorded from 11 different sites within Indian Subcontinent. Using Sound Analysis Pro, I extracted values of 13 variables characterising the vocalisation of *H.v.varius*. These variables were analysed using Principal Component Analysis followed by ANOVA and Tukey HSD posthoc test. I found that Common Hawk-cuckoos can be divided into six sub-groups based on the dialect variation. The dialect variation was strongly correlated to various habitat structures. Vocalisations of the population in most of the moist deciduous forest except one were characterised by low frequencies, less frequency modulation, high amplitude, and high pitch. Vocalisations of populations in dry scrub and dry deciduous forests were characterised by low amplitude, low pitch, high frequency, and more frequency modulation of varying degrees. Wetland populations were characterised by low amplitudes, low frequency, and low pitch vocalisations. Habitat structure was found to be the decisive factor in shaping the dialects of Common hawk-cuckoo.

Pantanal anuran call recognition

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The Pantanal, situated in the neotropical floodplains of the upper Paraguay river and its tributaries, is the largest wetland ecosystem in the world, and was declared a National Heritage Site by the Brazilian Constitution of 1988 and a Biosphere Reserve by UNESCO in 2000. The Pantanal wetlands harbor large populations of species that are rare in the Americas. It is home to at least 650 bird, 260 fish, 80 mammal, 30 anuran, and 50 reptile species. In order to study the anuran population and their behaviour anuran sound recognition tools are needed. With this purpose a template-based recognition application was developed. From field recordings call templates were selected form 14 different species. The temporal and spectral characteristics of these templates show different types of call strategies. The recorded sounds are compared with the different templates by cross-correlating the spectrograms. Resulting strong correlation indicates the presence of the specific species. This straightforward approach allows for implementation on different platforms. When implemented in wireless bioacoustic monitoring nodes, such recognition tools allow for automated retrieving of important field data. In addition, such tools can be deployed on a smartphone as an anuran recognition app. In this way they can be used as a tool to service ecotourism in the Pantanal region.

Summary of the first African bioacoustics community conference and future directions

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The African Bioacoustics Community (ABC) was established in 2018, to provide a networking forum for people working on all aspects of bioacoustics research on the continent. The launch included a dedicated website and social media presence. Seed funding for the first conference was provided through a University of Cape Town grant. Further sponsorship was provided by the Acoustical Society of America which facilitated student attendance. The conference spanned 6 days from the 2nd Dec to 7th Dec 2018 and included three workshops ('Eco-acoustics in a Nutshell', 'Introduction to Machine Learning', 'Acoustic Monitoring of Humpback Dolphins'). In total, eight well regarded plenary speakers were featured and additional special sessions were given on 'Developing Networks' and 'Real Time Passive Acoustic Mitigation'. Evening events included the 'Ice Breaker' dinner, and themed evenings on 'Underwater Noise in the Marine Environment' and 'Science Communication'. In total 77 abstracts were received, and 130 delegates attended, with more than half of the presentations focussed on research taking place within Africa. Although registration fees were kept low (1300 ZAR to 2000 ZAR, est. 90 to 140 USD), financial constraints did prevent attendance from international researchers, especially students, working on the African continent. Research from non-African countries was encouraged, to facilitate networking and promotion of scientific best practice and there was a strong representation from European researchers. A low carbon and plastics footprint was encouraged, reflected in the conference merchandise and provision of vegetarian food throughout. Feedback was resoundingly positive, and continuation of this conference was supported.

Does a dog's eye size influence pet directed speech?

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Pet-directed speech (PDS) is a type of speech production commonly directed towards domesticated animals and is closely related to infant-directed speech (IDS). Compared to adult-directed speech, both PDS and IDS are characterised by higher fundamental frequency (perceived as voice pitch), exaggerated pitch contours, and hyper-articulation of vowels. These enhanced vocal patterns are thought to teach an understanding of language to a listener, to gain and maintain a listener's attention, and to establish positive relationships between a speaker and listener. Furthermore, PDS appears to arise in the presence of a listener that retains juvenile (neotenic) features and traits. Compared to their wild counterparts, many domesticated animals retain neotenic features, such as floppy ears, fuzziness, big eyes, and short snouts into adulthood. These infant-like features are often described as 'cute' and can increase desire for interaction while motivating care-taking behaviour and reducing aggressiveness. The current study aimed to establish a relationship between neoteny, cuteness ratings, and the use of pet directed speech toward dogs. To test this, we recorded the speech of 48 participants reacting to 12 images of dogs varying in breed, body-size, and eye-size (either original, reduced, or enlarged eye size). Additionally, participants rated how cute, friendly, cuddly, sweet, and pretty each dog was. We predicted that images of dogs with enlarged eye-size (signalling neotony) would result in exaggerated PDS use. Furthermore, we predicted that PDS would be exaggerated toward dogs with naturally retained neotenic features, who are typically thought to be younger, and that scored higher in the attractive traits questionnaire.

The potential for heterospecific individual vocal recognition in captive wolves

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Playback studies are useful to the study of reactions of individuals to acoustic or visual signals. Concerning the acoustic signals, this technique consists in recording a sound and then reproducing it in the presence of the study subjects and observing their reactions. The stimuli may be sounds of repertoire of the study species, or may belong to another species. The wolf is widely studied with playback techniques because of their characteristic vocal repertoire and because of the importance of vocal communication to their social interactions. In our study we investigated the wolves' ability to recognise familiar individuals of a heterospecific species, i.e. humans, by their voices. To test this ability, we studied captive wolves at five centres in Spain. We recorded the voices of the keepers, the human with whom wolves have more interactions, and four other voices of people who were the same sex and age class as the keepers, that we called "strangers". We had two types of stimuli: the "call", the phrase with which keepers spoken when calling the wolves, which is different for each centre, and the "sentence", a phrase without meaning for wolves, which was the same for every centre. Stimuli consisted of five voices: keeper's voice was always the fourth trial, whereas strangers' voices were pseudo-randomly presented across trial 1-3 and 5. Based on a habituation-discrimination paradigm, we expect that wolves react differently to keeper's voice, paying more attention toward the speaker, with a longer response in the call than the sentence condition.

Soundscapes and antropic impacts on the sounds of the threatened Brazilian Dry Forest

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The Seasonal Dry Tropical Forests (SDTF) represents 20% of all tropical forests and present a significant number of endemic species, are susceptible to desertification process and are often neglected by environmental preserve actions. In Brazil, the SDTF called Caatinga is considered one of the most threatened biomes within the country, with less than 2% of its area protected by law and a historical lack of knowledge and investments in research and conservation. The study of soundscapes has potential to evaluate environmental health, changes in land use, climate change, in several temporal and spatial scales. We used acoustic indices and visualisation of temporal patterns through false colour spectrograms and spectral energy distribution to describe the acoustic diversity and track variation on temporal and spatial patterns in occupation of the Caatinga acoustic space. Our main goal was to acoustically characterise the Caatinga, validating the use of passive acoustic monitoring to track diel patterns, seasonal changes and anthropic impacts. We found a consistent pattern of biophony, with bird peak calling activity during the day, insects occupying the acoustic space at night, and variation on these patterns between dry and rainy seasons. Seasonal changes can be explained by the drastic change on the landscape and environmental conditions. Caatinga is growing, therefore we also measure the influence of a wind farm on soundscape characteristics, seeking to understand which groups are most affected by turbine noise and how this impact varies along a distance gradient.

Song pattern variations in populations of *Cicadetta brevipennis* and *C. cerdaniensis* complexes in Eastern Europe

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Old master of entomology J. A. Scopoli described in 1772 a small cicada from Ydria as *Cicada montana* (now *Cicadetta montana*). Only recently, mainly through bioacoustic approach it became clear that this species is actually a complex of species reaching till now already 18 described and well delimited but morphologically very similar taxa. On the basis of different song characteristics four groups of species were recognised. During our field research in Greece, Bulgaria and Romania we found an interesting case of cicada populations from *C. brevipennis* group with a similar but different binary repeated pattern comprising one long and one short echeme. There appears to be a lowland population with the same temporal song parameters as in other parts of Europe. In the higher parts of Rhodopes however, the duration of the short echeme and the preceding interval becomes longer with increasing geographic longitude, reaching ten times longer values at the most eastern part of these mountain range. Another interesting case of song variations in Eastern Europe we found inside the C. cerdaniensis song group. In Southern Romania (e.g. Baile Herculane) and Western Bulgaria, the "normal" *C. cantilatrix* was found. Only in Stara planina region, we found an isolated population with traits of both species *C. cantilatrix* and *C. sibillae*, described from Switzerland and Northern Italy, another example of high diversity in *C. montana* complex of species.

AudioMoth: Monitoring the environment on smart acoustic sensors

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Satellite imaging is often used to monitor large protected tropical forests; however, it cannot monitor human disturbances or elusive species under the canopy. Monitoring entire reserves with ground-level manual visual surveys is difficult and costly. Acoustic monitoring is an efficient alternative. Unfortunately, available sensors are often too expensive to be used to cover an entire reserve. Researchers with limited budgets are unlikely to deploy high-cost devices in locations where they're likely to suffer damage. These devices are also too power-hungry to use for extended periods of time and are often limited by their storage capacity when monitoring passively. Here we present AudioMoth: an open-source, full-spectrum acoustic logger. Its cost is reduced using a fit for purpose smartphone microphone, a low-power M4 Cortex processor and a re-purposed enclosure built using locally-sourced parts. Detection algorithms further optimise the device, only recording in response to defined acoustic events. Switching from passive monitoring drastically reduces the storage and energy requirements, meaning AudioMoth can be deployed for long-term surveys.

Dawn to dusk, dusk to dawn: Assessing bird and anuran activity through soundscape monitoring

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Recent years shown an expanding knowledge of animal behaviour thanks to improved assessing tools and protocols. Also, soundscape assessment opened a wider range of information regarding not only focused species or groups, but also insights on their relations. For field researchers, knowing when is best to be at field is crucial for the success of many inquiries. In this work we provide an evaluated period of acoustic activity of anurans and birds in south Brazilian rainforest patches. Our research was conducted at four Conservation Units in the State of Santa Catarina, with field works ranging from 2016's spring until 2019's summer. Using autonomous recording units, the soundscape sampling protocol was of one of every ten minutes during five days at each place. A database of annotations was made from audio and visual analysis of samples spectrograms (Window: Hanning, 1024) and then converted to an activity chart for each species that ranked at least 100 annotations. A total of 13 bird and 14 anuran species were evaluated so far, being *Chiroxiphia caudata* and *Boana bischoff* respectively the most present bird and anuran singing species in the soundscape. As expected, birds sing most at dawn during spring and anurans at dusk during summer, but their activity period ranged for all day long with simpler calls and more annotations for single individuals instead great choruses. Samples and database can be requested at the Arquivo Bioacústico Catarinense (ECZ/UFSC).

An analysis of temporal integration in bat vocal communication

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Vocal communication is a key feature of vertebrate behaviour, especially in birds and mammals. Vocalisations carry information that can trigger a range of vital behaviours in the receiver, e.g. in the context of mating, foraging or predation avoidance. Therefore, correct interpretation of the often very complex signals is crucial, calling for detailed auditory analysis by the receiver. Currently, it is still being debated whether such an analysis depends more on the short-term acoustic spectrum or on the slow modulation envelopes (i.e. the temporal code). Bats often live in large communities and display a large repertoire of complex social vocalisations. Here we study the temporal integration time that may underlie species-specific communication in the bat *Phyllostomus discolor*. Combining formal psychophysics and neurophysiology, we compare behavioural thresholds to responses of single neurons in the bat auditory cortex. We use bats' vocalisations from different social contexts and manipulate the spectro-temporal information content. Inside a short window, the phase of the signal is randomised, i.e. spectral information remains while temporal information is lost. Our study will give novel insights into auditory processing of social communication signals under different contexts, helping us to better understand temporal integration times that might underlie species-specific communication.

Pattern and characteristics of avian soundscape in urban greenspaces of Delhi

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The diversity of avian communities has been used as an important indicator for monitoring terrestrial habitats. Acoustic sampling is now being used by many researchers to monitor avian soundscapes. Several acoustic indices have been developed to quantify their acoustic characteristics which can be used as a simple measure to compare across habitats. To study the variation in avian communities and their singing activity in the urban landscape, we examined the acoustic characteristics and composition of the avian soundscape in various green habitats of National Capital Territory of Delhi (NCT). Automated recording units were deployed at different sites including parks and forested areas and were programmed to record ambient soundscape for three hours (from 5 am to 8 am focusing primarily on birds' morning chorus). We used Ecoacoustics Audio Analysis Software developed by Ecoacoustics Research Group at the Queensland University of Technology for visualising spectrograms and calculating acoustic indices. We created power spectral density curve from the recordings. We also identified the number of bird species in the vocalising communities as a measure of species richness and compared across sites along with their acoustic pattern revealed from the audio analysis. It was observed that few generalist species dominated the choruses in urban parks as compared to the forest sites. Also, the intensity of choruses in urban parks was comparably more than the forest sites. This preliminary study was to examine this approach to monitor avian soundscape and to understand their acoustic pattern in relation to habitat conditions.

"I don't care": Does capture and blood sampling affect Tree Pipit males?

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Ringing is the most common technique of individual marking of passerine birds, which helped to reveal many secrets of their behaviour and ecology. However, several studies showed various potential risks of ringing. Furthermore, birds to be ringed are often substantially handled before release (e.g., to obtain morphometric data, blood or feather samples), and all such procedures may affect future behaviour of a captured individual. Previous field studies testing for the impact of ringing followed only the birds that were captures. We used the individual acoustic monitoring, which allowed us to identify Tree Pipit (*Anthus trivialis*) males from recordings of their song, and therefore to monitor also non-ringed individuals. We tested if ringing, handling, and collecting blood samples affected time spent by males at the locality, their ability to maintain stable territories during the breeding season, and their annual return rates. During 2011 – 2018, we repeatedly recorded individual Tree Pipit males at one locality (altogether 62 ringed and 43 non-ringed ones) and observed their territorial behaviour. We did not find any significant differences between these two groups. The same proportion of ringed and non-ringed males kept stable territories during the season, spent comparable time at the locality (since the day of ringing/first observation until last confirmed presence), and returned next year from the wintering grounds. Apart from demonstrating that Tree Pipits are not affected by ringing and associated handling, we confirm that individual acoustic monitoring is a suitable non-invasive method to monitor spontaneous behaviour of animals.

Pitch-elevation cross modal correspondences in domestic dogs

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Crossmodal correspondences are perceptual phenomena in which certain non-redundant features of a stimulus, such as auditory pitch and spatial elevation, are intuitively paired. While a number of correspondences have been discovered in humans to date (e.g. high pitch is intuitively felt to be angular, luminant and elevated in space), their evolutionary and developmental origins remain unclear. Here we examined for the first time the existence of audio-visual crossmodal correspondences in domestic dogs, and specifically the known human correspondence in which high auditory pitch is associated with high spatial elevation. In an audio-visual attention task, we found that dogs preferentially attended to audio-visual stimuli that were congruent with human intuitions (high auditory pitch paired with a spatially elevated visual stimulus) compared to incongruent (low pitch with elevated visual stimulus). This result suggests that crossmodal correspondence is not a uniquely human or primate phenomenon and may stem from mechanisms unrelated to linguistic processing.

Effects of species and body size on the acoustic variables of pup ultrasonic isolation calls in six gerbil species

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Gerbils (Gerbillinae), inhabiting arid areas of Asia and Africa, display different ecological specialisations and sociality. Adults primarily use ultrasound, but some species produce also audible vocalisations. Pup vocal behaviour is poorly known. For six species (*Dipodillus campestris, Gerbillus perpallidus, Meriones unguiculatus, Meriones vinogradovi, Sekeetamys calurus, Pachyuromys duprasi*), we compared ultrasonic isolation calls of captive 6-10-day old pups (each from a different litter; 10 pups per species, 60 pups in total). Each pup was recorded for 2 min at 220C using a recorder Pettersson D1000X (384 kHz, 16 bit) and weighed and measured for body variables. Calls (20 per pup, 1200 in total) were examined using Avisoft SASLab Pro software for duration and fundamental frequency variables and contour shape. All species had one type of contours they prefer. All the five contour variants occurred in *Dipodillus campestris, Gerbillus perpallidus* and *Meriones vinogradovi*. Most short calls were produced by *Pachyuromys duprasi* (56±33 ms), the longest calls were produced by *Meriones vinogradovi* (159±38 ms). The maximum fundamental frequency was the highest in *Dipodillus campestris* (74.8±5.59 kHz) and ranged of 35-55 kHz in other species. Pups of *Dipodillus campestris* were the smallest in body weight and size, pups of *Meriones vinogradovi* were the biggest in body weight and size. GLMM analysis revealed a higher effect of species compared to body size, on the acoustics. This research was supported by an RSF grant (19-14-00037).

Nocturnal singing in diurnal active birds in different kinds of environments

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The predominant number of bird species is active during the day, which is also reflected in their vocal activity. The intensity of singing differs throughout the day but the peaks of vocal activity fall on the morning and evening hours. It is commonly believed that diurnal active birds mainly sleep during the night. However, a few studies confirm nocturnal singing in diurnal active birds. Many hypotheses have been proposed to explain this phenomenon (e.g. elevated light level, mate attraction, territory defence, predator avoidance), but still, we have not known how common and intensive this behaviour is. In our study, we investigated: (1) which of diurnal bird species sing at night (defined as the time from one hour after sunset to 2:00 a.m.), (2) how intensively they vocalise, and (3) does the intensity of nocturnal singing differ in various kinds of environments? Using autonomous sound recorders we recorded soundscape in 56 random points (Upper Nurzec River Valley, Poland): 28 located in the forest and 28 in the open area. In the next step, each bird song was classified to the species by manually scanning sonograms. Furthermore, we noted time of beginning of each song and the number of songs sung by a particular species in each point. Finally, we determined the scale and intensity of nocturnal singing in diurnal bird species. Our study is the first step to understanding the function of this behaviour across bird species inhabiting central Europe.

Measure of barks reproducibility as information of vocal tract dog's control capacity

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Across species, the production of vocalisations requires a minimum control of the vocal tract, to produce a sound that can be identified/categorised as a particular vocalisation within the repertoire of each species. In order to evaluate the capacity of dogs to control their vocal tract, we measured the reproducibility of barks produced by a Belgian shepherd that barks on request. We recorded bursts of 10 barks over 10 days. Barks were recorded under the same conditions especially at the same time of the day in order to place the dog in comparable "vocal fatigue" conditions. Measurements (performed with PRAAT software) concerned time measurements (total duration of bark, duration of sub-segments), intensity, and also on frequency measurements. Data analysis shows that the barks recorded (on request) in the same conditions, are very similar within a burst and between bursts. The poor dispersions of the acoustic characteristics of the vocalisations produced by a dog in the same controlled conditions, illustrates the dog capacity to finely control its vocal tract.

Passive acoustics identifies a new blue whale population in the Indian Ocean

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Blue whales were brought to the edge of extinction by 20th Century's commercial whaling. While some populations are increasing, the recovery rate of blue whales in the Southern Hemisphere has been slow, and they remain classified as endangered by the IUCN Red list. Ironically, although the blue whale is the largest animal on Earth, they have been difficult to study in the Southern Hemisphere; thus, our knowledge about their population structure, distribution and migration, remains sparse. Blue whales within a population produce highly stereotyped songs allowing us to distinguish and monitor different 'acoustic populations'. We examined whether a blue whale call (the 'DGD-call') that had been described as a call-variant of a known population, was in fact produced by a different, and as yet, unknown blue whale population. Using a signal processing algorithm, we identified the prevalence of the DGD-call in 17-years of continuous hydroacoustic data recorded at two North Indian Ocean sites. We show that rather than being a variant call, that across the 17 years the DGD-call dominates the underwater soundscape recorded at these sites. Seasonal differences in call detections between our recording sites shows that at least some of the DGD-whales remain year-round in these tropical waters, and that the whales migrate from West-to-East annually. We argue that the DGD-producing blue whales are an entirely different population. This study highlights the use of passive acoustic monitoring and shows that for the blue whales of the Southern Hemisphere, this is an efficient approach to study this cryptic species.

Evolution and maintenance of family-level song differences across generations in captive Java sparrows (*Lonchura oryzivora*)

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Geographic dialects are a common and well-reported phenomenon in avian vocalisations, found on numerous scales from geographically separate populations to microgeographic variation at a single site. However, there is limited research into distinct song differences at smaller, family-level scales. Fine-scale research, particularly in captivity where detailed records are available, can help us to better understand song and dialect evolution. Recordings and archive songs were taken from a lab-based avicultural population of Java sparrows, consisting of several distinct social lineages. Recordings were analysed in Luscinia and a series of spectro-temporal measurements were used to compare songs within and between lineages. Songs were reliably inherited along social lines i.e. sons sang a song similar to that of their social father, even if nestlings had been cross-fostered. Song characteristics of individual lineages remained distinguishable across all generations recorded. Song structures were also examined to determine key changes during the transmission process e.g. addition/deletion of syllables, reordering of sections. This information could contribute to the construction of phylogenies to determine if changes in song traits can be used to reliably recreate lineages. The results of this study may help us to predict the rate of song evolution during transmission. The presence of family-level song differences could also have implications for mate choice, especially if such differences are salient, and may have consequences for population-level dialect research.

Vocal development & individuality in the Humboldt Penguin (*Spheniscus humboldti*)

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Humboldt penguins (*Spheniscus humboldti*) are regarded as the least studied of penguins and vulnerable by the IUCN red list since 2000. The species primarily produces two types of vocalisations, the contact call and display song, that are vital for their communication system and found to be individually distinctive. The aims of this study were to investigate the vocal development and confirm the existence of individual vocal cues in this species. We recorded a captive colony of Humboldt penguins in Syracuse, NY for 11 months. To meet the goals of this study, we designated recorded calls as being emitted by a sexually unpaired (juvenile) sender or a sexually paired (mature) sender. We also divided vocalisations by sex to examine differences between male and female vocalisations. Discriminant function analyses (DFA) and permuted discriminant function analyses (pDFA) were used to detect the acoustic variables that differed between maturity classes, sex, and individuals. During our data collection about 93% of the display songs were produced by sexually paired individuals and 90% were by males. These results suggest that the display song vocalisation is important for paired individuals and males, but not for unpaired individuals and females. Contact calls were not easily discriminable by maturity class or sex, according to the DFA and pDFA. Both the display song and contact call were found to be individually distinctive by the formant analysis. The results from this study validate the value of formants in communicating a sender's identity for this vulnerable species.

The use of a specific multimodal signal to initiate group territorial defence in a cooperative breeding-bird species

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Cooperative behaviour is a prominent feature in cooperative-breeding species and continues to pose challenges to our understanding about the evolution of social relationships and task coordination between members of the same social group. One of the most conspicuous cooperative behaviour is assuredly the production of acoustic duets and choruses, which can be defined as an interactive vocal display, involving several individuals who are synchronising their behaviour to sing in a time coordinated manner. Synchronising behaviour to sing in a coordinated way might become quite challenging when more than two individuals need to cooperate. Thus, group members could use a specific signal to initiate and organise their cooperation and coordination. In this study, we investigate the possible existence of a specific multimodal signal, used to initiate communal singing in the Yellow-breasted barbet (*Trachyphonus margaritatus*). This bird species occurs in pairs or social groups and defends his territory thorough the year, mainly by producing loud tonal duets and choruses. We conducted playback experiments to induce and record with video camera, a territorial defensive reaction from birds. We tested 12 groups (38 individuals) from two distinct wild populations in Djibouti,Africa. We found that barbets use a multimodal signal to initiate duets and choruses. This signal is composed by an acoustic component called “wheet calls sequence”, and a visual component which is a typical body posture with the tail raised and fanned. We suggest that the multimodal signal serves to attract attention and elicit a response from the partner.

Predation threat and acoustic communication in Croaking Gouramis (Labyrinth Fishes)

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Predation is an important biotic factor that influences habitat use and communication during agonistic and reproductive behaviour in animals. One strategy to reduce the predation threat is to modify intraspecific signalling to increase vigilance. We investigated acoustic communication during agonistic interactions between two croaking gourami (*Trichopsis vittata,* Osphronemidae) in the presence and absence of a predator (*Astronotus ocellatus,* Cichlidae) in an adjoining tank. The following variables were investigated: the time (latency) from the start of the experiment until the first agonistic interaction (beginning of the lateral displaying-phase, LD, during which gouramis spread their unpaired fins and produce croaking sounds), the duration of the entire LD-phase, as well as the number of and the intervals between the LD-sequences within the LD-phase. The sound features investigated included the latency until sound production started, the number of croaking sounds, the sound pressure level and the dominant frequency. Preliminary results show that the latency until the first agonistic interaction and the intervals between LD-sequences increased, whereas the number of sequences decreased in the predator experiments. The number of vocalisations dropped by approximately one-half. The duration of the entire LD-phase, however, did not differ. This is the first study indicating that predators affect acoustic communication during fighting behaviour in vocalising fish. The decrease in acoustic and visual signalling and the increase in the duration of breaks between fighting sequences could improve the fish's vigilance and subsequently reduce predation risk. This research was supported by the Austrian Science Fund (P31045).

Human-like plosive consonant variation in budgerigar warble

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Human speech is comprised of two broad sound classes: voiced and voiceless. Voiced sounds are made with quasi-periodic vibration of the vocal folds and have received considerable attention in research on non-human animal acoustic communication. Voiceless sounds, however, have received far less attention. These sounds lack periodicity and are often the result of articulatory movement above the energy source. In their complex socially learned song, budgerigars also concatenate voiced and voiceless sounds to create a vast repertoire of non-stereotyped song units. However, the variability and the mechanisms underlying the production of budgerigar voiceless sounds is not well-understood. Here, we analyse budgerigar pre-periodic plosives from two independent populations to better understand the amount of variation in these relatively simple acoustic structures. We measure voice onset time (VOT) and the spectral centre of gravity (COG). In both populations, we find a large degree of variation in voiceless plosives and a strong negative correlation between VOT and COG values. In previously published human data, both VOT and COG measurements are also negatively correlated and are related to the point of lingual articulation in the vocal tract. Our findings are consistent with these human data, suggesting that budgerigars have a fine-degree of control in creating a vast repertoire of voiceless sounds and offer insight into the productive capabilities of non-human animals.

Sounds from underground: The secret communications of the Edible Dormouse (*Glis glis*)

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The Gliridae (Rodentia) family exhibits extensive vocalisations that range from ultrasonic to those which are audible to humans. The largest species from this group is the edible dormouse (*Glis glis*), which occur across Europe and Asia Minor inhabiting deciduous and mixed forests. Until now, seven types of edible dormice calls have been identified in subjects in captivity (depending on behavioural contexts), with only tree vocalisations being reported under natural conditions. In 2018, edible dormouse vocalisations were recorded using a Pettersson d500x acoustic monitoring device in caves located in Częstochowska Upland (Poland). These calls display greater complexity and consist of different types of syllables. According to spectral and temporal analyses, three main categories of syllables (or notes) were found; these differed in frequency and pulse length, regardless of the behavioural context. The results demonstrate that the vocal repertoire of edible dormice is more complex than originally hypothesised, and requires further research.

Vocal personality as signature of individual variation and consistency in wild-derived male house mice

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House mice (*Mus musculus*) emit ultrasonic vocalisations (USVs) that can be modulated during different social contexts, especially during courtship and mating. The number and features of USVs might provide individual signatures used to identify individuals. Our goal was to investigate individual consistency and individual variation in different parameters: vocal performance, vocal repertoire and spectrographic and temporal features of USVs within and between individuals. We analysed USVs recorded from 22 mice during three sampling periods (three weeks) with and without female odour stimulation. We found that mice increased the USV emission 17x during the stimulation phase. The majority of spectro-temporal analyses were performed during this phase, and we only included mice vocalising during all three weeks (n = 19). We used a semi-automatic detection method (Automatic Mouse Ultrasound Detector or A-MUD), and we manually classified the USVs in 15 different syllable types. We performed univariate and multivariate analysis on our data, to detect whether individuals might be identified by their vocalisations, and which parameters were potential candidates for individual recognition. Overall, mice were consistent over time in both their vocal performance and repertoire. We found that low singing individuals were less consistent in USV emission, and USV spectrographic and temporal features, when compared to mice vocalising more. Furthermore, frequency and temporal parameters, together with syllable type usage might be potential candidates for individual identification. These results might lead to experiments aiming to investigate individual recognition by conspecifics.

A phased array emitter for sand-borne vibrations

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Numerous arthropods live embedded in substrates and receive acoustic waves that locate preys, predators or mates. One of these insects is the antlion larva. It is a predator that detects sand-borne vibrations emitted by the displacement of a prey, usually an ant.
We studied an antlion waiting for its prey to be trapped in the conical pit it built in a dry granular media. In our first study we focused on the threshold in sand-borne vibration yielding a response of the antlion. We demonstrated that the antlions are sensitive to vibrations in the Ångstrom amplitude. We now address the question of spatial localisation of prey by the same predator. The response of the antlion by sand tossing informs in an exemplary way his ability to locate a prey: it projects sand in its the direction. The series of pulses produced by the gait of the preys is a signal that the antlion receives repeatedly as energy pulses transported at the group velocity. If we consider localisation associated to the reception of a phase difference transported by the carrier, one would rather consider the phase velocity. Under normal circumstances phase velocity and group velocity are in the same direction. In order to discriminate the phase velocity and the group velocity we built up an array of piezo-transducers emitting surface-wave vibrations with a phase delay: within the pulse carrying the energy, wavefronts are propagating in a tilted direction. We examine the responses of the antlions to this signal.

Individual cues in dog whines

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Several animal species have individual specific cues in their vocalisations facilitating discrimination and recognition of others. This can be obviously adaptive in mother-offspring relationship, but also among adults in social, group living species, especially in case of contact calls. In the Canidae family wolf howls, dingo and dog barks and dhole's biphonic whistle whines are known to carry individual cues. The dog is especially interesting in this regard as they form heterospecific groups with humans, thus individual recognition might be more important on an interspecific than intraspecific level. In particularly contact seeking vocalisations, such as separation whines emitted in the absence of the attachment person (owner) are promising candidates for individual discriminability and recognition. In this study, we collected acoustic data on 2426 single whines recorded during separation from 60 dogs, and performed acoustic analysis, measuring 50 parameters. We applied a Principal Component Analysis to overcome collinearity and run a Quadratic Discriminant Analysis using 13 dogs' data having more than 40 single whines. Our results show that the analyses were able to differentiate the individuals with an overall 62% success (chance level based on randomization was 11%), suggesting that whines indeed have a potential for individual recognition. As a further step we will analyse biphonic and whistle whines of dogs to explore whether these vocalisations have similar role in communication as the dhole's whines. Finally, we are planning a to apply machine learning methods, to see whether the algorithms can perform better differentiating individual dogs based on their whines.

Are there individual differences in dog calls before two months of age?

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Over the last decades, several studies have shown that both animal and human vocalisations contain indexical information about physical cues and/or social attributes (e.g. aggressiveness, dominance) that are relevant in wide range of situations. However, the origins and development of these inter-individual differences remain under-investigated. In humans, a recent study has shown that the fundamental frequency (F0) of babies' cries can predict F0 throughout childhood and adulthood. While this finding suggests that information encoded in the F0 is established at early stage of human development, similar longitudinal studies are yet to be conducted in nonhuman animals. Here, we investigated whether individual differences in F0 are already present in neonate dogs (1-week-old) and whether this neonate F0 predicts inter-individual differences in the F0 of puppies (2-months-old). We recorded calls of Beagle dogs (n > 11) from at least two different litters, during their 1st, 3rd, 6th and 9th week of life. Acoustics recordings were conducted while the individual puppy was temporarily isolated from its mother. We then analysed F0 acoustic parameters (e.g. mean F0, range, F0 contour) of the recorded calls and conducted linear mixed model regressions, with body weight, litter size and neonate F0 as predictors and puppy F0 as the response variable.

Study on detection of respiratory disease in pigs using body-conducted sounds

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The difficulty to identify pigs suffering from diseases in the daily management of pig farms has been increasing as the farms grow into large-scale operations and the farming population of Japan decreases. The development of techniques for an early detection of these diseases is therefore required, especially because overlooking these diseases leads to their aggravation and spread, which result in economic loss because of higher treatment costs and pig deaths. In this study, we developed a wireless recording system to collect body-conducted sounds from individual pigs and detect early stages of respiratory diseases. We conducted two experiments: 1) we tested if breathing and heart sounds could be extracted from the body-conducted sounds recorded from the pig's ear; 2) the pigs were inoculated with a virus that causes the porcine reproductive and respiratory syndrome, a respiratory disease, and the body-conducted sounds before virus inoculation and 3, 5, 7, and 10 days after inoculation were compared. The results of zero crossing and a mel-frequency cepstrum coefficients analyses indicated that the body-conducted sounds before and after inoculation were significantly different. Therefore, we conclude that the early detection of the respiratory diseases in pigs can be achieved by assessing the acoustic features of body-conducted sounds.

Dynamic changes in ultrasonic vocalisations during the early phase of courtship in wild-derived house mice

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Complex ultrasonic vocalisations (USVs) emitted by male house mice during courtship, have been suggested to influence their mating and reproductive success. Females are attracted to male USVs, which provide information about males' species and kinship. Our general aim was to test whether USV emission correlates with kinship of experimentally mated pairs and influence male subsequent reproductive success. Therefore, we recorded 26 wild-derived male house mice (*Mus musculus musculus*), paired with either unrelated (n = 15), or related (n = 11) females. We used the Automatic Mouse Ultrasound Detector (A-MUD) to detect and extract vocalisations and manually labelled USVs according to 15 different syllable types. We detected significantly more USVs after a perforated divider was removed and males began to directly interact with females, showing dynamic changes in the rate of USV emitted during the early phase of courtship. USVs were significantly longer and more complex when males were experimentally paired with genetically unrelated compared to related females, which provides further evidence that mice show kin discrimination. We found that unrelated mice had higher reproductive success compared to incestuous pairings, which is consistent with inbreeding avoidance. Furthermore, length and number of vocalisations were significantly correlated with the latency of a pair's first litter. This is one of the first studies, to our knowledge, to show that USV emission depends upon genetic compatibility of mating partners, and to show a correlation between USV emission and subsequent reproductive success in wild derived house mice.

First insights into vocal communication of Cape fur seals

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The Cape fur seal is the only pinniped resident to the southern African coastline, yet almost nothing is known about this species and virtually no description of its vocal behaviour exists. This study presents the first insights into the use of vocalisation by this species.
Fur seals are highly vocal, social animals living in large colonies. Individuality in vocalisations has been shown for many fur seal species and plays an important role in social dynamics and breeding systems of this group. Here, the first description of Cape fur seal vocal behaviour is presented. Recordings were made in a non-breeding season, when pups are already exploratory and affiliate with non-parental adults. Special attention is given to mother and pup communication and individuality of vocalisations.

Tap-dancing improves song performance and stereotypy: Song-dance interactions in a socially monogamous songbird

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Many songbirds combine their vocalisation (i.e. song) with body movements (i.e. dance) during courtship. Vocalisations have been elucidated in previous songbird studies, whereas less attention has been paid to dance display and the coordination with song. In blue-capped cordon-bleus, a socially monogamous songbird, both males and females perform "tap-dance" like display by rapidly stamping their feet against the perch several times while one bobbing. It produces rhythmical non-vocal sounds and often overlaps with songs. Generally, the dance display is expressed depending on social contexts. Cordon-bleus usually perform both song and dance when they are close to potential mating partners and perform only song without dance when they are alone. We have previously revealed that they adjusted dance performances when singing, bobbing faster and taking fewer steps in one bobbing compared to not singing. In this study we examined if singing behaviour is adjusted when it is accompanied by dance and how cordon-bleus regulate dance display during song. By comparing song traits between with and without dance display, we found that song performances and stereotypy improved when it is accompanied by dance display. By quantifying the timing of first bobbing and bobbing tempo during song, we also found that there are significant individual differences in the timing of bobbing while no individual differences was detected in bobbing tempo. These results imply that cordon-bleus accordingly adjust both song and dance display to enhance multimodal signals.

Acoustic monitoring of nocturnal bird migration on the coastline of the Baltic Sea

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The Polish Baltic Sea coast is an important place on a bird's migratory route. The passerine migration has been studied there for decades, mostly by bird-ringing programmes and direct observations. However, these popular bird research methods are mainly restricted to daytime, whereas most birds migrate at night. This encourage us to try to support the traditional methods by extending the standard schemes with acoustic monitoring.
The study presents the first results of the long-term research on the acoustics of migrating passerine birds. Field recordings were collected nightly during autumn bird migration. Over 50 hours of recordings were manually annotated. As night flight calls are sporadic events, the balanced set for training was created. Different signal representations as well as various classification methods, including convolutional neural networks, were examined. Obtained results are promising and they show a great potential of acoustic monitoring to supplement the research on bird migration.

The impact of breeding on the vocal abilities of purebred cats

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Vocal communication of cats includes a wide range of sounds from quiet purrs and trills to loud distress vocalisations. Cats are said to have one of the widest ‘vocabularies’ of all carnivore species, and this may be related to the fact that in the natural environment vocal communication is important when they spend much active time in poor lighting conditions. There is some evidence that cats are able to modify their vocalisations when communicating with people. The aim of this work was to validate if the breeding process has effect on cats' vocalisation. 232 minutes of vocal recordings from 20 adult Siberian Cats and 20 Persian Cats were collected and used in a phonetic study in order to test some recording and analysis methods. Siberian cats were chosen as a new, open breed, with a comparison to Persian cats as representatives of the old breed. Cats' responses to behavioural stimuli in two test situations were recorded: vocalisation before serving food and isolation calls (closing the cat in a cage for 5 min). Vocalisations were detected and segmented, with voiced and unvoiced vocalisations being differentiated. The recordings were processed using PRAAT, Raven Pro and Audacity software. The vocalisations were analysed for duration, formants, pitch, jitter, shimmer and other acoustic parameters. This study was supported by research project BM-2208.

Voice pitch across a lifetime: Longitudinal evidence for early emergence and long-term stability

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Human voice pitch communicates a vast amount of biologically and socially relevant information. Voice pitch varies widely between individuals, particularly when comparing children to adults and men to women, but also within these age-sex classes. Yet, little is known about when these individual differences emerge, how pitch changes within a single individual's lifetime, and what mechanisms contribute to pitch variability. Here, we conducted two longitudinal studies: (1) we measured the pitch of babies' cries at four months of age and of their speech utterances at five years of age, and measured 2D:4D ratio as an index of prenatal testosterone exposure; (2) we measured the voice pitch of men and women from age seven to 56 as they participated in the British television documentary the Up Series. Our results showed: (1) The pitch of babies' cries predicted the pitch of their speech five years later, explaining 41% of the inter-individual variance in childhood pitch. Moreover, childhood 2D:4D digit ratios positively predicted voice pitch in both infancy and childhood; (2) Despite sharp pubertal decreases in voice pitch among males, we found that pitch remained remarkably stable after age 28. In fact, men's pre-pubertal voice pitch at age seven strongly predicted their voice pitch at every subsequent adult age, explaining up to 64% of the variance in voice pitch after puberty. These findings suggest that a substantial proportion of between-individual differences in voice pitch, which convey important biosocial information about speakers and predict reproductive success in men, may partly originate in utero as a result of prenatal androgen exposure, and thus may already be present soon after birth.

High accuracy comparison of human and bird hearing

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About fifty bird species audiograms have been measured until now. The bird audiograms usually consist of just three or five values, occasionally of more. There is no system of measurement standard to exist that defines which values should be measured and how. In contrast to human whereas audiograms which are defined by the ISO 226 standard. It means that one cannot easily compare bird audiograms among them, nor compare bird and human audiograms. We developed a mathematical approximation to unify the bird audiograms into the same basis. By using this procedure, we have determined the most accurate up-to-date Average Bird Audiogram. The aim of this presentation is to demonstrate actual comparison of both human and the average bird audiograms.

Vocal imitation in a Grey seals pup

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Vocal imitation happens when novel sounds are produced by imitating previously heard sounds. Comparative studies on imitation can pinpoint the mechanisms enabling plasticity in sound production and usage in different species. Grey seals (*Halychoerus grypus*), like other pinnipeds, naturally produce a range of sounds and have good control over the supra-laryngeal vocal tract, potentially supporting the ability to acquire new sounds. We studied 5-30 day-old Grey seals pups during their rehabilitation at Sealcentre Pieterburen. We analysed the acoustic features of each animal and then selected a model call of an individual from the previous year that showed completely different acoustic features. We presented a playback to a group of five grey seals pups and we recorded their acoustic reaction. This 'novel' playback was played to the focal animals for 28 days, 30 minutes a day, while recording them. One individual of the group started to imitate the model and therefore to change its acoustic features. We analysed the variation of the formant frequencies, the centre of gravity and harmonicity of this animal before and after the experiment compared to the model and to the other member of the group. Preliminary results show a remarkable acoustic similarity between this seal after the playbacks and the model, compared to the same animal before the experiment and the other seals of the group. Overall, our study suggests grey seals pups can spontaneously produce sounds outside their original repertoire through the imitation of a model and may therefore be capable of vocal production learning.

Dogs (*Canis familiaris*) with auditory and/or visual sensory impairment are as capable as any dogs to communicate and cooperate with humans

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Research on the genetic basis of deafness in dogs has identified two pigmentation loci whose alleles, when expressed, suppress both the pigmentation of the fur and the development of melanocytes in the eye and the cochlea. Dogs with homozygous genotype for any of the three recessive alleles of the "spotting" locus S systematically have white fur and blue eyes, and may exhibit deafness. Dogs with homozygous genotype for the dominant allele of the "merle" locus M are also systematically white and frequently deaf. In addition, they frequently exhibit ophthalmic abnormalities (microphthalmia, cataract, or absence of eyeball) and/or blindness. Still to this day, sensory-impaired puppies are frequently euthanised at the breeder's request, because the old myth says that they cannot be trained, are aggressive, and have cortical lesions and reduced mental abilities. Research on sensory-impaired dogs therefore has a societal stake. There is evidence that sensory-impaired dogs do not differ in aggressiveness from sensory-normal dogs. However, there is no data in double-merle dogs on (i) the prevalence of the double (visual-auditory) sensory impairment, (ii) their capacities to be trained, (iii) the sensory modality they use for training, communication and navigation, and (iv) their abilities to cooperate with humans in working tasks. To address these questions, we submitted a 5-page survey questionnaire to about 100 owners of double-merle dogs from three countries (France, US, Italy). Preliminary results indicate that sensory-impaired dogs are as capable as sensory-normal dogs to communicate and cooperate with humans.

Aperiodicity in human voices is sexually dimorphic but not related to facial sexual dimorphism in Cameroon, Czech, Brazil, and Namibia

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According to current research, ratings of facial and vocal masculinity/femininity are often correlated which suggests that voices and faces may convey backup signal of common underlying quality. A number of quantifiable vocal and facial features has been shown to significantly correspond with ratings of masculinity/femininity and clearly differ intersexually. But our earlier findings did not find any intra-sexual association of F0 and formants and facial features. Here we build upon our earlier findings and focus on intra-sexual variation in facial shape dimorphism assessed by geometric morphometrics (GM), and dimorphic acoustic features related to perturbation in voice. Also, little is known about the relationship between facial and vocal traits in different populations. Here we search for possible association between facial GM and sexually dimorphic voice perturbation measures in four samples, namely from Brazil, Cameroon, Czech, and Namibia. GM scores of sexual dimorphism were computed from standardised facial photographs. CPPs, HNR, jitter (local, local absolute, rap, ppq5, ddp) and shimmer (local, local dB, apq3, apq5, apq11, dda) were computed from short (population) standardised utterances, using PRAAT. Settings recommended by PRAAT authors were utilised. Jitter and shimmer measures were highly inter-correlated and therefore we reduced them to single Jitter and Shimmer variable using PCA. Independent-samples T tests were used to assess sexual dimorphism of perturbation variables and Pearson correlations for correlation between GM shape scores of facial masculinity/femininity and perturbation variables. GM, CPPs, HNR, Jitter and Shimmer was assessed separately for each sample. HNR, Jitter, and Shimmer were sexually dimorphic in all four populations, with men's voices being higher in aperiodicity. In contrast CPPs was higher in men but this difference was statistically significant only in Czech and Namibian populations. Nevertheless, GM scores did not correlate significantly with perturbation variables with exception of Jitter in Czech men ($r = 0.503$, $p = 0.002$). Our results suggest that facial and vocal masculinity/femininity are more complex phenomena, and/or they signal different qualities.

Incorporation of digital technology into the music education for beginners

Stepanov Sergey

Children Music School

Numerical Cognition
How does the child's brain detect music patterns?
AudioVisual Integration Enhances Kids' Stimulus in Memory Function
New technique that uses EEG, ENG, EMG data based on how child perceives patterns (sound, visual, toucher).
Mathematical Module in Linear Recognizing of Music Patterns.
3345. 5432. 1123. 3020. 3345. 5432. 1123. 2010.
Ode to Joy Ludvig van Bethoven
3330. 3330. 3512. 3000. 4444. 4333. 3223. 2050. 3330. 3330. 3512. 3000. 4444. 4333. 5542. 1000.
Jingle Bells
Digital Key changes our notion of cognitive abilities , save time and improve child's brain plasticity .
https://lnkd.in/gdUvDRS
NeuromusicLab Reflection Ukraine

Echolocation/FlashSonar: An environment-friendly technique of perception

Thomas Tajo

Visioneers and OFID, Belgium

Echolocation is a non-visual perceptual technique employed by bats and blind individuals to perceive and interact with the world around them. Bats send out high frequency ultrasound signals, beyond the range of human hearing, into the environment, to obtain three-dimensional image of the world from the acoustic reflections. Under the Perceptual Navigational approach developed by the Visioneers, blind individuals are taught to use sound within the range of human hearing to echolocate. They send out echo-signal in the form of crisp tongue-clicks into the environment. By interpreting the reflections of their clicks blind individuals are able to form three-dimensional image of the objects and environments around them. Thus, my paper will examine how Echolocation or FlashSonar that is employed by blind human beings to obtain and process three dimensional information with acoustic reflections for active navigations. Has the potential to provide us with a different culture of perception: with a different way to use our bodies and senses to perceive and interact with the world. A different form and technique of perception that harnesses the potential of our non-visual senses. Which is environment-friendly, energy-saving, and hence less destructive to the planet.

Comparative studies about developmental change of temporal properties in vocal sequences between songbirds and human infants

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Vocalisation and respiration systems are closely related because vocalisations require the expiration airflow. Vocal learning is acquisition of new vocalisations through social experiences. Among vocal learners, songbirds and humans learn songs and speech, respectively. Songs and speech are vocal sequences and are consisted of several syllables and variable sequences. Highly sophisticated control of breathing might be required for these sequential vocalisations, and that would be acquired through the development in vocal learners. So, we focused on the developmental change of temporal parameters of vocal sequences in Bengalese finches, one of songbird species, and in human infants. The initial vocalisations in Bengalese finches had longer inter-note-intervals (INIs) than note durations (NDs). After that, INI and ND became to converge into an equal length until 60 days post hatching. In human infants, their early vocalisations had longer INI than ND too, and then both durations converged until 6-months old. While INI and ND converged in later in both species, INI in Bengalese finches became shorter and ND gradually became longer in infants. The difference between birds and infants suggests that learning sequential vocalisations have the common developmental mechanism to equate the length of INIs and NDs in a species-specific manner. We will discuss the relationship between the species difference in developmental change of temporal properties and the difference of ventilation system. This work was supported by JSPS # 16J40180, JSPS #16H06319, MEXT #4903, JP17H06380.

Wildlife at the British Library: 50 years of preserving the sounds of the natural world

Cheryl Tipp

The British Library, United Kingdom

The British library's collection of wildlife and environmental sound recordings was founded in 1969 as a resource for research, education and creativity. Five decades later, the collection is one of the largest and most comprehensive in the world, containing more than 250,000 recordings of birds, mammals, invertebrates, amphibians, reptiles, fish and their environments. In 2016, the library was awarded a £9.5 million grant from the National Lottery Heritage Fund to digitise its most unique and at risk recordings. This included over 100,000 analogue wildlife recordings, covering some of the oldest and most important sounds in the collection. More than 50,000 sounds have been digitised so far and many of these will soon be available online under a Creative Commons license. As the collection celebrates its 50th anniversary, this poster takes a look at how the collection has evolved and what it hopes to achieve over the next 50 years.

Parrot vocal communication when solving a cooperative task

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We investigated the vocal communication of pairs of peach-fronted conures (*Eupsittula aurea*) performing the cooperative 'loose-string test'. The setup consisted of a small board on wheels with food rewards, placed at a distance from two adjacent bird cages. A loose string was passed through two eyelets on the board and each end placed in a separate bird cage. Only if both ends of the string were pulled simultaneously by two parrots, would they move board and food reward within reach. Two females and two males were tested to clarify their understanding of the paradigm and to record their concomitant vocal communication when visually isolating them from each other and delaying one bird's access to the string. Results showed that the peach-fronted conures could solve the cooperative task, seemingly understanding the paradigm and that the social status of each bird influenced its performance and vocal communication. Individuals varied considerably in their use of calls during the cooperative tasks. The most successful individual often used a particular call prior to trials when the cooperative dyad was visually isolated, increasing the likelihood of successful completion of these trials. In addition, we showed that individuals converged their calls (effectively imitating each other's calls) mainly after failed trials, and that same-sex pairs converged more often than mixed pairs. This strongly suggest that call-convergence is used to reconcile the pair after failed trials, since same-sex pairs were non-aggressive, whereas mixed pairs always showed aggression. We suggest that vocal communication plays an important role during parrot cooperation.

Structure and function of drumming in middle spotted woodpecker (*Dendrocoptes medius*)

Kyle Turner

Amateur Sound Recordist, United Kingdom

Sound recordings made of Middle Spotted Woodpeckers in France during four breeding seasons demonstrated occasional use of weak and erratic drumming at potential nest hole sites. Eighty-nine drum roll elements were analysed, the majority being combined with tapping. Strike patterns and amplitude showed no regularity. Five additional, verified, recordings (four from Germany and one from Luxembourg) confirm the idiosyncratic nature of these instrumental signals. After a century of conflicting evidence for drumming in this species, this is the first study to give a clear description of this form of communication and to relate it to its behavioural context. The poster will present tables of incidence, spectrograms, pulse train analyses (showing amplitude of strikes) and interval counts. Comparisons with different forms of drumming in other European woodpecker species will also be illustrated. Headphones will be available to listen to a selection of examples.

Bioacoustic monitoring of animal vocal behaviour for conservation

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The popularity of bioacoustics for threatened species monitoring has surged. Large volumes of acoustic data can be collected autonomously and remotely with minimal human effort. The approach is commonly used to detect cryptic species and, more recently, to estimate abundance or density. However, the potential for conservation-relevant information to be derived from acoustic signatures associated with particular behaviour is less well-exploited. Animal vocal behaviour can reveal important information about critical life history events. In this study, we argue that the overlap of the disciplines of bioacoustics, vocal communication, and conservation behaviour— thus, “acoustic conservation behaviour”— has much to offer threatened species monitoring. In particular, vocalisations can serve as indicators of behavioural states and contexts that provide insight into populations as it relates to their conservation. We explore the information available from monitoring species' vocalisations that relate to reproduction and recruitment, alarm and defence, and social behaviour, and how this information could translate into potential conservation benefits. While there are still challenges to processing acoustic data, we conclude that acoustic conservation behaviour may improve threatened species monitoring where vocalisations reveal behaviours that are informative for management and decision-making.

Genomic architecture of vocal communication: Phenotyping signalling behaviours in hybrid offspring of *X. laevis* and *X. petersii*

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For courtship and mating, the behaviours of both the signaller and the receiver must co-evolve. Vocal signalling is essential for this co-ordination in many taxa. In Xenopus, no evidence of any plasticity or learning has been shown and species-specific vocal signals are considered only genetically determined. Thus, their spectro-temporal structure reflects the architecture of their genome. Male advertisement calls are used by females to locate a mate and female calls communicate physiological receptiveness. Recently diverged closely-related species *X. laevis* and *X. petersii* produce calls with different spectro-temporal characteristics and generate fertile hybrids of both sexes. This allow us to ask whether the same genetic changes responsible for generating each species' male calls also control the female's ability to hear and produce calls, or if each has a distinct genetic basis. Previous results show that male hybrid calls are both temporally and spectrally intermediate to their parental species, and that the peripheral auditory system of female hybrids may be more sensitive to hybrid spectral features. We here present a study of the behaviour and vocal production of female hybrids. Varying their physiological state and the genotype of a male used during separation-reunion assays, we investigate hybrid vocal production and potential mating preferences toward hybrid males. Results of this study on first generation hybrids will define parameters to quantify vocal behaviour traits, essential for further mapping associations between genomic loci and vocal communication variants using second generation hybrids.

Age-related song repertoire changes in a songbird: The black redstart

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Songbirds learn their songs but their sensitive periods vary: some species end their learning period when several months-old while others learn throughout their lives. We investigated the turnover of song repertoires in a migratory population of a territorial songbird, the black redstart (*Phoenicurus ochruros*), following colour-ringed individuals during seven breeding seasons (2007-2008 and 2015-2019). Birds have an uneven spatial distribution resulting in groups of 2-8 territorial males sharing most of their songs (microdialects). We recorded 17 one-year-old males on the day of their arrival from migration (March) and again one month later. Most birds (15/17) sang the local dialect when they arrived but two males sang different song types. We did not observe modifications during their first breeding season but one year later these latter two individuals added some songs from the local dialect to their repertoire and one of them progressively dropped all of his non-shared songs. Eighteen additional males aged at least two years old were recorded over two consecutive breeding seasons. None of them added or dropped any songs from one year to the next. These results suggest that male black redstarts learn their songs during their first autumn, prior to migration. If they return to the exact hamlet where they learned their songs they do not modify their repertoires, but if they return to a neighbouring hamlet they are able to learn the specific dialect of that hamlet; however, they do not express it immediately, suggesting the existence of a delayed vocal imitation.

Syllable types and acoustic variables of ultrasonic vocalisation in pup and adult fat-tailed gerbils (*Pachyuromys duprasi*)

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Ultrasonic vocalisations (USVs) of laboratory rodents indicate animal emotional arousal and may serve as models of human disorders. We analysed spectrographically USV calls of pup and adult fat-tailed gerbils (*Pachyuromys duprasi*) during 420-s tests, including isolation, touch and handling. Based on combination of six different USV syllable contour shapes and six different note compositions, we classified 782 USV syllables of 24 pups aged 5 - 10 days to 18 types and 232 syllables of seven adults to 24 types. Pups and adults shared 16 of these 26 USV types. Percentages of USV syllables with certain contour shapes differed between pups and adults. The contour shape and note composition significantly affected most acoustic variables of USV syllables in either pups or adults. The 1-note USV syllables were most common in either pups or adults. Pup USV syllables were overall longer and higher frequency than adult ones, reminiscent of the USV ontogenetic pathway of bats and distinctive to rats and mice. We discuss that the USV syllable types of fat-tailed gerbils were generally similar in contour shapes and note compositions with USV syllable types of mice and rats. In fat-tailed gerbils, the overall USV fundamental frequency range was from 18 kHz to 120 kHz, and the duration of USV calls ranges from 2 ms to 350 ms. This frequency range is comparable with those reported in rats, from 20 kHz to over 90 kHz, whereas the duration range in rats is different, from approximately 10 ms to over 3500 ms. This research was supported by RSF (grant 19-14-00037).

Male impala (*Aepyceros melampus*) rutting calls: Bout structure, the acoustics and remarkable similarity of the rutting and alarm

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This study investigates the bout structure and the acoustics of male rutting calls in a free-ranging population of common impala (*Aepyceros melampus melampus*) at Okambara Elephant Ranch, Namibia. The 202 analysed bouts contained 13.5 ± 6.5 (from 4 to 38) rutting calls per bout. We identified five types of rutting calls: nasal snorts; three types of roars: pant-roars with rapid alternation of inhalations and exhalations; interrupted roars, with one to few short inhalations; purely exhalatory continuous roars; and roar-snorts, with transit of short roar to snort without pause. All bouts contained both snorts and roars. of the total number of 2723 rutting calls within 202 bouts, snorts comprised 67.2%, continuous roars 6.9%, interrupted roars 9.8%, pant-roars 10.0% and roar-snorts 6.1%. Bouts mostly started with snorts (86.1% of the bouts) and ended with snorts (92.1% of the bouts). Acoustic comparison of 43 continuous roars, 91 interrupted roars and 68 pant-roars did not reveal differences in the average fundamental frequency (ranging of 49.5 - 51.4 Hz) or in values of the first, second and fourth formants; the third formant was higher in the interrupted roars. The length of the elongated vocal tract during the maximal retraction of the larynx during the roaring calculated based on the first four formants, varied from 379 to 384 mm and did not differ between the three types of the roars. Snorts were remarkable similar between the rutting context (toward conspecifics) and alarm contest (toward people), similar to findings for the topi antelope (*Damaliscus lunatus*). This research was supported by RFBR (grant 19-04-00133).

Diversity of calls and their behavioural contexts in a social passerine, Jungle Babbler (*Turdoides striata*)

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Social animals typically have a well-developed and complex communication system that modulates the many interactions that play a critical role in forming and maintaining social bonds in these animals. In social birds, communication is mostly manifested as vocalisations which often occur in large and complex repertoires. In this regard, long-lived social birds with their vast repertoire of solitary as well as interactive behaviours and associated vocalisations provide a fascinating system to study the effects of complexity in sociality and communication on one another. To do so we need to identify and quantitatively characterise both the vocalisation and the behavioural contexts in which they are produced. This study aims to characterise the vocal repertoire and the associated behaviours in a social passerine, Jungle Babbler (*Turdoides striata*). Jungle Babblers (JB) are ubiquitous in India and are found in groups of 3 - 20 individuals. They display cooperative breeding, where non-parents also help in raising offspring. Groups of JB were followed year-round and all vocalisation and the associated behaviours were recorded. Detailed acoustic analyses reveal the presence of ten distinct call-types, associated with different behavioural contexts. We also found that the birds partition their time activity both on diel and seasonal scales wherein some behaviours are more likely to occur during certain times of the day and time of the year than others while some other behaviours occur with equal probability irrespective of diel or seasonal scale.

Postnatal ontogeny of ultrasonic calls and body size in yellow steppe lemming (*Eolagurus luteus*)

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Arvicolinae species vocalise in ultrasonic (USV) range, but pathway of vocal ontogeny in this taxonomic group remains unknown. We recorded USV calls of 120 yellow steppe lemmings in Moscow Zoo (Russia) during February -June 2018. Subjects were recorded at one of 12 post-natal-day (PND) age-classes: PND 1 - 4, 5 - 8, 9 - 12, 13 - 16, 17 - 20, 21 - 24, 28 - 32, 33 - 36, 37 - 40 (pups), PND 41 - 60 (adolescents); PND 60 and older (breeding adults). We recorded 10 individuals per age-class, 120 in total, each isolated for 2 min at 220C on an unfamiliar territory using Pettersson D1000X (384 kHz, 16 bit). Then, we measured body mass, body length and head length. In total 1176 USV calls (up to 10 per individual) were analysed spectrographically. USV duration decreased from 70 ± 21 ms at PND 1 - 4 to 37 ± 7 ms at PND 9 - 12 ($r = -0.53$, $p < 0.001$), and then remained unchanged (29 ± 3 ms) to adulthood. The maximum f0 decreased from 49.1 - 52.9 kHz at PND 1 - 12 to 39.4 ± 4.0 in adults ($r = -0.47$, $p < 0.001$). The beginning and minimum f0 did not change with age. The end f0 and peak frequency reached maxima at PND 9 - 12 (42.9 ± 5.5 kHz and 41.2 ± 4.7 kHz respectively) coinciding with eye opening. We detected USV contours ascending (61.3%), flat (21.3%), chevron (11.4%), descending (2.1%) and wave (3.8%). Nonlinear phenomena were presented in 33.1% USV calls at any age; 3.3% USV calls contained two nonlinear phenomena. We detected frequency jumps (31.6%), biphonation (3.7%) and subharmonics (1.1%). This USV ontogenetic pathway (decreasing f0 and call shortening) is similar with those of domestic mice. This research was supported by RSF (grant 19-14-00037).