XXV International Bioacoustics Congress
Murnau I Bavaria, Germany

IBAC2015

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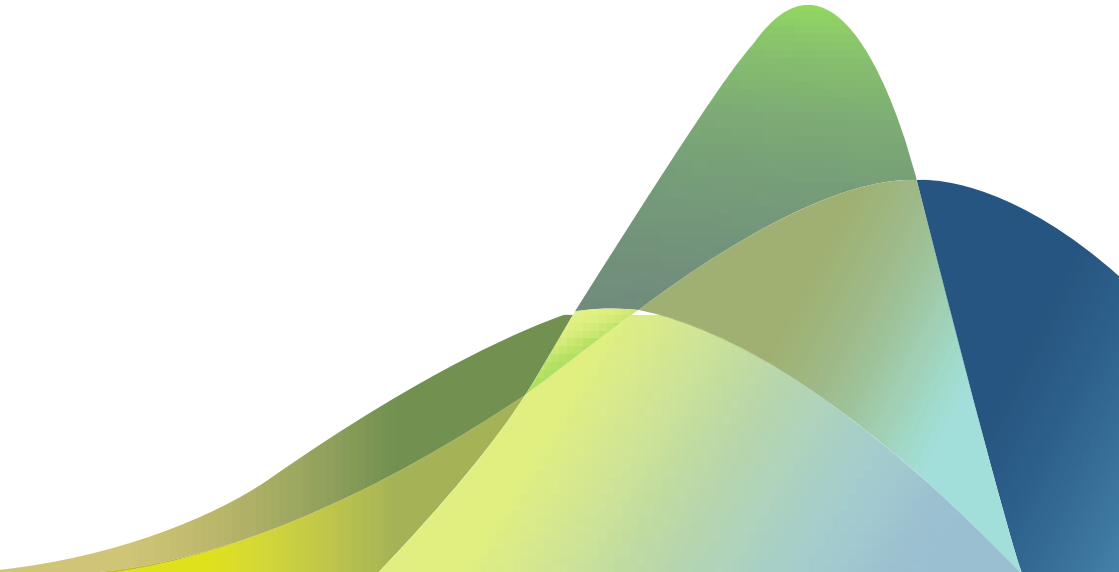
Murnau I Bavaria, Germany

7 – 12 September 2015



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(IBAC)

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SUPPORT

We gratefully acknowledge the financial support of **Dodotronic, Avisoft Bioacoustics, Noldus** and **Metris B.V.**

ADDITIONAL SUPPORT

Special thanks go to **Richard Ranft** – IASA, United Kingdom for his unfailing and uncomplaining support regarding buildup and maintenance of the IBAC Website, to **Michelle Rasch** regarding the conference layout; to **Swarovski Optik,** who generously sponsored the Best Poster Award, the binocular **SWAROVSKI OPTIK SLC 42 (SLC 10x42).**

„These binoculars can go everywhere with you. You can take the binoculars with you on your extended observation trips in the surrounding area, both during the day and at twilight.
The SLC 10x42 binoculars are sturdy in any weather, day in day out, and also stand out thanks to their particularly high optical quality. You will enjoy these rugged, ergonomic binoculars for many years.“

Last, but not least to **Taylor & Francis Group** who are enriching the conference with a special price, a **1-YEAR-SUBSCRIPTION FOR THE JOURNAL BIOACOUSTICS,** for the Best Oral Presenation of Junior Participants.

Thank you very much!

Welcome to the **XXV International Congress of the Bioacoustics Council**. Our conference venue is the Culture and Convention Centre / Kultur- und Tagungszentrum Murnau, KTM.

REGISTRATION

The registration desk at the Room "Münter" is open the following days:

Sunday, September 06th	**17.00 – 19.00**
Monday, September 07th	**08.00 – 09.30**

Please follow the signs.

Upon registration please confirm your registration for one of the excursions, for the Social Dinner and for the visit of *Max Planck Institute for Ornithology* in Seewiesen.

BEST POSTER AWARD

The Best Poster Award is open for every poster presentation and will be awarded by the Jury. The **Poster Award Ceremony,** to which everybody is invited to join, will take place on **Thursday, September 10th,** after the Social Dinner.

BEST ORAL PRESENTATION FOR JUNIOR PARTICIPANTS

This award is open for every oral presentation of junior participants. The winner will be selected by all participants with the help of a voting sheet. The **Award Ceremony** will take place on **Friday, September 11th,** during the Closing Remarks of Ole N. Larsen.

EXHIBITORS

Noldus | The Netherlands
Metris B.V. | The Netherlands
Location: FOYER OF THE CONFERENCE VENUE

ORAL PRESENTATIONS

Oral presentations (talks including discussion) are divided into three groups:

Plenary talks: 60 min
Symposium talks: 20 minutes
Open Oral Session talks: 15 minutes

To upload and test your talk, please come to the conference office the day before your talk is scheduled. **PLEASE MAKE SURE YOUR TALK RUNS ON A WINDOWS 7 ENVIRONMENT.** Your presentation will be deleted after your talk.

Location: LECTURE HALL 1 AND 2

POSTER PRESENTATION

Poster presentations are divided into two parts á two days – Monday/Tuesday and Thursday/Friday. Posters will be changed on Wednesday.

Posters must be A0 size maximum, in portrait orientation (vertical), so 84.1 cm wide x 118.9 cm high. Mounting material will be provided.

During the "Open Bar", poster session continues.

Please see poster list for scheduling
(also available online)

Location: ROOM 'STAFFELSEE' AND ROOM 3

EXCURSION

ATTENTION: due to the large number of registrations for the ´**Murnauer Moos hike'** (more than 120), we offer a third exciting possibility to spend the free afternoon.
We booked about 50 places on a **round-trip boat on the ´Staffelsee´,** the marvelous lake close to Murnau. Eighty minutes of sightseeing with a waterfall, wonderful nature and a nice place to sit are offered to all who join in the boat trip.

Please indicate upon registration, whether you are willing to change.

Upon registration you´ll get more information about the excursion of your choice, the **"Beer Seminar",** the **"Murnauer Moos"** or the **"Staffelsee".**

VISIT OF MAX PLANCK INSTITUTE FOR ORNITHOLOGY (MPIO)

Two busses will bring you the **Max Planck Institute for Ornithology,** Seewiesen, on Saturday. Departure from the congress center (entrance hall) at 09.00, arrival at MPIO around 10.00.
We will organize guided tours for a duration of approx. 2.5 hours. After a lunchbreak at the monastery of Andechs the busses will bring you back to Murnau around 15.00.

Upon registration you´ll get more detailed information.

INTERNET ACCESS

Free WLAN Access is available at the conference center. There´s no code required.

FOOD

During the coffee breaks coffee, tea and water will be provided. You´ll have the opportunity to get more snacks and drinks at the **Restaurant "Auszeit",** next to the conference venue.
A range of restaurants is available within walking distance of the conference center.

ALL CONFERENCE STAFF CAN BE RECOGNIZED BY THEIR BLUE T-SHIRTS AND BADGES. IF YOU HAVE ANY QUESTIONS, ANYONE OF US WILL BE HAPPY TO HELP. ■

USEFUL LOCAL INFORMATION

NATIONAL EMERGENCY NUMBERS
TEL. 110 / 112
Fire department, police, emergency care

HOSPITAL BGU MURNAU
Prof.-Küntscher-Straße 8
82418 Murnau a. Staffelsee
Tel. 08841 48 0

HOSPITAL GARMISCH-PARTENKIRCHEN
Auenstraße 6
82567 Garmisch-Partenkirchen
Tel. 08821 77 0

POLICE DEPARTMENT MURNAU
Barbarastraße 9
82418 Murnau a. Staffelsee
Tel. 08841 61 76 0

ROADSIDE ASSISTANCE (ADAC)
Tel. 0180 22 22 22

TOURIST INFORMATION MURNAU
Kohlgruber Straße 1
82418 Murnau a. Staffelsee
Te. 08841 61 41 0
www.murnau.de

RENT-A-CAR
St.-Martin-Straße 17
82418 Murnau a. Staffelsee
Tel. 08821 93 42 42

TAXI SERVICE MURNAU
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TRAIN STATION MURNAU
Bahnhofsplatz 1
82418 Murnau a. Staffelsee

BUS STATION
Kohlgruber Straße 1
82418 Murnau a. Staffelsee

SUNDAY I Sept 6th, 2015

17.00 – 19.00 Registration

MONDAY I Sept 7th, 2015

08.00 – 09.30 Registration

09.30 – 10.00 Welcome/Opening
Manfred Gahr

10.00 – 11.00 PLENARY TALK
Mike Ryan
What you hear ain't what you get

11.00 – 13.00 SYMPOSIUM 1
Control of vocal production
Coen Elemans
Sue Anne Zollinger

11.00 Friedrich Ladich
Sound-producing mechanisms and neuronal control in fishes: A unique diversity in vertebrates

11.20 Marcos Gridi-Papp
Laryngeal muscles and vocal control in amphibians and reptiles

11.40 Coen Elemans
Sue Anne Zollinger
Universal mechanisms of sound production and control in birds and mammals

12.00 Constance Scharff
Molecular toolkits for control of vocal production

12.20 Christian T. Herbst
Monitoring the mammalian and avian sound source with electroglottography

12.40 Steffen Hage
Vocal motor control mechanisms in the monkey brain

13.00 – 14.30 **LUNCH**

14.30 – 16.30 SYMPOSIUM 2
Communication over various spatial scales
Fanny Rybak
Thierry Aubin

14.30 Rohini Balakrishnan
Determinants and consequences of acoustic baffling behaviour in tree crickets

14.50 Paulo Fonseca
Acoustic active space in the Lusitanian toadfish and the effect of anthropogenic noise

15.10 Max Ringler
Acoustic ranging in Poison Frogs. *Allobates femoralis* uses signal cues beyond intensity to assess caller distance

15.30 Ole N. Larsen
Call transmission advantage for parrots at dawn in tropical dry forest

15.50 Clément Cornec
Booming far: the long-range vocal communication of a lekking bird

16.10 Solveig C. Mouterde
Active space of individual signatures in propagated calls of zebra finches: From acoustics to perception

16.30 – 17.00 **COFFEE BREAK**

17.00 – 19.00 POSTER SESSION 1
(POSTER 1 – 80)

19.00 – 20.00 **OPEN BAR**

TUESDAY I Sept 8th, 2015

08.30 – 09.30 PLENARY TALK
Daniel Robert
Sound frequency analysis through cochlea-like mechanism in an insect

09.30 – 10.00 **COFFEE BREAK**

10.00 – 12.00 SYMPOSIUM 3
Acoustic communication of arthropods
Tony Robillard

10.00 Stefan Schoeneich
Neurobiology of acoustic communication: Neural networks for singing and song pattern recognition in crickets

10.20 Camille Desjonquères
Acoustic diversity in freshwater habitats: the effect of lateral connectivity in a riverine floodplain

10.40 Ranjana Jaiswara
Species boundary delineation using multiple approaches: A case study on a field cricket *genus Teleogryllus* in India

11.00 Fabio Sarria
Non-invasive measurement of travelling waves in the inner ear of neotropical bushcrickets

11.20 Rafael Rodriguez
Environmentally-induced runaways: vibrational communication in Enchenopa treehoppers *(Hemiptera membracidae)*

11.40 Arne K. D. Schmidt
No evidence of acoustic signal divergence in a tropical cricket assemblage

12.00 – 13.30 **LUNCH**

13.30 – 15.30 SYMPOSIUM 4
Ecoacoustics
Jerôme Sueur

13.30 Pieretti Nadia
Application of a recently introduced acoustic index in marine soundscapes of a shallow water coast (Lampedusa Island, Italy)

13.50 Susan Parks
Ecological insights form bioacoustics activity levels measured from long-term acoustic monitoring at NEON observatory sites

14.10 Gianni Pavan
SABIOD Italy: A pilot study of wild soundscapes. The RNI Sassofratino pilot study

14.30 Diego Llusia
Heterospecific songs influence dawn chorusing in forest bird communities

14.50 Stowell Dan
Classifying multiple bird species in crowdsourced smartphone audio

15.10 Frédéric Bertucci
Large scale acoustic survey as a new tool for the evaluation of coral reef biodiversity (Moorea, French Polynesia)

15.30 – 16.00 **COFFEE BREAK**

16.00 – 18.00 OPEN ORAL SESSION 1
Henrik Brumm

16.00 Antonieta Labra Lillo
Interaction between calls and scents in lizard antipredator behaviour

16.15 Karla Rivera Caceres
Duet code development in plain wrens *(Cantorchillus modestus zeledoni)*

16.30 Marie Roch
Management of acoustic metadata for bioacoustics

16.45 Thierry Aubin
Should I stay or should I go? A slight acoustic variation gives an opposite meaning to a songbird alarm call

17.00 Daisuke Mizuguchi
Underwater vocal exchange between male and female in captive bearded seals

17.15 Sandra Goutte
Acoustic communication of the earless toad *(Brachycephalus pitanga)*

17.30 D'Amelio Pietro
Motor control and recognition of unlearned vocalisations

17.45 Andrèa Thiebault
Honking in traffic: use of calls in a foraging seabird

18.00 POSTER SESSION 2
(Poster 1 – 80)

WEDNESDAY | Sept 9th, 2015

08.30 – 09.30 PLENARY TALK
Julia Fischer
Referential communication revisited: the case of vervet monkey alarm calls

09.30 – 10.00 **COFFEE BREAK**

10.00 – 12.00 SYMPOSIUM 5
Vocal Communication and Cognition
Auguste von Bayern

10.00 Elodie Briefer
Emotional contagion through whinnies in horses

10.20 W. Tecumseh Fitch
Songbirds without song? Corvid communication from a comparative perspective

10.40 Katie E. Slocombe
Flexibility in chimpanzee vocal communication

11.00 Thorsten S. J. Balsby
Communication and social complexity in orange fronted conures *(Aratinga canicularis)*

11.20 Julie Oswald
Geographic variation in delphinid whistles – implications for classifier development

11.40 All speakers
General discussion: Cognition and communication – can a comparative approach across taxa work?

12.00 – 12.30 GENERAL ASSEMBLY MEETING

12.30 – 13.30 **LUNCH**
CHANGE OF POSTER

13.30 EXCURSION

THURSDAY | Sept 10th, 2015

08.30 – 09.30 PLENARY TALK
Vincent Janik
How does vocal learning affect marine mammal communication?

09.30 – 10.00 **COFFEE BREAK**

10.00 – 12.00 SYMPOSIUM 6
Mechanisms of vocal learning
Manfred Gahr

10.00 Robert Lachlan
Evolution and function of vocal learning in the chaffinch *(Fringilla coelebs)*

10.20 Veronika Beeck
Call Convergence in socially affiliated African savannah elephants *(Loxodonta africana)*

10.40 Nicole Geberzahn
Towards an understanding of developmental and perceptual mechanisms of vocal individuality in the zebra finch

11.00 Jinhong Luo
The Lombard effect emerges in bat infants: implications for the development of auditory feedback

11.20 Alejandro Salinas-Melgoza
The military macaw maintains homogeneity of a contact call across populations over a modified landscape in western Mexico

11.40 Andries ter Maat
Vocal learning in social groups of zebra finches

12.00 – 13.00 **LUNCH**

13.30 – 15.30 SYMPOSIUM 7
Techniques in bioacoustics
Andries ter Maat

13.30 Sarah Hallerberg
Bag-of-calls analysis reveals group-specific vocal repertoire in long-finned pilot whales

13.50 Philip Wadewitz
Advances in the quantitative analysis of graded vocal repertoires

14.10 Marie SA Fernandez
Impact of visual contact on vocal interaction dynamics of pair bonded birds

14.30 Karen Rowe
Automated recognition software improves detectability for a range of bird species' vocalizations

14.50 Ian Agranat
Unravelling zero crossing and full spectrum, what does it all mean?

15.10 Ladislav Ptacek
Application of speaker recognition methods for chiff-chaff individual identification

15.30 – 16.00 **COFFEE BREAK**

16.00 – 17.30 OPEN ORAL SESSION 2
Albertine Leitão

16.00 Dylan Gomes
Foraging decisions in clutter and noise: the effect of environmental complexity on multimodal signal use in a frog-eating bat

16.15 Nao Ota
Tap dancing birds: the multimodal mutual courtship display of males and females in a socially monogamous songbird

16.30 Ivano Pelicella
WaveFalcon, a new smart recorder

16.45 Dinesh Bhatt
Onset of dawn chorus in a tropical songbird, the Pied Bush Chat *(Saxicola caprata)*: relationships with weather and Sunrise

17.00 Tony Robillard
Evolution of mechanisms of sound production in Agnotecous crickets: multiple strategies to produce highfrequencies

17.15 Juliette Linossier
Song and genetic divergence related to different migratory patterns in a songbird, the blackcap *(Sylvia atricapilla)*

17.30 – 19.30 POSTER SESSION 3
(Poster 81 – 160)

19.30 Social Dinner/ Poster Award

FRIDAY I Sept 11th, 2015

08.30 – 09.30 PLENARY TALK
Peter Slater
Studies of the solos, duets and choruses of *"Thryothorus"* wrens

09.30 – 10.00 **COFFEE BREAK**

10.00 – 12.00 SYMPOSIUM 8
Vocalizing females
Michelle Hall

10.00 Karan J. Odom
Similarities and differences in female and male song in troupials *(Icterus icterus):* structural, diel and seasonal comparisons

10.20 Jacqueline R. Miller
Sexual dimorphism in vocal behaviour: exploring the pheromyscine mice of North and Central America

10.40 Lauryn Benedict
Female song in new world wood-warblers

11.00 Irina Beme
Is female song ancestral in songbirds?

11.20 Johana Goyes Vallejos
Female calling behaviour in the Smooth Guardian Frog *(Limnonectes palavanensis)* of Borneo. Evidence for sexrole reversal?

11.40 Clementine Vignal
Vocal negotiation over parental care? Partners adjust their time spent incubating on their acoustic exchanges at the nest

12.00 – 13.30 **LUNCH**

13.30 – 15.30 SYMPOSIUM 9
Music, speech and language
Carel ten Cate

13.30 Bruno Gingras, Emily Doolittle
A music theoretical approach to birdsong

13.50 Andrea Ravignani
The evolution of rhythm: a comparative approach to speech and music

14.10 Marisa Hoeschele
Using bioacoustics to compare avian and human acoustic perception

14.30 Buddhamas Kriengwatana
A general auditory bias for disregarding inter-speaker speech variability? Evidence in humans and songbirds

14.50 Kurt Hammerschmidt
Structural complexity can be a misleading indicator for advanced communication: the case of mouse courtship songs

15.10 Carel ten Cate
Linguistic rule learning in birds

15.30 – 16.00 **COFFEE BREAK**

16.00 – 17.30 OPEN ORAL SESSION 3
Michiel Vellema

16.00 Lucyna Wojas
Social eavesdropping on acoustic cues in non-learning model bird species

16.15 Clara P. Amorim
Multimodal and mismatching communication in vocal fish

16.30 James Campbell
Sound field characteristics of small tanks in the context of noise exposure experiments

16.45 Sonja Vernes
A novel approach reveals first molecular networks in the bat brain: implications for vocal communication

17.00 Pauline Salvin
Functions of female signals: the copulation solicitation and the mate sampling aid hypotheses in the domestic canary

17.15 Vera Klimšová
Impalas recognize predator vocalizations and heterospecific alarms of sympatric and allopatric species

17.00 – 19.00 POSTER SESSION 4
(Poster 81 – 160)

19.00 Closing Remarks
Ole N. Larsen

OPEN BAR

SATURDAY | Sept 12th, 2015

09.00 Visit to the Max Planck Institute for Ornithology, Seewiesen

OVERVIEW	SUNDAY I Sept 6th	MONDAY I Sept 7th	TUESDAY I Sept 8th
08.00 – 08.30		REGISTRATION	
08.30 – 09.00			**Sound frequency analysis through cochlea-like mechanism in an insect** Daniel Robert
09.00 – 09.30			
09.30 – 10.00		Manfred Gahr **Welcome I Opening**	**COFFEE BREAK**
10.00 – 10.30		**What you hear ain't what you get** Mike Ryan	SYMPOSIUM 3 **Acoustic communication of arthropods** Tony Robillard
10.30 – 11.00			
11.00 – 11.30		SYMPOSIUM 1 **Control of vocal production** Coen Elemans Sue Anne Zollinger	
11.30 – 12.00			
12.00 – 12.30			**LUNCH**
12.30 – 13.00			
13.00 – 13.30		**LUNCH**	
13.30 – 14.00			SYMPOSIUM 4 **Ecoacoustics** Jerôme Sueur
14.00 – 14.30			
14.30 – 15.00		SYMPOSIUM 2 **Communication over various spatial scales** Fanny Rybak Thierry Aubin	
15.00 – 15.30			
15.30 – 16.00			**COFFEE BREAK**
16.00 – 16.30			OPEN ORAL SESSION 1 Henrik Brumm
16.30 – 17.00		**COFFEE BREAK**	
17.00 – 17.30	REGISTRATION	POSTER SESSION 1 – 80	
17.30 – 18.00			
18.00 – 18.30			POSTER SESSION 1 – 80
18.30 – 19.00			
19.00 – 19.30		**BAR**	
19.30 – 20.00			

WEDNESDAY I Sept 9th	THURSDAY I Sept 10th	FRIDAY I Sept 11th	SATURDAY I Sept 12th
Referential communication revisited: the case of vervet monkey alarm calls Julia Fischer	**How does vocal learning affect marine mammal communication?** Vincent Janik	**Studies of the solos, duets an choruses ob *„Thryothorus“* wrens** Peter Slater	
COFFEE BREAK	**COFFEE BREAK**	**COFFEE BREAK**	
SYMPOSIUM 5 **Vocal communications and cognition** Auguste von Bayern	SYMPOSIUM 6 **Mechanisms of vocal learning** Manfred Gahr	SMYPOSIUM 8 **Vocalizing females** Michelle Hall	
GEN. ASS. MEETING			
LUNCH	**LUNCH**	**LUNCH**	
	SYMPOSIUM 7 **Techniques in bioacoustics** Andries ter Maat	SYMPOSIUM 9 **Music, speech and language** Carel ten Cate	
	COFFEE BREAK	**COFFEE BREAK**	
	OPEN ORAL SESSION 2 Albertine Leitão	OPEN ORAL SESSION 3 Michiel Vellema	
	POSTER SESSION 81 – 160	POSTER SESSION 81 – 160	
		Ole N. Larsen **Closing remarks**	
	Social Dinner I Award Ceremony	**BAR**	

VISIT MPIO

EXCURSION

ABSTRACTS OF PLENARY SPEAKERS (A – Z)

Location: Lecture Hall 1/2

WEDNESDAY | Sept 9th 08.30 – 09.30

Fischer, Julia
Cognitive Ethology Laboratory, German Primate Center, Göttingen

Referential communication revisited: the case of vervet monkey alarm calls

ABSTRACT Elucidating the origins of speech has been a major driver in studies of animal vocal communication. I will here discuss three aspects that have been deemed central in this regard, namely semanticity, vocal learning, and intentionality. The classic example of semantic communication are the alarm calls of vervet monkeys, who give three distinct alarm calls in response to their three main predator classes, and the calls alone are sufficient to elicit different escape strategies. The calls were thus deemed as being "functionally referential", and assumed to provide important insights into the evolution of speech. We used comprehensive quantitative analysis to re-assess the structural variation within their vocalizations. Although the three different alarm calls indeed differ significantly, we found substantial overlap in acoustic structure with calls produced in non-alarm contexts, indicating that these alarm calls are indexical rather than symbolic. Playback experiments on Green monkeys, the West African congeners of vervets further show that responses are guided by both the acoustic information available and contextual cues. Analyses of the variation of alarm calls in different Chlorocebus populations as well as several studies that explored the degree of vocal production learning underscore the view that the structure of non-human primate vocalizations is largely innate, while there is some flexibility in call usage. I will conclude with a brief discussion of differences in the intentional structure of human and non-human primate communication and provide an outlook future questions that I deem promising.

THURSDAY | Sept 10th 08.30 – 09.30

Janik, Vincent M.
University of St Andrews, United Kingdom

How does vocal learning affect marine mammal communication?

ABSTRACT The most obvious cases of vocal production learning involve the copying of novel calls or songs that are very different from the learner's usual repertoire. Species such as bottlenose dolphins and harbour seals can copy such signals, but little is known about the constraints in their learning skills and several other species use experience to modify their calls in a comparatively subtle way. We have developed a new training paradigm that allows us to quantify animal vocal learning capacity and compare them across species. By training animals to copy sounds from their own repertoire that we then alter in a step-wise procedure we can test the degree of modification the animals can implement, up to sounds that are not part of their usual repertoire. Grey seals trained in this way showed an interesting tendency to copy formant modulations but not modulations of the fundamental frequency. First results from bottlenose dolphins indicate that they learn to copy novel sounds very quickly using this paradigm. We hope that characterising vocal learning skills in this way will ultimately help to reconstruct the context in which vocal learning evolved.

Many seals and baleen whales produce song and may use learning when acquiring new song types. Grey seals, however, are not known to sing, which makes their learning skills harder to interpret. In one of our playback studies, wild grey seal pups copied sound combinations in their environment when producing contact calls. Similarly, bottlenose dolphins used vocal learning for individual recognition. In laboratory and field studies, we found that individually specific signature whistles were used for individual recognition, negotiating

reunions and, when copied by other dolphins, for addressing conspecifics. In developmental studies we have shown that signature whistles are formed early in life and that their modulation pattern does not relate to sex, age or size of the animal. Thus, new signature whistles types appear to be truly arbitrary and introduced de novo into the communication repertoire of the group. While we still know little about the mechanism used to develop novel modulation patterns, first studies suggest that the infants use model whistles in their environment that they then alter to create a novel signal. Comparing pinnipeds and cetaceans overall, the most likely contexts for the evolution of vocal learning in marine mammals are sexual selection and individual or group recognition. The degree of flexibility in learning skills seems to differ between species and may be linked to ranging patterns and social structure.

TUESDAY | Sept 8th 08.30 – 09.30

Robert, Daniel
University of Bristol, United Kindom
Montealegre-Z, F.
Sarria, F.
University of Lincoln, United Kingdom
Jonsson, B. T.
University of Bristol and Lincoln, United Kingdom

Sound frequency analysis through cochlea-like mechanism in an insect

ABSTRACT In mammals, hearing involves three canonical stages for the processing of impinging sound waves: 1. an eardrum collecting sound, 2. a middle ear impedance converter, and 2. a cochlear frequency analyzer. Some insects are endowed with an equivalent functional biophysical arrangement for auditory processing. In rainforest katydids, amongst some of the smallest ears know from animals, we could show that ears perform the crucial stage of air-to-liquid impedance conversion and signal amplification. This particular process that of energy coupling is enabled through a distinct tympanal lever system. Further along the chain of hearing, the important process of spectral analysis is achieved through dispersive wave propagation across a fluid substrate, similarly to what happens in the mammalian cochlea. This evidence illustrates that two remote organisms at the phylogenetic level, katydids and mammals, have evolved a series of convergent solutions to common biophysical problems, despite their reliance on very different morphological substrates.

MONDAY | Sept 7th 10.00 – 11.00

Ryan, Michael
University of Texas, USA & Smithsonian Tropical Research Institute, Panama

What you hear ain't what you get

ABSTRACT An underlying assumption of neuroethology is that our sensory, perceptual, and cognitive systems have evolved under selection to give us an accurate representation of the world around us. This need not be the case, as the brain evolves to perform many tasks and its function cannot always be optimized for all domains. These issue are especially relevant to sexual selection by mate choice in which it is often assumed that all mate choice evolved under selection to choose males with "good genes" (heritable variation for survivorship). We know, however, that various sensory, perceptual, and cognitive biases also influence what "sounds good". I will review how peripheral auditory tuning, Weber's Law, cocktail part effects, nonlinear interactions among auditory and visual modalities, and irrational choice all bias what choosers find attractive in the acoustic signals of their mates.

FRIDAY | Sept 11th 08.30 – 09.30

Slater, Peter J. B.
School of Biology, University of St Andrews, United Kingdom

Studies of the solos, duets and choruses of „Thryothorus" wrens

ABSTRACT In this talk I shall review the work that my collaborators and I have carried out on a group of Central American wrens, all formerly placed in the genus Thryothorus. Interest in the phenomenon of duetting led us to study the plain wren (Thryothorus , now Cantorchilus, modestus) in

Costa Rica, and we then broadened our perspective to study some 23 other species demonstrating a variety of singing styles. We combined the study of their songs with phylogenetic analysis, and this led us to the conclusion that these species should be more properly placed in four separate genera (Cantorchilus, Pheugopedius, Thryophilus and Thryothorus). These new groupings differ in their most usual singing style, while within a group most species sang in a similar fashion. However, certain species sing differently from their closest relatives, leading to questions as to why evolution has favoured such divergence.

Following on from this broad comparative work, we have concentrated in particular on a few of these species. Perhaps the most striking is the plain-tailed wren (Pheugopedius euophrys) from Ecuador, which lives in groups that sing highly stereotyped and coordinated four-part choruses. Playback of simulated songs of groups of four and of two shows that these are responded to differently in line with the numerical odds hypothesis. Furthermore, the initial response of small groups to larger ones is to sing a much longer song more typical of a larger group, suggesting that they attempt to repel intruders by appearing to be more numerous than they are. In the stripe-breasted wren (Cantorchilus thoracicus), which is unusual in having two quite different song forms, we have examined the difference in function between these. One, the "hoot" solo song, is especially common in unpaired males, and seems to be an advertising signal. The other, the "complex" song, with which a male's mate sometimes joins to form duets, is mainly used in interactions with other birds, and thus the most frequent in response to playback. In the happy wren (Pheugopedius felix) our results suggest that duets are used in cooperative territory defence rather than mate guarding, and we have gone on to look at how the two members of a pair integrate their contributions. The concentration of much recent research into duetting has been on function, yet the remarkable speed and synchrony of the duets in species such as these wrens raises many questions about the mechanisms involved. We have begun to look at these in this species, but much remains to be done. The issue of development is also almost untouched on when it comes to duetting and raises some particularly interesting, and challenging, issues. ■

BEST ORAL PRESENTATION FOR JUNIOR PARTICIPANTS

CEREMONY ON FRIDAY,
Sept 11th, 2015

during the "Closing Remarks"
of Ole.N. Larsen

AWARD:
1-YEAR-SUBSCRIPTION OF JOURNAL "BIOACOUSTICS"

ABSTRACTS OF SYMPOSIUM SPEAKERS (A – Z of first author)

Presenting author is underlined

Location: Lecture Hall 1/2

THURSDAY | Sept 10th 14.50 – 15.10

Agranat, Ian
Wildlife Acoustics, Inc., U.S.A.

Unravelling zero crossing and full spectrum, what does it all mean?

ABSTRACT Full spectrum and zero-crossing recording technology has been used to record and analyze the echolocation calls of bats for decades, and more recent advances in analysis software combine these technologies by extracting zero crossing information from full spectrum recordings using different combinations of signal processing techniques. We explain the physics behind full spectrum and zero crossing technologies and modern hybrid algorithms for bat biologists and ecologists to better understand and appreciate the advantages, disadvantages, and modern capabilities in available technology. We first look at zero crossing and full spectrum recording technologies, how they work, and their relative advantages and disadvantages in a number of areas. We then explore a simple technique for extracting zero crossing data from full spectrum recordings using band-pass filtering and adaptive thresholds. Later we look at more advanced signal processing techniques including Gaussian noise reduction, echo cancellation, call tracing and adaptive filtering, and how these techniques can be used to enhance a full spectrum signal in order to extract richer zero crossing data. This approach also shows promise for analysis of birdsong as well. We conclude that while zero crossing recordings do have some advantages in limited circumstances, it is far better to record in full spectrum to record bats and use modern signal processing techniques to enhance the signal before either analyzing using full spectrum tools or extracting zero crossing information and analyzing using zero crossing or hybrid tools.

TUESDAY | Sept 8th 16.45 – 17.00

Aubin, Thierry
Université Paris Sud, France
Mathevon, N.
Université Jean Monnet, St. Etienne, France
Magrath, R.D.
Australian National University, Canberra, Australia

Should I stay or should I go? A slight acoustic variation gives an opposite meaning to a songbird alarm call

ABSTRACT Predation is a powerful force shaping alarm acoustic signals. In many birds, the flee and the mobbing alarm calls are both used to announce a predator but elicit opposite responses from receivers, respectively a quick fly to cover or an approach and an harassment of the predator. Although previous studies have reported structural differences between both signals in bird species, there is a lack of investigations aiming to understand the acoustic basis of the switch between both functional types of alarm signals. In the superb fairy-wren Malurus cyaneus, flee and mobbing calls present strong similitudes. They are both characterized by the same high-pitched carrier frequency on which is applied a broad and fast frequency modulation, with the mobbing call presenting a low-pitched and short introductory element. By playback experiments with synthetic calls, we examined which structural details drive the functional difference between mobbing and flee calls. We showed that the functional switch between both calls is due to a simple variation of the slope of the carrier frequency, and does not depend on the other parameters composing both signals. Our result highlights the importance of the carrier slope in determining the meaning of alarm calls and supports the idea of a broadly shared coding rule among birds. Due to their importance for survival, alarm calls have evolved under strong constraints. We hypothesize

that, in the evolutionary history of alarm calls, both signals have a common ancestor but that the mobbing call has diverged from a pre-existent flee call possibly in the context of social cooperation.

MONDAY | Sept 7th 14.30 – 14.50

Balakrishnan, Rohini
Deb, R.
Indian Institute of Science, India

Determinants and consequences of acoustic baffling behaviour in tree crickets

ABSTRACT Male tree crickets make acoustic baffles in the form of a hole chewed into a leaf from which they sing. These leaf baffles act as amplifiers that increase the intensity of their calling songs, which they use to attract conspecific females. The ecological context, fitness benefits and selection pressures that could have led to the evolution of baffling behaviour are unknown and have not been investigated so far. In the tree cricket Oecanthus henryi, only a small proportion of males were found to sing from baffles in the field although most males were capable of building baffles. We examined the factors that influence baffling behaviour and found that the decision to baffle involves a complex interplay between available leaf size, male body size and a male's inherent call intensity. We then examined the advantages of baffling for long-distance acoustic mate attraction in an ecologically and spatially realistic context by building three-dimensional acoustic simulation models that took into account male spacing, female positions and hearing threshold, sound transmission losses and sound fields of males in choruses. Baffling did increase numbers of females attracted but also influenced the subsequent mating behaviour of females in ways that should increase the fitness of bafflers. The implications of these findings for the evolution of baffling behaviour will be discussed.

WEDNESDAY | Sept 9th 11.00 – 11.20

Balsby, Thorsten J.S.
Aarhus University, Denmark

Communication and social complexity in orange fronted conures *(Aratinga canicularis)*

ABSTRACT During the non-breeding season the orange fronted conure lives in small flock of 2-20 individuals, which are characterized by daily fission-fusion flock dynamics. The local population that we work with in Santa Rosa National park, Costa Rica has at least 1500 individuals based on capture recapture estimates. Such social complexity may pose substantial challenges to the communication system. Orange-fronted conures exchange multiple contacts calls prior to decisions about flock fusion. During these exchanges the contact calls changes and the contact calls of the interactants may increase or decrease in similarity. Playback experiments have shown that these changes have signal function and that increases in similarity between interactants can be used to address specific individuals within the communication network. The fission-fusion flock dynamics enables selective recruitment of individuals. If individuals have the cognitive abilities the decisions on who to recruit may involve prior interactions with specific individuals. One experiment suggests that orange-fronted conures, in addition to discriminate between known and unknown individuals, among the known individuals adjust their response according to how well the playback imitated their contact call in previous interactions.

THURSDAY | Sept 10th 10.20 – 10.40

Beeck, Veronika
Stoeger, A. S.
University of Vienna, Austria

Call convergence in socially affiliated african savanna elephants *(Loxodonta africana)*

ABSTRACT Among just a few mammalian species, including humans, elephants have evolved advanced vocal learning skills. Since these reports stem from captive individuals in rather unnatural social environments, the function of elephant vocal learning within their natural communication system is unknown. Vocal learning may be involved in the convergence of vocalizations among socially

affiliated individuals when animals are housed together in captivity or naturally form social groups. In the African elephant (Loxodonta africana) the family unit is centered around predominately, but not exclusively, closely related females and their offspring. It builds the stable core of a complex matrilineal fission-fusion social system which is based on mutual cooperation and maintained by acoustic communication. Captive groups, in contrast to groups in the natural system, are often composed of unrelated females of different heritages. During my master thesis I studied call convergence in two groups of zoo-kept African elephants (Vienna Zoo, Austria, and Basel Zoo, Switzerland), which consisted each of four unrelated, but socially affiliated adult females that have been housed together for several years. Using multivariate analysis, I found that their most commonly used social call, the "rumble", varied significantly in source and filter-related parameters between the groups. Given the females different genetic and geographical heritage, I conclude that that the study subjects matched some of the acoustic features of their calls to each other along with establishing social bonds. However, significant acoustic differences persisted between individuals of each zoo group, indicating that potentially both, group and individual identity are encoded in rumbles by a different subset of acoustical parameters. Call convergence and vocal learning might function to strengthen the bonds between individuals during group formation and may further provide means of long-distance group identification within the elephant´s natural communicative system.

FRIDAY | Sept 11th 11.00 – 11.20

Beme, Irina
Goretskaia, M.I.
Lomonosov Moscow State University, Russian Federation

Is female song ancestral in songbirds?

ABSTRACT Bird song is generally associated with males, however in recent years the number of articles devoted to female song increase. In the tropics female singing is appear to be more widespread (Kroodsma et al. 1996; Morton, 1996; Langmore, 1998; Slater & Mann 2004; Morton, 1996). In 2014 Odom et al (Odom et al., 2014) have published an article, in which the authors based on the analysis of the 1141 species claiming that female song is widespread and ancestral in passerine. Hear we analyzed the cases of female singing in 1309 species of different passerine families (18 complete families, two subfamilies in Thurdidae and three subfamilies in Sylviidae in Oscinae and 4 complete families and two subfamilies in Tiraniidae in Suboscinae), in order to understand the female song evolution and its connection with species biology and ways of settlement of the main groups of passerines. In total 30% of analyzing species have female song. In Australia the percent of female song consist of 28, in Europe - 10%, and has maximum in Africa (33%) and America (37%). We have not revealed a direct relation between female song and duet singing (in suboscinae duet singing consists of 64% of species with singing female, in oscinae -51%) and carotenoid-based color. According to our data female song occurs in different passerine families and probably is not ancestral to all birds of this order. Females of subocinae practically lose their ability to sing after penetration into the Old World, while in America the proportion of female song increases. The same tendency is for oscinae. Hence female song is more widespread in young group of oscinae and suboscinae (Ericson et al., 2002). We hypothesis that female song appear independently in different families of passerine.

FRIDAY | Sept 11th 10.40 – 11.00

Benedict, Lauryn
Najar, N.
University of Northern Colorado, U.S.A.

Female song in New World wood-warblers

ABSTRACT Recent advances have revealed that female birdsong is widespread and multifunctional. Female song was likely ancestral among songbirds and persists in many lineages today. Nevertheless, many species lack female song, and researchers are interested in understanding the selective factors that promote and counter the persistence of this trait. Female song is associated with life-history traits including year-round territoriality, non-migra-

tory behavior, sexual monochromatism, and monogamy. Most studies examining these relationships have looked at clades with a non-migratory ancestor and have found that gains of migratory behavior are strongly correlated with losses of female song (and duetting). Here we ask if the reverse pattern exists: in a large clade of songbirds with a migratory ancestor, do losses of migratory behavior correlate with gains of female song and visual signaling traits? We investigated correlations between female song, migration and dichromatism in 107 species of New World Warblers (Family Parulidae). All of these species are predominantly monogamous and territorial when breeding, 50 (47%) are migratory, 49 (46%) are monochromatic, and 25 (23%) show female song. On a robust genetic phylogeny both parsimony and maximum likelihood methods recover migration and monomorphism as the ancestral state in warblers. Female song is generally not reconstructed as present in any deep nodes of the phylogeny, indicating that most extant species with female song evolved this trait independently and relatively recently. Gains of female song do not correlate with losses of migration. Losses of dichromatism do correlate with losses of migration. Thus, in this clade, visual signals are associated with sedentary versus migratory lifestyles, but female acoustic signals are not. Our results show a different pattern from that seen in similar studies and support the hypothesis that losses, but not gains, of female song are driven by life-history.

TUESDAY | Sept 8th 15.10 – 15.30

Bertucci, Frédéric
Lecchini, D.
Centre de Recherches Insulaires et Observatoire de l'Environnement (CRIOBE), French Polynesia
Parmentier, E.
University of Liège, France

Large scale acoustic survey as a new tool for the evaluation of coral reef biodiversity (Moorea, French Polynesia)

ABSTRACT Passive acoustics took advantage of sound production in fishes as it offers natural acoustic tags to identify and follow populations in the field over long periods. However, there are no studies addressing sound production of fish communities within an entire biotope, on a long term basis and using this information in a monitoring perspective. Coral reefs are hot spot of biodiversity but are strongly impacted by climate change. Their monitoring and conservation are therefore crucial. Our study, funded by Total Foundation, aims to develop a methodology allowing environmental monitoring by means of a description of the marine soundscapes along the Northern coast of Moorea Island. Long terms acoustic recorders were positioned at 10m depth on the outer slope of 4 Marine Protected Areas and 4 non-Marine Protected Areas and collected data daily at a rate of 5min/hour during 48h hours. Four replicates were made for each area i.e. three replicates during the hot season and one replicate during the cold season. Results show that ambient sound intensity and acoustic diversity differ between areas and that these differences might be linked to the fish communities and to the type of habitats observed in situ. Overall, our study may pave the way for a new, large scale, acoustics based monitoring tool in the effort to preserve coral reefs. Soundscape analysis in air has proven very useful for determining how habitat structure may predict soundscapes and for assessing species present in habitats where other survey methods may be logistically difficult. Soundscapes are now considered an important part of landscape ecology. Yet, our knowledge of underwater soundscapes is still in its infancy, especially in coral reefs.

THURSDAY | Sept 10th 16.45 – 17.00

Bhatt, Dinesh
Dadwal, N.
Gurukula Kangri University, Haridwar, Uttarakhand, India

Onset of dawn chorus in a tropical songbird, the Pied Bush Chat *(Saxicola caprata):* relationships with weather and sunrise

ABSTRACT The avian dawn song chorus is a daily period of high song activity performed during the breeding season. The timing of dawn chorus is likely the result of a number of environmental, social and intrinsic factors. In this study, an attempt has been made to understand the relationships between

dawn chorus start times of male Pied Bush Chat (Saxicola caprata) and environmental variables such as ambient temperature, sunrise time, cloud cover, rain rate, wind speed, wind direction, lunar phase, humidity etc. We recorded dawn song chorus of the male Pied Bush Chat at 12 different sites in the rural landscape of district Haridwar (29°N), India. Sunrise time and other morning weather parameters were acquired from weather station of the Department of Zoology and Environmental Science, G.K.U., Haridwar. Results indicated that extrinsic factors play a significant role in influencing dawn chorus start times in the Pied Bush Chat. Males commenced their dawn chorus earlier when the moon was above the horizon at dawn. When it was raining or there were clouds, males started singing later. We noticed that dawn chorus started at early times as the breeding season progressed relative to twilight/ sunrise. Males also showed differences in daily song onset during initial breeding stages such as female attraction, territorial establishment and nest sites inspections. However, once the males have settled in their respective territories, the onset of dawn chorus occurred in a more synchronized manner. Thus, it seems that a number of environmental and social factors influenced the onset of dawn chorus in Pied Bush Chat singly or jointly.

WEDNESDAY | Sept 9th 10.00 – 10.25

Briefer, Elodie
Mandel, R.
Maigrot, A.-L.
Briefer Freymond, S.
Bachmann, I.
Hillmann, E.
ETH Zürich, Switzerland

Emotional contagion through whinnies in horses

ABSTRACT Emotional contagion through acoustic, visual or olfactory signals is at the basis of empathy and has been studied in only a limited number of species. This phenomenon could have a positive or negative impact on conspecifics. Indeed, contagion of positive emotions (e.g. joy) could improve welfare, whereas contagion of negative emotions (e.g. fear) could have the opposite effect. We tested emotional contagion through vocalisations in domestic horses. To this aim, we played back, to 18 horses in 5 different farms, whinnies of familiar (same farm) and unfamiliar horses (different farm), recorded during emotionally positive (social reunion) and negative (social separation) situations. Our results show that horses are more alert (higher head position, more head movements, ears forward for a longer duration, less time spent eating and faster response) when hearing unfamiliar compared to familiar whinnies. They are also more stressed (more movements and vocalisations, faster respiration and heart rate) when hearing negative than positive whinnies produced by familiar individuals. Horses are thus able to differentiate between whinnies indicating different levels of familiarity and different emotional valence. Our study suggests that hearing negative whinnies produced by familiar horses within a farm could trigger stress in all horses.

FRIDAY | Sept 11th 16.30 – 16.45

Campbell, James
Slabbekoorn, H.
Sabet, S.S.
Leiden University, The Netherlands

Sound field characteristics of small tanks in the context of noise exposure experiments

ABSTRACT Anthropogenic noise in marine ecosystems can affect the fitness of fish species by masking important acoustic signals as well as causing immediate physiological and behavioral changes. Although all fish are capable of detecting the particle motion component of a sound field and only species possessing a swim bladder can detect the pressure component, a majority of experiments examining the effect of anthropogenic noise on fish have focused exclusively on reporting pressure. In small aquarium acoustic experiments, due to the unique acoustic characteristics of these tanks, the relationship between particle motion and pressure may not be representative of open water conditions. To compare the effects of particle motion and pressure on fish behavior, we conducted a startle response experiment exposing zebrafish (Danio rerio) to a series of white noise pulses (50-2000Hz) in a confined region of a small glass aquarium in

which the measured particle motion and pressure components showed no spatial correlation. We compared the levels of sound pressure and particle motion at the fish's location during sound exposure to the occurrence, intensity, and directionality of the resulting startle responses. While the post-exposure swimming speed of individuals showed no relationship with either component, the probability of a post-exposure freezing response was positively correlated with particle motion, thus highlighting the importance of reporting particle motion measurements in small tank experiments. No relationship was found between the direction of startle response and the direction of particle motion, but particle ellipticity measurements suggest the acoustic conditions may have inhibited the individual's ability to localize the sound source. While current models of sound localization in fish imply that particle ellipticity is a crucial component of localizing sound sources, to our knowledge this is the first study which quantifies particle ellipticity in the context of sound source localization in fish.

MONDAY | Sept 7th 15.50 – 16.10

Cornec, Clément
Hingrat, Y.
Rybak, F.
Université Paris Sud, France

Booming far: the long-range vocal communication of a lekking bird

ABSTRACT The pressures of selection acting on message transmission by acoustic signals are particularly high in long distance communication networks. In the north-african houbara bustard (Chlamydotis undulata undulata) males produce strikingly low-frequency vocalisations called "booms" as a component of their courtship performed on sites separated at least 550 m apart. We investigated the acoustic features in booms involved in long-range coding-decoding processes of species-specific identity. We first assessed the degradations of acoustic parameters during booms transmission in the natural habitat of the bustard and showed that the frequency content of the booms was reliably transmitted up to 600 m. Second, by testing males' behavioural responses to the playback of modified signals we showed that the value of the 1st harmonic and the frequency modulation are key parameters for species identification, and that a sequence of booms elicited stronger responses than a single boom. Thus, the coding-decoding of information relies on sequentially redundant and propagation-resistant features, making the booms particularly well adapted to exchange information between males separated by long distances on their displays sites. Moreover we showed that during the booming phase of courtship, two sensory modalities - acoustic and visual - act in synergy. While the visual component is not necessary to induce agonistic response, it could act as an amplifier and reduces the time of detection of the signaller. The utilisation of these adaptive strategies allows houbara males to maximize the active space of vocalizations emitted in exploded leks.

TUESDAY | Sept 8th 17.30 – 17.50

D'Amelio, Pietro
Adreani, M.
Klumb, M.
Trost, L.
Gahr, M.
ter Maat, A.
Max Planck Institute for Ornithology, Seewiesen, Germany

Motor control and recognition of unlearned vocalizations

ABSTRACT In the clade of birds, according to the current phylogeny, vocal learning evolved at least twice. How and why this spectacular behavior evolved is not yet completely clear. A pathway enabling the modification of spectral features of the vocalizations must have come before and, possibly, independently from vocal learning. One reason for the evolution of this pathway might be that it favors vocal recognition. To be recognized, vocalizations need to be individually distinct, i.e. vocalizations show a bigger variability between individuals than within individuals. Vocal recognition and motor control of unlearned vocalizations are not frequently investigated in avian vocal learners. However their study might aid the understanding of vocal evolution and potentiate comparative analysis.

Here I aim to present the results of 2 studies to show that: 1) some unlearned vocalizations types of a vocal learner species are individually recognized, 2) lesions of the telencephalic nuclei of the vocal pathway influence the spectral features of these unlearned vocalizations whereas they do not influence their temporal pattern (i.e. duetting with the partner). In summary I demonstrate that even unlearned vocalizations can be partly modified by the vocal control system. Also some unlearned vocalizations are individually recognized. Taken together these studies shed light on to the evolution of the song system in the songbird brain and help formulating of hypotheses on the evolution of the auditory dependent vocal ontogeny.

TUESDAY | Sept 8th 10.20 – 10.40

Desjonquères, Camille
Llusia, D.
Sueur, J.
Muséum national d'Histoire naturelle, Paris, Université Paris-Sud, France
Rybak, F.
Université Paris-Sud, France
Castella, E.
University of Geneva, Switzerland

Acoustic diversity in freshwater habitats: the effect of lateral connectivity in a riverine floodplain

ABSTRACT Little is known about bioacoustics in freshwater habitats (i.e. ponds, rivers, lakes) despite the use of sounds by several taxa such as amphibians, fish, crustaceans and insects to communicate underwater. In particular, arthropods show high species diversity in such ecosystems and their acoustic productions still need to be investigated. In riverine floodplains, habitat dynamics and macro-invertebrate communities are prominently driven by the extent of connection of waterbodies to the main river channel. According to the intermediate disturbance hypothesis, macro-invertebrate richness is expected to be maximal at intermediate values of connectivity. In this study, we investigated the effect of habitat connectivity on acoustic richness in order to explore whether taxonomic and acoustic diversities co-vary. A long term acoustic monitoring program was conducted at six floodplain channels of the French Rhône river differing in their degree of connectivity with the main river. The number of sound types from a sample of 1440 recordings of one minute was identified by visual inspection of spectrograms and compared with the number of arthropod species of each community. We detected a high acoustic diversity of 124 different sound types with 6 +/- 2 sound types per recording. Unlike what was shown for the species richness, we found that the lowest acoustic richness was reached at intermediate connectivity values. Most of the recorded sounds could not be identified, stressing out the need to learn more about the identity and behaviour of the aquatic species producing acoustic signals underwater. This study highlights that sound diversity is acomplementary facet of biodiversity, linked with taxonomic diversity, but with distinctive features. Exploring the aquatic acoustic diversity could provide insights into conservation priorities of the endangered floodplain habitats.

FRIDAY | Sept 11th 13.30 – 13.50

Bruno Gingras
University of Innsbruck, Austria
Doolittle, Emily
Cornish College of the Arts, U.S.A.

A music theoretical approach to birdsong

ABSTRACT In this talk I discuss how scientific and musical analysis can be used together to gain deeper understanding of birdsong. Technological tools measure frequencies and durations precisely and statistical analysis enables determination of whether apparent patterns occur above chance level, while music theoretical analysis allows for more nuanced understanding of pitch, rhythmic, and structural relationships. The song of the hermit thrush, admired by musicians and ornithologists alike, has long been ascribed with following "major and minor keys," using "pentatonic scales," and "meeting perfectly the requirements of human music." These human-music-specific attributions are very unlikely in birdsong. Together with music theorist and cognitive biologist Bruno Gingras (University of Innsbruck), evolutionary and cogniti-

ve biologist Tecumseh Fitch (University of Vienna) and computational psychologist Dominik Endres (University of Tübingen), we show that the song instead follows the harmonic series. This is a physical rather than a culturally determined pattern, and thus is plausible in hermit thrush song. The harmonic series shows up in much human music as well, so there is indeed significant overlap between pitch relationships chosen by hermit thrushes and those which appear in some human music. The musician wren is also famed for the "musical" quality of its song. Together with ornithologist Henrik Brumm (Max Planck Institute for Ornithology), we show that it sings consonant intervals – those based on small integer ratios between adjacent pitches – more often than dissonant intervals, with a particular preference for the simplest integer ratios, perfect consonances. Though "consonance" and "dissonance" are human concepts, preference for small integer ratios between adjacent pitches may occur in multiple species. Not all birdsongs are as amenable to pitch analysis as these two, but in future collaborations, rhythmic, timbral, and structural analysis could equally be combined with scientific methods to gain greater understanding of a variety of birdsongs.

MONDAY | Sept 7th 11.40 – 12.00

Elemans, Coen
University of Southern Denmark, Denmark
Zollinger, S. A.
Max Planck Institute for Ornithology, Seewiesen, Germany

Universal mechanisms of sound production and control in birds and mammals

ABSTRACT As animals vocalise, their vocal organ transforms motor commands into acoustic signals for social communication. In birds, the physical mechanisms by which vocalisations are produced and controlled remain unresolved because of the extreme difficulty in obtaining in vivo measurements. Here, we introduce an ex vivo preparation of the avian vocal organ that allows simultaneous high-speed imaging, muscle stimulation, and kinematic and acoustic analyses to reveal the mechanisms of vocal production in birds across a wide range of taxa. Remarkably, we find that all species tested employ the myoelastic-aerodynamic (MEAD) mechanism, the same mechanism used to produce human speech. Furthermore, we show substantial redundancy in the control of key vocal parameters demonstrating that vocal signals are not specified by unique motor commands. We suggest that such motor redundancy can accelerate vocal learning and is common to MEAD sound production across birds and mammals, including humans.

THURSDAY | Sept 10th 14.10 – 14.30

Fernandez, Marie S. A.
Perez, E. C.
Vignal, C.
Université de Lyon, France
Griffith, S. C.
Macquarie University, Australia
Soula, H. A.
EPI BEAGLE INRIA, Lyon, France

Impact of visual contact on vocal interaction dynamics of pair bonded birds

ABSTRACT Animal social interactions usually revolve around several sensory modalities. For birds, these are primarily visual and acoustic. However, some habitat specificities or large distances may temporarily hinder or limit visual information transmission making acoustic transmission a central channel of communication. Here we show the impact of visual limitation on the vocal dynamics between zebra finches partners. Pairs were acoustically recorded during a separation/reunion protocol with gradually decreasing distance without visual contact. The vocal activity of each bird was recorded throughout the protocol. We developed an in-house software suite that automatically detects vocalizations from the recording and allows for individual tagging of vocalizations, as well as automatic removal of non-calls (wings or cage noise). Using these automatic detection/extraction algorithms, we obtained the call sequences and the temporal vocal dynamics for each individual in each condition. Without visual contact, pairs display more correlated vocal exchanges than with visual contact.

This high correlation renders the response's delay more predictable than without visual contact. We also analysed the sequences of caller's identity (turn-taking) during an exchange with or without visual contact. We show that in the absence of visual contact, the identity of a caller is well predicted by the knowledge of the identity of the previous one (Markov process). Thus, both the temporal correlation and Markov properties of acoustic interactions indicate that in the absence of visual clues the decision to emit a call is taken on a very short-term basis and solely on acoustic information (both temporal and identity of caller). Strikingly, when individuals are in visual contact both these features disappear indicating that birds adapt their calling dynamics to cope with limited visual cues. Our next goal is to apply this tool to larger groups of individuals to be able to study acoustic and social network in groups of birds.

WEDNESDAY | Sept 9th 10.20 – 10.40

Fitch, W. Tecumseh
Bugnyar, T.
University of Vienna, Austria

Songbirds without song? Corvid communication from a comparative perspective

ABSTRACT Corvids are oscine passerines („songbirds") from a phylogenetic viewpoint, and yet they lack the male advertisement song typical of most other songbirds. Curiously, one of the main song areas (HVC) in corvid brains is nonetheless well developed. Are corvids songbirds without song, and if so, what is the function of primitively vocal areas? We will suggest that song behavior, supported by vocal learning, can occasionally be observed in corvids, but that its social importance is reduced. In its place, a suite of other learned behaviours such as the „self-aggrandizing displays" of ravens have evolved which utilize corvid vocal social learning capacities, in both sexes. In general corvids have large brains and highly developed learning abilities and social cognition. It is possible that this neural circuitry plays a role in other non-display behaviours as well, and that this re-purposing represents an exaptation of the „standard" neural circuitry for song learning.

MONDAY | Sept 7th 14.50 – 15.10

Fonseca, Paulo
Alves, D.
Universidade de Lisboa, Portugal
Amorim, M. C. P.
MARE, ISPA-Instituto Universitário, Portugal

Acoustic active space in the Lusitanian toadfish and the effect of anthropogenic noise

ABSTRACT Mate attraction is mediated by acoustic signals in the Lusitanian toadfish, Halobatrachus didactylus. Males aggregate in suitable shallow habitats and advertise their presence to females with a loud sound, the boatwhistle (BW, c. 140 dB SPL, i.e. re. 1 μPa, at 0.1 m). The acoustic active space of male BW is dependent not only on propagation constraints of the habitat, but also on the background noise that is affected by anthropogenic noise such as generated by boating activities. We measured attenuation of BWs and of its representative pure tone components (120 Hz and 240 Hz) in an estuary breeding site (the Tagus estuary). BWs produced by breeding males were recorded with 2 m spaced equalized hydrophones in a linear array. Vocalization active space was estimated by comparing the envelopes of auditory evoked potentials (AEPs) using these recordings as stimuli, i.e. with BW recorded at increasing distances from the source. Another estimation was obtained by comparing attenuation of frequency tones with auditory sensitivity. These measurements point to an active space for the BW at c. 2 m deep water ranging between 6 and 13 m, depending on its spectral characteristics. In the presence of boat noise this range was strongly affected. Noise from small outboard motorboats and a larger ferryboat, presented at 130 dB SPL, reduced the active space to c. 2.5-4 m and 7-8.5 m, respectively. We further measured the vocal interactions (call alternation) between males at increasing distances. Vocalizations of close neighbors were entrained while the interaction pattern disappeared in distances above a few meters, pointing to an active space of BW of the same magnitude or a little longer.

THURSDAY | Sept 10th 10.40 – 11.00

Geberzahn, Nicole
Le Maguer, L.
Nagle L.
Université Paris Ouest Nanterre La Defense, France: Université Paris Lumières, France
Zsebök, S.
Aubin T.
Université Paris Sud, France
Derégnaucourt S.
Université Paris Ouest Nanterre La Defense, France; Université Paris Lumières, France; Institute Universitaire de France

Towards an understanding of developmental and perceptual mechanisms of vocal individuality in the zebra finch

ABSTRACT Understanding the origins of language is a challenge in human sciences and evolutionary biology. If language is a human attribute, one of its components – vocal learning – is shared with other species including oscine songbirds. Experiments to address central questions about vocal culture that cannot be conducted on humans for ethical reasons can be done with captive populations of birds. We used a songbird, the zebra finch (Taeniopygia guttata) to study transgenerational transmission of song under experimental conditions. The main component of the zebra finch song is the motif, a stereotyped sequence of syllables, which is repeated several times in a song often with connecting call-like syllables in between different motif renditions. The way motif renditions and connecting syllables are organized characterizes the phrase structure of the song. Typically, each male finch produces a different song which thus carries an individual signature. How do individual signals evolve in an environment with uniform song? Which song features are used for individual recognition in such a case? To study these questions we used 10 males producing the same song motif as founders of a colony and raised them with females in an aviary. We found that most of the males that hatched in the colony (n= 50) produced a close copy of the colony motif. However, males largely varied in their phrase structures. Next, we used an instrumental discrimination task (Go/Nogo) to study whether phrase structure rather than the motif serves as an individual signature. First results suggest, that zebra finches use the´motif and not the phrase structure of the song to recognize individual conspecifics. Thus, while transgenerational changes in the song seem to emphasize individual differences in the phrase structure, it seems to be nevertheless the motif which carries the individual signature.

THURSDAY | Sept 10th 16.00 – 16.15

Gomes, Dylan
Smithsonian Tropical Research Institute (STRI), Panama
Halfwerk, W.
VU Amsterdam, The Netherlands; STRI, Panama
Page, R.
STRI, U.S.A.

Foraging decisions in clutter and noise: the effect of environmental complexity on multimodal signal use in a frog-eating bat

ABSTRACT Conspicuous signals are used throughout the animal kingdom to attract mates and to keep competitors at bay. However, eavesdroppers frequently intercept these signals. Signalling in multiple sensory modalities can increase signal effectiveness to the intended receiver, especially in noisy environments, but may also give similar advantages to eavesdropping predators. Furthermore, conspecifics and predators can perceive the same signals/cues in different sensory modalities. Thus, variation in the sensory environment can differentially impact conspecific communication and predator eavesdropping. To cope with sensory variation, many bats use multiple sensory modalities while foraging. The frog-eating bat, Trachops cirrhosus, uses two types of sound while hunting. It eavesdrops on low frequency frog mating calls, and uses ultrasonic echolocation calls to search for frogs. While the acoustic component of the frog mating display is prominent, the dynamically moving vocal sac provides a salient signal to female frogs (in the visual domain) and to frog-eating bats (via echolocation). To understand how bats use multimodal prey signals under different sensory conditions, I used playbacks of túngara frog (Physalaemus pustulosus) mating calls, and a newly developed robotic frog model to mimic foraging opportunities

of a main prey species. Playbacks were broadcast as two-choice test, coupling one with a dynamically inflating robofrog (multimodal signal) and the other with a static model, and quantified bats' approach behavior under varying levels of noise and echoacoustic clutter. Our results suggest that the multimodal signal enhances localization of the mating display when confronted with background noise. Furthermore, bats show longer search times with the addition of echo-acoustic clutter and background noise. Understanding how bats rely on passive listening (prey-generated sound) and active foraging (echolocation) in different sensory environments is important for determining the impact of sensory disturbances on foraging bats as well as understanding selection pressures shaping the sexual advertisement calls of its prey.

TUESDAY | Sept 8th 17.15 – 17.30

Goutte, Sandra
Toledo, L.F.
Universidade Estadual de Campinas (UNICAMP), Brazil

Acoustic communication of the earless toad *Brachycephalus pitanga*

ABSTRACT As in most anurans, males Brachycephalus pitanga produce advertisement calls to attract potential mates. However, B. pitanga lacks the typical anuran tympanic ear: tympanic membrane, Ostia pharyngea, tympanic annulus and stapes. This particularity makes the tiny toad anatomically « deaf » to sounds above one kHz – frequencies below one kHz being transmitted to the inner ear via the operculum system. The advertisement call of B. pitanga, with a dominant frequency around four kHz, falls in the range normally detected by anurans via their tympanic ear. As vocalizations have a high energetic cost for the emitting males and may attract predators, it is not likely that these vocalizations are an ancestral behavior lacking function. We therefore postulated that this species must have evolved a different hearing pathway for sounds with a frequency above one kHz, such as their own advertisement calls. In this study, we aimed at uncovering how B. pitanga perceives airborne sounds above one kHz by investigating the sound transmission pathway, from the environment to the inner ear. B. pitanga lacking a tympanum, we searched for another interface between the air and the body for sound transmission. We used laser Doppler vibrometry and compared the resonance frequencies and oscillations amplitude of potential entry points on the body of the toad. To have a better understanding of the internal sound transmission pathway, we also built a 3D reconstruction of the internal ear structures. We thereby describe in details the characteristics of B. pitanga internal ear structures and propose a hearing pathway for airborne sound above one kHz. These results shed light on the possible alternative hearing pathways in other earless anurans.

FRIDAY | Sept 11th 11.20 – 11.40

Goyes Vallejos, Johana
University of Connecticut, U.S.A.

Female calling behavior in the smooth guardian frog *Limnonectes palavanensis* of Borneo. Evidence for sex-role reversal?

ABSTRACT Female frogs typically remain silent, while males produce advertisement calls to attract mates. In some species, females also vocalize, usually as a response to a male advertisement call. In the smooth guardian frog (Limnonectes palavanensis), found on Borneo, males are smaller than females and provide parental care, attending eggs and transporting tadpoles from the leaf litter to water. I found that males call to attract females, but do so infrequently, and females call in response. Females also vocalize spontaneously, forming small choruses to which the males respond with a short courtship call. Behavioral observations showed that multiple females approach a calling male, and females alternate their calls when more than one calling female is present. In addition, I examined the function of female calling and its role in possible sex-role reversal. When presented with a playback stimulus of a calling female, females increased calling rate and sometimes moved towards the source of the stimulus, indicating a predisposition for agonistic behavior. Males did not exhibit aggressive behavior. These observations are consistent with sex-role reversal in this species.

MONDAY | Sept 7th, 11.20-11.40

Gridi-Papp, Marcos
University of the Pacific, U.S.A.

Laryngeal muscles and vocal control in amphibians and reptiles

ABSTRACT Most ectotherm tetrapods have vocal cords but lack intrinsic laryngeal muscles attached to them. The arytenoid cartilages are pivoted open by the laryngeal dilator muscle and pivoted closed by two laryngeal constrictor muscles that together form a sphincter. In amphibians, a fourth muscle called the posterior laryngeal constrictor has been suggested to stretch the vocal cords, but experiments of electrical stimulation rejected the idea and revealed the the role of tis muscle is to adduct the vocal cords into the airflow for phonation. We are currently evaluating a potential fifth laryngeal muscle in amphibians. Researchers have noted that the laryngeal dilator muscle has a secondary attachment to the cricoid cartilage. We examined this attachment and found that in túngara frogs (Engystomops = "Physalaemus" postulosus) the laryngeal dilator is actually divided into two bundles: superficial and deep. The superficial portion of the dilator muscle corresponds to the traditional description of the dilator muscle. The deep bundle of the dilator muscle attaches to the arytenoid cartilage and to the cricoid cartilage. It is only innervated by the short branch of the laryngeal nerve and it is the only laryngeal muscle innervated by this nerve. All other laryngeal muscles are innervated by the recurrent laryngeal nerve. We are currently evaluating its potential role in active control of the fundamental frequency or of the acoustic complexity in male advertisement calls.

MONDAY | Sept 7th 12.40 – 13.00

Hage, Steffen
University of Tübingen, Germany

Vocal motor control mechanisms in the monkey brain

ABSTRACT Vocal communication is a complex behavioral pattern that can be found in all mammalian species. It can be subdivided into learned vocal patterns such as human speech, and genetically pre-programmed vocalizations, which include those of non-human primates and most other mammals. In my talk, I will give an overview on our recent studies on vocalization-related cognitive control processes in the cerebral cortex, and how these processes might be influenced by the auditory system. We performed these studies with a broad range of different methodological approaches including neurophysiological, neuroethological and psychophysical techniques in rhesus monkeys. In particular, we studied evolutionary aspects of human speech control with our newly established primate model and recorded single neurons in the vocalizing rhesus monkey. We found a neuronal correlate of volitional call initiation in the prefrontal cortex that suggests a cardinal role of this structure in cognitive processes that are involved in vocal motor control mechanisms. Furthermore, our data indicate that the ventrolateral prefrontal cortex plays an important role in audio-vocal integration processes, which might be a pre-requisite for complex audio-vocal communication processes, which can be found in non-human primates.

THURSDAY | Sept 10th 13.30 – 13.50

Hallerberg, Sarah
Timme, M.
Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany
Vester, H.
OceanSounds e.V., Germany
Hammerschmidt, K.
German Primate Center, Göttingen, Germany

Bag-of-calls analysis reveals group-specific vocal repertoire in long-finned pilot whales

ABSTRACT Besides humans, several marine mammal species exhibit prerequisites to evolve language: high cognitive abilities, flexibility in vocal production and advanced social interactions. Here, we describe and analyse the vocal repertoire of long-finned pilot whales (Globicephalus melas) recorded in northern Norway. Observer based ana-

lysis reveals a complex vocal repertoire with 140 different call types, call sequences, call repetitions and group-specific differences in the usage of call types. Developing and applying a new automated analysis method, the bag-of-calls approach, we find that groups of pilot whales can be distinguished purely by statistical properties of their vocalisations. Comparing inter- and intra-group differences of ensembles of calls allows to identify and quantify group-specificity. Consequently, the bag-of-calls approach is a valid method to specify difference and concordance in acoustic communication in the absence of exact knowledge about signalers, which is common observing marine mammals under natural conditions.

FRIDAY | Sept 11th 14.50 – 15.10

Hammerschmidt, Kurt
Fischer, J.
German Primate Center, Göttingen, Germany

Structural complexity can be a misleading indicator for advanced communication: The case of mouse courtship songs

ABSTRACT In animal communication, the identification of structurally complex vocal utterances often is frequently taken as evidence for flexibility in vocal production, including the capacity for vocal learning. This was the case in male mouse courtship songs. Their complex and variant ultrasonic vocalizations were described as "song", and it was suggested that they might be similar to bird song, and learning might be involved in their development. Studies on cross-fostered, deaf born as well as deafened mice, however, failed to identify substantial differences between the vocalizations of these mice and control subjects. These findings clearly indicated that mice do not need auditory feedback to develop and produce their strain-specific vocalizations. Moreover, the USVs of mice that lack Esco2 in the growth zone of the cerebral cortex, which results in the lack of hippocampal and neocortical structures, did not differ from those of control mice. Apparently, cortical structures are not necessary to develop these vocalizations or to produce these sounds in the appropriate context. These results question the potential of mice to study the genetic foundation of vocal learning. Furthermore, the findings indicate that a complex acoustic structure is not necessarily linked to greater flexibility or voluntary control. This highlights the limited explanatory power of structural analyses of sounds alone to identify production mechanisms.

MONDAY | Sept 7th 12.20 – 12.40

Herbst, Christan T.
University of Vienna, Austria

Monitoring the mammalian and avian sound source with electroglottography

ABSTRACT In both mammals and birds, the laryngeal/syringeal sound generator is the causal link in the sound production chain from neural motor control to vocal output, largely governing features such as the regularity of the vibratory patterns (periodic vs. irregular), the fundamental frequency, or the physical efficiency when converting aerodynamic to acoustic energy. Monitoring the dynamic properties of the sound source during voice production is thus a central goal in bioacoustic research, yet experimental difficulties when performing invasive measurements such as (high-speed) video endoscopy in vivo prevail. In humans, an alternative low cost, non-invasive impedance measurement method for monitoring vocal fold vibration has been successfully utilized in the past decades: electroglottography (EGG). A low intensity, high-frequency current is passed between two electrodes placed on each side of the larynx. The admittance variations resulting from vocal fold (de)contacting during laryngeal sound production are largely proportional to the time-varying relative vocal fold contact area. The EGG signal has found to be a reliable physiological correlate of vocal fold vibration, reflecting the oscillatory regime (periodic or irregular, including bifurcations), and the fundamental frequency. Research in humans suggests that landmarks in the EGG waveform may also give certain insights into pre-phonatory settings governed by intrinsic laryngeal musculature, and their adjustment during vocalization. In this presentation it will be demonstrated that electroglottography is well suited for analyzing mammalian voice production, based on recent studies with (hemi)larynx preparations of

various mammalian species, utilizing simultaneous high-speed video recordings. Ongoing research by this author will extend the experimental paradigm to analysis of in vivo sound production, e.g., in calves, dogs, and Japanese macaques. Finally, collaborative studies conducted in Dr. Elemans' lab suggest that the EGG approach is well applicable to birds, giving insights into dynamics of the oscillating syringeal membranes.

FRIDAY | Sept 11th 14.10 – 14.30

Hoeschele, Marisa
Fitch, W. T.
University of Vienna, Austria
Sturdy, C. B.
University of Alberta, Canada
Guillette, L. M.
University of St. Andrews, U.K.

Using bioacoustics to compare avian and human acoustic perception

ABSTRACT The bioacoustics of animal vocalizations can give us surprising insights into acoustic pattern learning abilities across species. This can be especially useful when looking for human-like acoustic abilities in other species. Human speech signals can give us insight into what kinds of features are important in human language perception. In one study, the perception of metrical patterns in human speech were evaluated in humans and budgerigars. First, we looked at previous research studying the structure of metrical patterns in human speech. We used this information to create two syllable nonsense words where either the first or the second syllable was emphasized, and we trained both species to discriminate the two patterns of emphasis. We found that both humans and budgerigars were able to detect metrical phonology in these signals, suggesting that detecting these kinds of patterns may be a general acoustic perceptual ability, at least in vocal learning animals. In another study, we evaluated relative pitch perception in the black-capped chickadee. Relative pitch is the ability to identify the ratio difference between two notes, a common perceptual phenomenon in humans that is used frequently in music to create tension and release. While many avian species appear to have trouble with relative pitch, looking at the bioacoustics of black-capped chickadee song and previous perceptual research, we knew that relative pitch was readily produced and perceived by this species in the performance and evaluation of their species-specific song. We found that the relative pitch ratios used in natural songs are processed more readily than other arbitrary relative pitch relationships. In conclusion, by evaluating the natural vocalizations of species we gain insight in possible perceptual abilities that then can be tested in laboratory studies, leading to value insights on comparative perception.

TUESDAY | Sept 8th 10.40 – 11.00

Jaiswara, Ranjana
Dhiman, S.
Jain, M.
Indian Institute of Science Education and Research, Mohali, India

Species boundary delineation using multiple approaches: a case study on a field cricket *genus Teleogryllus* from India

ABSTRACT Unambiguous identification of species is a fundamental need for all biological studies. However, this becomes non-trivial in cases where individuals are inseparable morphologically. In this study, field cricket belonging to genus Teleogryllus were collected and their calling songs were recorded from different localities in India. We found external morphological differences to be very subtle and characters highly overlapping. Comparison of Chopard's (1969) description, based on the genitalia structure, suggest that individuals belong either to Teleogryllus mitratus (Burmeister, 1838) or to Teleogryllus testaceus Walker, 1869. Townsend (1980), however, redefined T. mitratus Burmeister and concluded that testaceus Walker is a synonym of mitratus Burmeister. Undertaking both Chopard (1969) and Townsend (1980) documentation, there arises a problem of ambiguity in species identity of the Teleogryllus species. In this study we aim to resolve this ambiguity using multiple data sets: morphology, acoustics and behavior. Preliminary results based on comparison of genitalic structures, acoustic analysis of calling songs and behavioural

isolation experiments lend support to Chopard (1969) in which he advocates the presence of two different species. We discuss our results in light of Chopard's hypothesis of possible hybridization between the two species and the importance of calling song of these species to serves as a means of premating behavioural isolation.

FRIDAY | Sept 11th 17.15 – 17.30

Klimšová, Vêra
Policht, R.
Czech University of Life Sciences Prague, Czech Republic

Impalas recognize predator vocalizations and heterospecific alarms of sympatric and allopatric species

ABSTRACT Heterospecific recognition of alarm calls and predator vocalizations has been reported in wide range of taxa. Some animal species even recognize and respond by the antipredator behaviour to alarm calls and predator vocalizations of allopatric species. Despite the fact that prey-predator interactions may be theoretically important in conservation efforts in context of acoustics, little is known about this ability in ungulates. Especially, in areas with rich assemblage of predators such as the Kruger National Park in South Africa a greater variability in recognition of different acoustic cues can be expected. By using playback experiments we simulated alarm calls of kudu (Tragelaphus strepsiceros) and helmeted guineafowl (Numida meleagris) and vocalizations of black-backed jackal (Canis mesomelas), spotted hyena (Crocuta crocuta) and lion (Panthera leo) and observed responses of focal impala (Aepyceros melampus) as ungulate model species. To test whether impalas adequately respond also to alarm of species not known to them we played calls of allopatric Eurasian jay (Garrulus glandarius). Non-alarm calls of several bird species were used as controls. The results showed that impalas responded by quicker look towards the source of sound, longer scanning of environment or escaping to both, alarm (jay including) and predator, calls rather than to controls. They were scanning the environment significantly longer after hearing the lion's roaring and initiated the scan quicker after exposed to alarms of kudu and guineafowl rather than to the jackal's howling. According to our best knowledge, this is the first study reporting ability of ungulate to differentiate between calls of apex- and meso-predators that compares the recognition of heterospecific alarms and predator vocalizations. Our findings may have an applied value in conservation. Especially large predators, important ecosystem components, frequently suffer local extinctions and knowing prey-predator acoustic interactions may increase success of repatriation initiatives of both prey and predator species.

Acknowledgement: CIGA 51120/1313/3104 and IGA 51120/1312/3113

FRIDAY | Sept 11th 14.30 – 14.50

Kriengwatana, Buddhamas
Leiden University, The Netherlands

A general auditory bias for disregarding inter-speaker speech variability? Evidence in humans and songbirds

ABSTRACT Human speech perception requires deciphering a highly variable signal. Vowel normalization is a proposed method by which humans can categorize vowels despite the extensive variation that stems from speaker/gender differences in vowel production. Studies in humans and non-human animals indicate that experience with very few speakers is sufficient for vowel categorization, and normalization of speaker differences in vowel production may arise from sensitivity to formant ratios. This study tests the hypothesis that normalization of speaker and gender differences in isolated vowels does not require prior experience with speaker-related variability because there is an inherent tendency for the auditory system to transform vowel formants into formant ratios. Using a behavioural Go/No-go task and identical stimuli, we compared Australian English adults' (naïve to Dutch) and zebra finches' (naïve to human speech) ability to categorize /ɪ/ and /ɪ/ vowels of an novel Dutch speaker after learning to discriminate those vowels from only one other speaker. Experiment 1 and 2 presented vowels of two speakers interspersed

or blocked, respectively. Results demonstrate that categorization of vowels is possible without prior exposure to speaker-related variability in speech for zebra finches, and in non-native vowel categories for humans. Therefore, this study is the first to provide evidence for what might be a species-shared auditory bias that may supersede speaker-related information during vowel categorization. It additionally provides behavioural evidence contradicting the hypothesis that vowel normalization is achieved via the use formant ratios F1/F3 and F2/F3. Therefore, investigations of alternative accounts of vowel normalization that incorporate the possibility of an auditory bias for disregarding inter-speaker variability are warranted.

TUESDAY | Sept 8th 16.00 – 16.15

Labra Lillo, Antonieta
Universidad de Chile, Chile and University of Oslo, Norway
Monachesi, M.R.
Instituto de Herpetología, Fundación Miguel Lillo, Argentina

Interaction between calls and scents in lizard antipredator behavior

ABSTRACT Distress calls are vocalizations produced by individuals when they are trapped by a predator. They may enhance the survival probabilities of the caught individual and/or of its conspecifics. The weeping lizard, Liolaemus chiliensis, emits distress calls that seem to benefit conspecifics as they react to these calls, specifically to simple down-modulated, with prolonged immobility, a behavior that would reduce their probabilities of being detected by the predator. This behavior has been recorded when lizards are confronted with distress calls. This lizard, however, emits a wide variety of distress calls, including complex calls with different types of non-linear phenomena. It has been proposed that these nonlinear sounds can honestly communicate fear, and if so, it is expected that alarmed lizards exhibit a stronger antipredator response when they are exposed to complex distress calls. We tested this hypothesis exposing individuals to simple and complex distress calls; the latter contained chaotic noise. In addition, and considering that evidence suggest that adults tend to live in pairs, we tested if the chemical environment, in this case, substrates with scents of the tested individual or from a conspecific of a different sex, may modulate the receiver response. There was an interplay between the type of calls and the chemical environment; individuals reacted with longer immobility after complex than simple calls, but when they were with their own scents (i.e. the own territory). When exposed to scents of a conspecific of a different sex, complex calls determined a shorter immobility than simple calls. These results suggest that the weeping lizard discriminates between simple and complex distress calls, but the triggered antipredator response is modulated by "where" lizards perceived the risk; a fearful call in the own territory is riskier. Funds: Fondecyt 1120181 (AL); Conicet scholarship (MR).

THURSDAY | Sept 10th 10.00 – 10.20

Lachlan, Robert F.
Queen Mary University of London, U.K.

Evolution and function of vocal learning in the chaffinch *(Fringilla coelebs)*

ABSTRACT Vocal learning in songbirds is remarkably diverse, and one facet of this is shown by variation between species in the precision with which they imitate tutors. We still lack a clear understanding of why this variation exists and even of why some species learn precisely. By applying spatially explicit cultural evolutionary simulations, it is possible to demonstrate that European chaffinches learn extremely precisely, with a "cultural mutation rate" of only 1%. But they do not show typical "dialectal" patterns of song variation, and do not preferentially share songs with neighbours, ruling out the majority of functional explanations for precise learning. A recent hypothesis proposes that precise learning is an assessment signal, in which males attempt to learn 'prototypical' versions of local song-types, and receivers learn prototypes in order to distinguish precise from imprecise learners. I used a computational bioacoustic analysis to identify prototypical exemplars of local song types in a Catalonian chaffinch population. In a playback study in the same population, territorial males responded more aggressively to prototypical than to less typical versions of song types, sup-

porting the assessment hypothesis. When the same stimuli were played back to a different population, unfamiliar with the song types, they were not distinguished between, suggesting that prototypes were in fact learned. Finally, I will discuss evidence that this system of precise imitation and assessment has rapidly broken down during the colonization of the Atlantic Island archipelagos. In these genetically isolated populations, syllable recombination and imprecise syllable imitation occur at far higher rates than on the mainland, demonstrating how learning behaviour can rapidly diverge between evenly closely related taxa.

MONDAY | Sept 7th 11.00 – 11.20

Ladich, Friedrich
University of Vienna, Austria

Sound-producing mechanisms and neuronal control in fishes: A unique diversity in vertebrates

ABSTRACT Fishes have evolved the largest diversity of sound-generating (sonic) mechanisms among vertebrates. The main group of sonic mechanisms is based on the swimbladder. These can be vibrated by intrinsic drumming muscles located in the swimbladder wall (toadfishes) or by extrinsic drumming muscles originating on structures such as the skull, vertebral processes or body wall musculature. Extrinsic drumming muscles insert either directly on the swimbladder (e.g. pimelodid catfish) or vibrate the swimbladder indirectly either via broad tendons (piranhas) or bony plates (doradid catfishes). Pectoral sound-producing mechanisms include the vibration of the pectoral girdle (sculpins), the rubbing of the enhanced pectoral spine in a groove of the shoulder girdle (catfishes) and the plucking of enhanced fin tendons (croaking gouramis). In addition, sounds can be produced by other structures such as head-neck articulation (seahorses) or pharyngeal teeth (clownfish). Two different sonic mechanisms (producing low- and high-frequency sounds) may be present simultaneously (catfishes, seahorses). Sonic organs can be similarly developed in males and females (croaking gourami), or they are sexually dimorphic (toadfishes) and may hypertrophy seasonally in males (cods). Sound-generating muscles are controlled by motor neurons forming vocal/sonic motor nuclei (VMN). Three major organization patterns of VMNs are known: VMNs positioned in the midline (toadfishes) or along the ventral border (pectoral mechanisms) of the posterior hindbrain and anterior spinal cord. The third pattern shows swimbladder muscles innervated solely by spinal motor neurons (piranhas). Those catfishes that possess two mechanisms have a midline VMN associated with swimbladder muscles and a multifunctional ventral nucleus for sonic and non-sonic (locomotion) pectoral functions (pectoral motor nuclei, PMN). VMNs are controlled by pacemaker neurons that receive inputs from other vocal nuclei. It remains to be investigated if vocal fishes have a common vocal pathway rostral to the VMNs.

THURSDAY | Sept 10th 17.00 – 17.15

Robillard, T.
Legendre, F.
Muséum national d´Histoire naturelle, Paris, France
Lafond, Augustin
Universidad Federal de Viçosa, Brazil; Muséum national d´Histoire naturelle, Paris, France

Evolution of mechanisms of sound production in agnotecous crickets: multiple strategies to produce high-frequencies

ABSTRACT Crickets are acknowledged for the diversity of their calling songs, which play a major role in reproduction and in preventing hybridization in closely related species. The general mechanism of sound production in crickets is well studied and is often considered as simple and stereotyped. However, its morphological and behavioral parameters can vary significantly, which may explain a wide array of the acoustic diversity observed in the calling songs of these insects. We studied the evolution of the sound generating system in the genus Agnotecous, which is characterized by the production of high-frequency calling songs. The species of this genus are very similar in terms of morphology, but they produce songs with a wide range of frequencies (10-20 kHz). The study consisted in fine scale analysis of the morphological and behavioral variables of the system. These multiple variables have then been studied in reference to the phylogeny of the genus,

using methods taking into account the phylogenetic relationships among the species: ancestral state reconstruction, phylogenetic PCA, comparisons of phylogenetic signal, phylogenetic generalized least square analyses. These analyses investigated evolutionary links between the stridulatory behavior and structures in order to understand how the mechanism participated in the diversification of the acoustic signals. Unexpectedly, we have found that the studied species developed two different strategies to produce high-frequencies: (1) some species increased the speed of the stridulatory movement until reaching directly high dominant frequencies, (2) while others exploited the vibration capacities of their forewings to amplify harmonic frequencies coming from slow stridulatory movements. These results support the hypothesis that such high-frequency songs evolved quickly, repeatedly and stepwise, by a form of punctuated evolution rather than by only the progressive increase of the ancestral fundamental frequency.

MONDAY | Sept 7th 15.30 – 15.50

Larsen, Ole.N.
University of Southern Denmark, Denmark
Balsby, T. J. S.
Aarhus University, Denmark
Dabelsteen, T.
University of Copenhagen, Denmark

Call transmission advantage for parrots at dawn in tropical dry forest

ABSTRACT Central American orange-fronted conures (Eupsittula canicularis) live in fission-fusion flocks outside the breeding season, where fission-fusion events may occur on a daily basis. When a flock flies over the forest, its members usually emit loud contact calls, to which perched individuals may respond and attract the flock for longer exchange of contact calls. These activities occur mainly in the morning and to a smaller extent late in the afternoon. There probably are several reasons for this diurnal variation in calling activity. Here we investigated whether diurnal variations in temperature and humidity and consequently in the speed of sound coincided with changes in calling activity. We hypothesized that one limiting factor could be development of midday sound speed gradients creating 'sound shadows'. To investigate such effects we performed a transmission experiment in a typical conure habitat in Costa Rica. We broadcast contact calls from a speaker placed at three different heights and recorded with two microphones at three different distances while simultaneously recording temperature and humidity at three different heights. In the morning neither temperature nor humidity gradients were found up to six meters above ground but at noon clear gradients had developed. The experiment demonstrated that temperature and humidity gradients at noon affected sound transmission significantly. Temperature and humidity induced changes in sound speed suggesting that at midday 'sound shadow zones' develop roughly between 60 and 70 m from a calling bird adding to the excess attenuation created by the ground effect and atmospheric attenuation. (Supported by the Danish Council for Independent Research - Natural Sciences #10-084844)

THURSDAY | Sept 10th 17.15 – 17.30

Linossier, Juliette
Zsebök, S.
Baudry, E.
Aubin, T.
Courvoisier, H.
Université Paris-Sud, France

Song and genetic divergence related to different migratory patterns in a songbird, the blackcap *Sylvia atricapilla*

ABSTRACT In songbirds, territorial songs are key regulators of sexual selection and are learned from conspecifics. The cultural transmission of songs leads to divergence in song characteristics within populations and ultimately can lead to speciation. Many songbirds also migrate and individual differences in migratory behaviors can influence population genetic structure and local song differentiation. The complex interactions of song structures, migratory routes and genetic diversity can underlie ongoing selection processes, and remain to be better understood. Blackcaps (Sylvia atricapilla) exhibit versatile territorial songs with geographical variations and show a large diversity of

populations from sedentary to migratory. It appears as a good model to study the relationships between migratory patterns, song variability and genetic diversity. We studied a population (2 groups) of migratory blackcaps around Paris and a population (3 groups) of sedentary blackcaps in Corsica. All the birds were ringed and blood samples were taken in order to study genetic relatedness using 17 microsatellite loci. A detailed song analysis showed that this species has a complex repertoire (>100 syllables) which required the development of a semi-supervised methods to classify different categories of syllables and compare sequences of syllables (custom-made program in Matlab). Our analysis showed no genetic structuring among populations. Individuals belonging to a same population are not genetically closer that individual from different populations. However we found a strong morphologic differentiation between sedentary and migratory populations. We also show that geographical variation in songs relies at least on both syllable and sequence content and, contrary to what we expect, that sedentary groups do not share more than migratory groups. Song dialects do not seem to act as barriers to gene flows and are strongly cultural rather than genetic.

TUESDAY | Sept 8th 14.30 – 14.50

Llusia Diego
Desjonquères, C.
Ulloa, J. S.
Sueur, J.
Muséum national d'Histoire naturelle, Université Paris-Sud, France
Aubin, T.
Université Paris-Sud, France

Heterospecific songs influence dawn chorusing in forest bird communities

ABSTRACT Animal acoustic communication is primarily involved in social interactions among conspecifics. The study of species interactions has been mostly restricted to masking interference or acoustic cues within predator-prey interactions. Further evidence of sound information sharing among animal species is still scarce. Here we report for the first time an experimental study examining acoustic interactions in bird dawn chorus, a widespread but poorly understood phenomenon. Community acoustic monitoring was conducted in twenty forest sites in France during three consecutive days. By remote-controlled playback tests, forest bird communities were exposed, only the second day, to acoustic stimuli of Parus major, a common species occurring in all the recorded sites. The stimuli started around 30 min before the time of the first song of P. major recorded the previous day. General linear mixed models indicated that this experimentally induced temporal shift in P. major elicited, as expected, earlier singing activity in P. major, but more surprisingly also in other species of the community, in comparison with pre- and post-stimulus days. Our results suggest that eavesdropping on other species plays an important role in the dawn chorusing behaviour, specifically influencing the time of species' singing activity within the dawn chorus. This constitutes a novel example of how heterospecific acoustic signals may act as cues providing information within an animal community.

THURSDAY | Sept 10th 11.00 – 11.20

Luo, Jinhong
Max Planck Institute for Ornithology, Germany
Wiegrebe, L.
Ludwig Maximilians University, Germany

The Lombard effect emerges early in bat infants: implications for the development of auditory feedback

ABSTRACT Auditory feedback, i.e. monitoring one's own vocalizations, is critical in learning and maintenance of both birdsong and human speech. However, only few studies have investigated the development of auditory feedback and results indicate a rather late developmental origin. The Lombard effect, a well-studied form of audio-vocal interaction, refers to the phenomenon that humans/animals increase their vocal loudness in response to increasing background noise. Here we investigated the postnatal development of the Lombard effect in echolocating bats which are the only known non-human terrestrial mammals capable of vocal

learning. Specifically, we tracked the ability of infant bats to adjust their vocalizations to playbacks of white noise, from the age of only a few days to three months. We found that infants increased their vocal loudness in noise even in the first week of testing. Moreover, we found that the magnitude of the Lombard effect did not change over the 3-month period. These findings demonstrate that bats have already fully developed the capacity for audio-vocal interaction at the age of one week, challenging the current view of late developmental origin of auditory feedback.

FRIDAY | Sept 11th 10.20 – 10.40

Miller, Jacqueline R.
Royal Ontario Museum, University of Toronto, Canada

Sexual dimorphism in vocal behaviour: exploring the peromyscine mice of North and Central America

ABSTRACT Several mammalian taxa produce stereotypic vocalizations, representing simple sequences to complex songs. Among the best investigated are cetaceans, primates, carnivores and bats, particularly with reference to song. Relatively little, however, is known regarding stereotypic acoustic behaviour in rodent species, with the exception of the laboratory rat and mouse. Here, as among avian species, research is focused on the male. Relatively few studies are available regarding vocal dimorphism, and even fewer investigate the potential influence of evolutionary constraint. I present a phylogenetic study of stereotypic vocal behavior in the peromyscine mice, an assemblage of deer mice and their relatives (Cricetidae: Neotominae). The behaviour of both males and females of 15 species was sampled, with each of the major species groups represented. Stereotypic vocalizations vary among species, and include single note pure-toned constant frequency (CF) vocalizations, harmonically rich CF vocalizations with non-linear elements, simple frequency modulated (FM) and temporally modulated (TM) vocalizations, and complex songs that are both strongly FM and TM. Both the presence and degree of sexual dimorphism in acoustic features varies among species. This is particularly interesting given the absence of size dimorphism in all species examined. A phylogeny constructed from sequence data representing both mitochondrial and nuclear genomes (Miller and Engstrom 2008) provides a backdrop to explore evolutionary patterns in this assemblage. The results suggest that dimorphism in vocal behaviour is, in part, phylogenetically constrained. Species whose vocalizations are sexually dimorphic have sibling species with sexually dimorphic vocal signals also. Only in one species sampled were stereotypic and complex vocalizations made solely by males. Dimorphism in acoustic signals occurs among peromyscine mice, and the existence of female stereotypic vocalizations merits further study. It is proposed that the investigation of mammalian vocal behaviour can provide a comparative context, through which deeper evolutionary and genomic influences can be explored.

TUESDAY | Sept 8th 17.00 – 17.15

Mizuguchi, Daisuke
Tsunokawa, M.
Kohshima, S.
Wildlife Research Center of Kyto University, Japan

Underwater vocal exchange between male and female in captive bearded seals

ABSTRACT Bearded seals produce complex sounds underwater mainly in breeding season. These sounds are suggested to have territorial and/or reproductive function. However, little is known about the behavioral context of the vocalization mainly because behavioral observation is difficult in the wild. In this study, we recorded behaviors and sounds of an adult male and two adult females in captivity to estimate the function of vocalization. Underwater sounds were recorded in Otaru aquarium, Japan, in the daytime between March 2012 and May 2013, using a hydrophone and a linear PCM recorder (frequency range: 20 Hz to 20 kHz). Additional 24-hour recordings were conducted in March 2015 to find diurnal change in vocal activity. Behavioral observation was conducted in the daytime to identify the caller of sounds and to record social behaviors. The adult male vocalized from December until April with a peak in March. Contrary to previous belief, two fema-

les also vocalized from mid March to April, breeding season reported in the wild. In order to examine whether they conduct "vocal exchange" following some temporal rules, we analyzed the intervals of vocalization between two seals that vocalized sequentially. The frequency distribution of the intervals were significantly different from that expected from the assumption that seals independently vocalized at their own pace ($P < 0.01$, Kolmogorov-Smirnov test) and had a sharp peak at 4.0 sec., suggesting "vocal exchange" between two seals. The 24-hour recordings revealed that seals vocalized all day and night in the breeding season, peaking in the early morning. No social behaviors were observed except muzzling by females against the throat of vocalizing male in March, which might be a signal to advertise their estrus. Our findings provide the first evidence that bearded seals use sounds for vocal exchange that might be useful for long-range communication to advertise their reproductive status.

MONDAY | Sept 7th 16.10 – 16.30

Mouterde, Solveig C.
Elie, J. E.
Theunissen, F. E.
University of California Berkeley, U.S.A
Mathevon, N.
Université Jean Monnet, St. Etienne, France

Active space of individual signatures in propagated calls of zebra finches: From acoustics to perception

ABSTRACT Reliable transmission of acoustic information about individual identity is of critical importance for pair bond maintenance in numerous monogamous songbirds. However, information transfer can be impaired by environmental constraints such as external noise or propagation-induced degradation. We focused on the impact of these constraints on the active space of bird calls, and their ability to extract identity information from highly degraded signals. We analyzed propagated signals using discriminant function analyses on a set of analytical parameters as well as on a complete spectrographic representation of the signals. We found that individual signature is remarkably resistant to propagation as caller identity can be recovered even at distances greater than a hundred meters. Male calls show stronger discriminability at long distances than female calls, and this difference can be explained by the more pronounced frequency modulation found in their calls. Operant conditioning experiments showed that female zebra finches were proficient in discriminating between calls of individual males propagated at long distance, and even more so when they can train themselves with increasingly degraded signals over time. While this result emphasizes the importance of perceptual learning, electrophysiological experiments also highlighted single neurons that showed high performances in discriminating unfamiliar individuals at long distance.

FRIDAY | Sept 11th 10.00 – 10.20

Odom, Karan J.
Omland, K. E.
University of Maryland, U.S.A.
Logue, D. M.
University of Lethbridge, U.S.A.

Similarities and differences in female and male song in troupials *(Icterus icterus)*: structural, diel, and seasonal comparisons

ABSTRACT Recent research emphasizes that female song in birds is more common than previously thought. Yet we still know very little about structural, temporal, or functional similarities and differences between male and female song, let alone the evolutionary processes operating on song in each sex. Song in temperate-breeding male passerines appears to be sexually selected, but the selection pressures acting on song in females may be quite different. Quantifying structural, diel, and seasonal variation between male and female song is an important first step in forming hypotheses about the function and evolution of female and male song. We compared song structure and singing rates for female and male Venezuelan troupials (Icterus icterus) for dawn versus day and for breeding versus non-breeding seasons. Female and male songs were similar in duration and frequency. Singing rates, however, varied substantially between males and females, particularly during dawn versus day time singing. Males sang the majority of dawn songs

during the breeding season, whereas females sang the majority of day time solos. Furthermore, females sang at similar rates during both the breeding and non-breeding season. It is important to note, during the day, most songs were answered by the mate to create duets. Our finding that females sing more solos during the day year-round while males sing more solos at dawn during the breeding season indicates that female song may be functionally distinct from male song in troupials. Such findings reinforce the need to explore alternative selection pressures contributing to the evolution of female song in birds.

WEDNESDAY | Sept 9th 11.20 – 11.40

Oswald, Julie N.
Bio-Waves, Inc., Encinitas, U.S.A.
Rankin, S.
NOAA Fisheries, Southwest Fisheries Science Center, La Jolla, U.S.A.
Gannier, A.
Fuchs, S.
Group de Recherche sur le Cetaces, Antibes, France
Janik, V.
University of St. Andrews, U.K.

Acoustic species recognition in delphinids

ABSTRACT Interspecific variation in vocalizations is commonly used for species recognition, especially in animals that have limited access to information from other sensory modalities. Delphinids are such a case where acoustic information is often the only modality available. Yet, species differences in vocalizations are often subtle. We studied species differences in vocalizations of two delphinid species (Delphinus delphis and Stenella coeruleoalba) in the tropical Pacific Ocean and Mediterranean Sea to evaluate the differences that exist between and within species. Fourteen variables describing frequency, shape and duration of whistles were measured and compared. Between-species comparisons showed that the degree of difference varied with location. Few significant differences were found between whistles produced by D. delphis and S. coeruleoalba in the tropical Pacific. In contrast, many significant differences were found between these same species within the Mediterranean. Using Discriminant Function Analysis (DFA), 69% of Mediterranean whistles were classified to the correct species. This correct classification score was significantly greater than chance (ɪ2 test, ɪ = 0.05). In contrast, the correct classification score for the tropical Pacific (55%) was not significantly greater than chance (ɪ2 test, p = 0.37). Thus, for these species, differences within the tropical Pacific are smaller than differences within the Mediterranean. These results suggest that the measured variables do not carry species-specific information for the tropical Pacific dolphins and that these dolphins may be using other whistle characteristics for species recognition. Delphinid repertoires are strongly influenced by vocal learning such as in the development of individually distinctive signature whistle types, and playback experiments have shown that animals sometimes react to whistles of other species as if they came from conspecifics. We suggest that the development of many individually distinctive signature whistle types may blur species differences in areas where dolphins maintain individualized social networks.

THURSDAY | Sept 10th 16.15 – 16.30

Ota, Nao
Soma, M.
Hokkaido University, Japan
Gahr, M.
Max Planck Institute for Ornithology, Seewiesen, Germany

Tap dancing birds: the multimodal mutual courtship display of males and females in a socially monogamous songbird

ABSTRACT Many birds perform courtship displays that combine movements and sounds. Past songbirds studies shed light on vocalization, while less attention has been paid to non-vocal sounds. We report here the first example of non-vocal sound production of the both sexes of a songbird, the blue-capped cordon-bleu (Uraeginthus cyanocephalus). This species is known for female song, but in addition to singing, both sexes perform courtship dance by holding a piece of nesting material and bobbing up and down. Interestingly, the bobbing produces rhythmical sounds. By recording these displays with

a high-speed video camera, we discovered that their visual courtship display includes incredibly rapid step-dancing during bobbing. Although we cannot deny the possibility that such stepping behavior functions as visual and/or tactile (i.e. vibration) signals, it is also possible that it produces acoustic signals due to higher sound pressure level. As a first step toward understanding the function of the dance display in blue-capped cordon-bleus, we investigated sex differences of dance performance (no. steps / bob, and bobbing rate). We also examined the effects of singing and partner's position on dance performance. Sex differences in dance performance were marginal as previously reported in song. Dance performance changed depending on whether the subjects were singing, which might contribute to avoiding interference between vocal and non-vocal sounds. However, stepping dance can also serve as a vibration signal because they intensified dance performance when partners were on the same perch. The fact that dance display of both sexes of socially monogamous songbirds produces non-vocal sounds in addition to song suggests that the evolution of multimodal and multicomponent courtship display as an intersexual communication should be considered.

FRIDAY | Sept 11th 16.15 – 16.30

P. Amorim M. Clara
Fonseca, P.J.
MARE, ISPA-Instituto Universitário, Lisboa, Portugal
Beauchaud, M.
Université Jean Monnet, St. Etienne, France

Multimodal and mismatching communication in vocal fish

ABSTRACT Agonistic contests are often mediated by multimodal communication but the way in which visual and acoustic signals interplay is not yet understood in fish. Previous experiments with the Lake Malawi cichlid fish Metriaclima zebra have shown that visual but not acoustic unimodal signals trigger male aggression. However, when acoustic signals were combined with visual information they reduced aggressiveness in this species. Here we tested how the spectral information content of agonistic sounds, which is size-related, modulates aggressive behaviour in a multimodal communication context. We visually exposed territorial M. zebra males to a size-matched male placed in a contiguous aquarium. Trials consisted in three periods of five min: PRE (visual only), PBK (acoustic + visual) and POST (visual only). Acoustic treatment consisted in the playback of agonistic sounds of smaller (high frequency) and larger (low frequency) males. As a control we used white noise or silence. We observed that low frequency sounds but not the other treatments resulted in a reduction of aggression during PBK and POST periods, suggesting that sound frequency provides effective information of fish size. Theory predicts that reduced aggression and shorter contests are expected when asymmetries between opponents are large. Our results also suggest that fish evaluate the relative information provided by visual and acoustic signals during contests. When sound frequency indicates a larger opponent (asymmetric contest) the acoustic channel overrides the visual one, but when it indicates a smaller opponent the visual channel seems to prevail as fish behaved as in a matched contest. This study indicates that the auditory and visual channels interplay in a complex way during the evaluation of an opponent to avoid 'dangerous' conflicts.

TUESDAY | Sept 8th 13.50 – 14.10

Parks, Susan
Denes, S. L.
Varshney, P.
Syracuse University, U.S.A.
Fristrup, K.
US National Parks, U.S.A.

Ecological insights from bioacoustics activity levels measured from long-term acoustic monitoring at NEON observatory sites

ABSTRACT The National Ecological Observatory Network (NEON) has established a framework through which a variety of environmental metrics will be continuously measured for multiple decades at stations located across the United States. Here we describe a multiyear project to demonstrate the benefits of incorporating continuous acoustic monitoring at NEON sites. Long-term recordings provide a wealth of data relating to species presence, animal behavior, and anthropogenic noise disturbance with

minimal environmental intrusion. The phenology of biological events such as avian, amphibian or insect chorusing activity can be determined through automated band limited energy detectors. Data from the NEON site at Harvard Forest, Massachusetts, collected between November 2013 and July 2015 were analyzed to assess the phenology of chorusing behaviors of bird species using customized automated detectors. Bird vocalizations are detectable throughout the year, however during the spring, a change in vocalization behavior was clearly detectable in the acoustic record. Assuming a qualitative definition of chorusing as the persistent presence of bird vocalizations, the onset of bird chorusing can be identified from long-term spectral plots of the acoustic data and onset can be compared between years. Assessment of acoustic activity at multiple time scales can provide multiple levels of data. Adding acoustics to the measurements already collected under the NEON protocol can provide high-resolution information on the presence and behavior of acoustically active species in birds, frogs, and insects, as well as the acoustic impact of human activity at these locations and allow for long-term monitoring combined with ground truthing assessments of biodiversity and ecosystem health from standardized traditional data collection methods at each site.

TUESDAY | Sept 8th 14.10 – 14.30

Pavan, Gianni
Favaretto, A.
Bovelacci, B.
Scaravelli, D.
Macchio, S.
Università di Pavia, Italy
Glotin, H.
Université de Toulon, France

SABIOD Italy: A pilot study of wild areas' soundscapes. The RNI Sassofratino pilot study

ABSTRACT The research was developed within the SABIOD (Scaled Acoustic Biodiversity) project granted by the French CNRS MASTODONS Project on Big Data acquisition, analysis and processing. SABIOD started in 2014 in cooperation with the University of Toulon (DYNI laboratories) and the JASON (Joint Acoustic Survey for Online Biodiversity) Project. The research in Italy is aimed at describing the acoustic environment (soundscape) of natural habitats with different level of protection and human presence. The program started in May 2014 in 4 locations by using autonomous recorders to measure the sounds produced by the animals (biophony, expressed as biodiversity, complexity and richness) and the anthropogenic noise (antropophony, expressed as quietness). The project is supported by the Italian Forestry Police (Corpo Forestale dello Stato, Ufficio per la tutela della Biodiversità - CFS UTB) that provides logistic support and the access to the Integral Nature Reserve "Sassofratino", in the National Park "Foreste Casentinesi", where the core of the research is run. This RNI, created in 1959, holds a pristine forest, received the Europen Diploma and is taken into consideration for the UNESCO "Millenarium Forests" program. In year 2015 the research is mainly focused on this area with 3 recorders coupled by the measure of temperature and humidity, the two main parameters, with the daily solar cycle, that drive the acoustic behaviour of animals. Results given by (bio)acoustic indexes taken from literature and new indexes developed for the purpose will be compared with compact long-term spectrograms and with the analytic results given by experts. Instrumentation, software and technical details will be also presented and discussed in order to define common protocols and metrics for soundscape analysis.

THURSDAY | Sept 10th 16.30 – 16.45

Pelicella, Ivano
Balsamo, F.
Dodotronic, Castel Gandolfo, Italy
Pavan, G.
Università di Pavia, Italy

WaveFalcon, a new soundscape smart recorder

ABSTRACT Recording soundscapes is mostly based on autonomous remote recorders to be programmed for a given recording schedule, e.g. 10 minutes every half-hour, deployed in the location to be monitored, and then recovered to download data and replace batteries. Their use implies several technical constraints, mainly related to storage and power. Nowadays the storage space is not the main issue

as SDXC cards reach 512GB of capacity; batteries are the most limiting factor and their replacement must be programmed prudentially to guarantee the continuity of the data acquisition. The WaveFalcon is a smart autonomous low-power recorder able to work either in stand-alone mode or web connected. Several web connection modes are available to balance battery usage and available bandwidth on the wireless channel that can be a Wi-Fi or a cellular network, possibly 3G or faster. To limit bandwidth and battery usage, the wireless connection can be limited to monitoring status (storage space available, battery level, scheduling of recording and of web access) to allow timely maintenance operations (data recovery and battery replacement), or it can be expanded to perform scheduled fpt of summary data or of recorded data, including real-time or near-real-time display on a public page. Recording of audio and ultrasonic data from different sensors can be continuous, scheduled, or on trigger. WaveFalcon provides temperature, humidity and light level recording as well as photo and video capture possibilities. An onboard GPS allows mobile applications and the synchronization of a cluster of units for sound source localization and wide area monitoring. Examples of use in the SABIOD-Italy project will be presented.

TUESDAY | Sept 8th 13.30 – 13.50

Pieretti, Nadia
Ceraulo, M.
Mazzola, S.
Filiciotto, F.
Maccarrone, V.
Farina, A.
Buscaino, G.
University of Urbino, Italy

Application of a recently introduced acoustic index in marine soundscapes of a shallow water coast (Lampedusa Island, Italy)

ABSTRACT Quantifying and characterizing the acoustic production of animals in marine soundscapes can be sometimes a challenging task to address. Geophonies (sounds from wind, rain and waves) or anthropophonies (fishing activities, cruise ships and other vessels) are present all year round and can lead to a biased interpretation of the biological sounds. Indeed, most of geophonies and anthropophonies have a low frequency range, i.e.less than 1kHz, which overlaps with the frequencies used by fishes for communication and other biologically important activities. In the present study we used the Acoustic Complexity Index (ACI) to elaborate one year of recordings (from 22 June 2013 to 6 June 2014) carried out in shallow coastal waters inside the Marine protected Area of Lampedusa, Italy. Data were collected using an autonomous recorder (SM2, Wildlife Acoustic, US; recording bandwidth: 2Hz – 192kHz; sensitivity: -165dB re: 1 V/uPa). The ACI was chosen since it is an algorithm designed to measure the spectral complexity of soundscapes, which tends to enhance the intrinsic variability of biotic sounds, and filter/reduce the more constant intensity values that characterize many types of geophonies or anthropophonies. The ACI was previously widely used to track the dynamics of terrestrial communities, but it was only recently applied to marine environments. Pros and cons of its extensive temporal application on one entire year of recordings of a marine soundscape are here described and evaluated.

THURSDAY | Sept 10th 15.10 – 15.30

Ptacek, Ladislav
Machlica, L.
Linhart,P.
Jaska, P.
Muller, L.
University of South Bohemia, Czech Republique

Application of speaker recognition methods for chiff-chaff individual identification

ABSTRACT This paper deals with the identification of chiff-chaff individuals using the Gaussian Mixture Model and Universal Background Model (GMM-UBM) supplemented by a Voice Activity Detection (VAD) algorithm. Contrary to usual Bird Individual Identification systems the one introduced here processes the live recordings without editing (cutting, song or syllable extracting, de-noising). The testing recordings were made outdoors under natural conditions and thus contain unwanted sounds and noises: crackling, aircraft engines,

blowing, simultaneous bird singing of the same or different species, etc. The method uses MFCC parametrization with the added VAD algorithm for automatic recognition of bird song activity. The identification runs on the open set, which means that any number of unknown birds may appear anytime during the process as is common in the nature. The achieved success rate of the identification varies between 69.6% and 93.5%, and the overall achieved accuracy is 78.6%. The results suggest that the task of automatic identification of individual birds, even within one species, is feasible in natural conditions. Main goal of the research was to prove the method of Automatic Individual Identification using GMM-UBM with VAD could supplement and even supersede the bird ringing using real recordings without post-editing.

FRIDAY | Sept 11th 13.50 – 14.10

Ravignani, Andrea
Vrije Universiteit Brussel, Belgium

The evolution of rhythm: a comparative approach to speech and music

ABSTRACT The human sense of rhythm has traditionally been studied along two dimensions, stemming from language sciences and experimental psychology. Linguists have performed acoustic analyses of phonological patterns in languages, comparing syllable stress and timing within and between human languages. Experimental psychologists interested in music have performed a variety of rhythm perception and synchronization experiments, where human participants were required to listen to series of marked events over time, and possibly synchronize their movements by e.g. finger tapping. The little comparative research relating non-human animal communication and perception to speech and music has mostly focused on spectral rather than temporal features. Here, I: (i) review and compare a number of contrasting hypotheses on the evolution of rhythm; (ii) propose crucial experiments and model species to support or reject these evolutionary hypotheses; (iii) suggest how three complementary approaches (observational, experimental, and mathematical) can elucidate the evolutionary history of the human sense of rhythm. First, audio-motor synchronization experiments are being performed in an increasing number of species. Mapping synchronization abilities to species either closely related by descent or occupying similar niches will help reconstruct the evolution of rhythm not only in those species, but also in humans. Second, interacting individuals can influence each other's timing, both across several modalities and in different animal taxa. A large body of observational and experimental research on animal chorusing is already available. Once its focus is shifted from the spectral to the temporal domain, published research on animal spontaneous chorusing can inform hypotheses of rhythm evolution in humans. Finally, empirical findings should be synthesized and combined via mathematical models of the evolutionary dynamics of rhythm. These models could resemble classical models of behavioural traits in evolutionary biology, must be informed by empirical bioacoustics, and should aim at generating additional testable hypotheses.

We acknowledge MASTODONS CNRS mission for supporting SABIOD http://sabiod.org & Univ Toulon Axe Information for supporting JASON.

MONDAY | Sept 7th 15.10 – 15.30

Ringler, Max
Hödl, W.
University of Vienna, Austria
Ringler, E.
University of Vet. Medicine, Vienna, Austria

Acoustic ranging in poison frogs – *Allobates femoralis* uses signal cues beyond intensity to assess caller distance

ABSTRACT Acoustic ranging – to properly asses the distance of a sound source, like a competing male – is especially important in the context where individuals live in highly territorial systems. There it is often used as a mechanism to maintain individual spacing to avoid costly physical conflicts between neighbouring individuals. At the same time accurate ranging allows territory holder to make reliable decisions on when to engage other proximate callers that might be competing for space and mates. As signal intensity is not a reliable cue for acoustic

ranging – a caller might not only be near or far, but also could vocalize more or less loud, be blocked by obstacles, or vocalize directionally – accurate ranging requires the integration of further signal cues. For birds and mammals, including humans, it has been shown previously, that reverberation characteristics and signal degradation are used to for acoustic distance assessment. In frogs so far clear evidence is missing, that signal characteristics other than signal intensity are used to asses signaller distance. To asses intensity independent ranging in frogs, we performed playback with the Neotropical poison frog Allobates femoralis. Males of this species are known for their stable, long-term territories, which are announce by prolonged advertisement calling. We used naturally degraded and reverberated signals which were recorded simultaneously across 0.75, 1.5, 3, 6, 12, and 24 m in Neotropical rainforest, the natural habitat of the study species. These signals were normalized and played back at equal intensity from equal distances to territorial males. The significantly differential responses of the focal males to these playback clearly shows, that also frogs can perceive and evaluate signal characteristics beyond intensity to evaluate the distance of a sound source.

TUESDAY | Sept 8th 16.15 – 16.30

Rivera Caceres, Karla
Searcy, W.A.
University of Miami, U.S.A.
Guerrero, E.Q.
University of St. Andrews, U.K.

Duet code development in plain wrens *(Cantorchilus modestus zeledoni)*

ABSTRACT One of the most striking properties of avian duets is the occurrence of answering rules ("duet codes") that individuals use to link their own song types to those of their partners. The mechanisms by which such rules are acquired have been little studied. In particular it is not clear at which stage individuals learn their duet codes. In a previous study with juvenile plain wrens (Cantorchilus modestus zeledoni) we found that individuals learn a code during early development. However, if codes acquired during early development do not change, then plain wrens must pair with individuals from the opposite sex that already share their specific codes. Such a pairing scheme seems too restrictive, so it seems more likely that the wrens can learn new duet codes as adults. We performed a removal experiment in adult plain wrens to determine whether individuals are able to acquire new answering rules as adults. We found that adult plain wrens are able answer to unfamiliar phrase types and when they do, their coordination is poorer than for familiar phrases. This suggests that individuals can potentially modify their duet codes during adulthood. If so, then what is important for juveniles to learn may be the general rules governing duet codes, rather than the specifics of the codes used by their models.

TUESDAY | Sept 8th 16.30 – 16.45

Roch, Marie
Herbert, S.
San Diego State University, U.S.A.
Baumann-Pickering, S.
Hildebrand, J.A.
Širovi ı, A.
Scripps Institution of Oceanography, La Jolla, U.S.A.
Berchok, C.L.
Cholewiak, D.
Oleson, E.M.
van Parijs, S.
Soldevilla, M.S.
NOAA National Marine Fisheries Service, Fisheries Science Centers, U.S.A.
Risch, D.
Scottish Association for Marine Science, Argyll, U.K.

Management of acoustic metadata for bioacoustics

ABSTRACT Recent expansion in the capabilities of passive acoustic monitoring of sound-producing animals is providing expansive data sets in many locations. These long-term data sets will allow the investigation of questions related to the ecology of sound-producing animals on time scales ranging from diel and seasonal to inter-annual and decadal. Analyses of these data often span multiple analysts from various research groups over several years of

effort, and as a consequence have begun to generate large amounts of scattered acoustic metadata. It has therefore become imperative to standardize the types of metadata being generated. A critical aspect of being able to learn from such large varied acoustic data sets is providing consistent and transparent access. This is juxtaposed with the need to include new information for specific research questions that evolve over time. Hence, a method is proposed for organizing acoustic metadata that addresses many of the problems associated with the retention of metadata from large passive acoustic data sets. A structure was developed for organizing acoustic metadata in a standardized manner along with a mechanism that implements the data representation into a client-server oriented database. The implementation was extended to access Internet available data products, permitting access to a variety of environmental information (e.g. sea surface temperature, ephemeris, etc.) from a wide range of sources as if they were part of the data service. This metadata service is in use at several institutions and is used track and analyze millions of acoustic detections.

TUESDAY | Sept 8th 11.20 – 11.40

Rodriguez, Rafael
University of Wisconsin-Milwaukee, U.S.A.

Environmentally-induced runaways: vibrational communication in Enchenopa treehoppers *(Hemiptera Membracidae)*

ABSTRACT Insects that communicate with substrate-borne vibrational signals lead rich and complex lives. Juveniles and adults cooperate and compete using varied signal repertoires, and their interactions unfold on complex settings, such as social groupings on their host plants. Here I summarize work by my research group on variation in mating signals and mate preferences arising from insect social and host plant environments. Our study animals, Enchenopa treehoppers, are plant-feeding vibrational insects wherein species evolve as novel host plants are colonized and signals and preferences diverge. We use treehopper and plant genotypes as treatments to assess the variation that they induce in treehopper behavioral phenotypes. This "black box" approach captures features that vary genetically among social groupings or host plants, providing great analytical power. We find that social groupings and host plants generate varied feedback loops between signals and preferences as causes and targets of selection. For example, experience of signaling modifies female mate preferences, which is expected to influence variation in signals and in turn alter females' experience of signaling, and so on. Some feedback loops are stabilizing and maintain variation. Others may lead to runaways. For example, we find strong signal-preference phenotypic covariance among treehoppers that develop on different host plants genotypes (and in different social groupings on different plants). Thus, conditions that are common in nature (variation in social and other biotic aspects of the environment) may often generate divergent sexual selection and promote speciation.

TUESDAY | Sept 8th 11.00 – 11.20

Sarria-S, Fabio A.
Jonsson, T.
Montealegre-Z., F.
University of Lincoln, U.K.

Non-invasive measurement of travelling waves in the inner ear of Neotropical bushcrickets

ABSTRACT In mammals, frequency analysis of acoustic signals is possible due to the mechanical anisotropy of the basilar membrane (BM) in the cochlea. Travelling waves (TW), propagating inside the cochlea fluid-filled cavity, generate amplitude maxima responses at frequency-specific locations along the BM, providing a spatial map of sound frequencies. Physiological and biophysical properties of TWs in the mammalian cochlea remain elusive, yet are vital to understand tonotopy and active amplification. In fact, a valid question is whether TW actually exist in the mammalian inner ear. Frequency analysis has also been observed in the hearing system of acoustically communicating insects through non-contact mechanical measurements using Laser Doppler Vibrometry (LDV). For instance, in locusts, frequency analysis is directly achieved in the tympanal membrane, while in bushcrickets, it is achieved through a more complex

WORKSHOP

THURSDAY | Sept 10th 15.30 – 17.30 (parallel session)

WORKSHOP: ANALYSIS OF ANIMAL ACOUSTIC SIGNALS IN R

This workshop is intended for students and researchers interested in analyzing the structure of animal acoustic signals. The workshop will focus on functions from the R package warbleR. This package is designed to streamline bioacoustic analysis, providing users with a workflow that facilitates automated spectrographic visualization and acoustic parameter measurements.

The functions in warbleR allow users to download recordings from the Xeno-Canto online repository, create maps of recording locations, automatically (or manually) detect signals, print spectrograms of full recordings or individual signals, and perform acoustic measurements. In addition we will review workflow procedures for quantitative (acoustic parameters) and qualitative analyses (visual classification).

Basic familiarity with the R environment is recommended. Participants are expected to bring their computers and install R and Rstudio in advance. R codes and sample sound files for running the analyses will be provided. The workshop will focus on bird vocalizations, but the methods and procedures are also applicable to signals from other taxa.

process, using a cochlea-like sensory transduction organ constituted by the crista acustica (CA) and the associated auditory vesicle (AV). TWs have been observed in the CA-AV of two bushcricket species using different in vivo experimental methods and LDV. One is invasive as it requires the rupturing of the dorsal cuticle protecting the hearing organ for CA's surface scans. The other one takes advantage of the transparency of the cuticle of some species, allowing access to the CA-AV structure in a non-invasive manner. This study focuses on the diversity of TW in the ears of different tropical species accessing the CA-AV in a non-invasive approach. Using LDV and a range of pure tones stimulation, we measured and compared the biophysical principles of TWs in living and intact specimens. Demonstrating the variability of travelling waves in the ears of different species as a response to sound frequency and distance. Finally, Bushcrickets' TWs and tonotopy response, suggest an alternative experimental model to study processes otherwise impossible to visualise in the mammalian cochlea.

THURSDAY | Sept 10th 14.30 – 14.50

Rowe, Karen
Adams, A. L.
Museum Victoria, Melbourne, Australia

Automated recognition software improves detectability for a range of bird species' vocalizations

ABSTRACT Effective conservation and management planning requires accurate assessment of species' presences across their distribution, but traditional survey methods can be prohibitively costly. Automated recording devices (ARDs) are increasingly used in place of observational techniques to survey avian communities within a region. Emerging automated pattern recognition technology has seen the development of software where users can generate species-specific recognizers theoretically capable of autonomously scanning the large volumes of collected audio recordings to detect vocalizations of a target species. We investigated the use of the Song Scope (Wildlife Acoustics, Maynard, MA, USA) bioacoustics monitoring software as a survey tool for generating

species-specific recognizers to autonomously scan audio files collected by ARDs, and evaluated their ability to correctly detect a range of species with varying vocalization types when compared to listening and visually scanning spectrograms. Although recognizers varied among species in their ability to correctly discern vocalizations of our target species and were generally associated with large false positive rates, we found that recognizers, particularly second pass recognizers which incorporated known vocalizations identified in the field recordings by the first pass recognizer, detected more species in more surveys and sites with consistently higher detection probabilities than listening and visually scanning spectrograms. Our results highlight the potential of using ARDs coupled with automated species recognizers as an effective survey method for a range of species' vocalization types. The ability to autonomously detect species has significant implications for informing conservation decisions and management protocols, and we suggest ways to improve the efficacy of self-generated automated recognizers for a range of users.

THURSDAY | Sept 10th 11.20 – 11.40

Salinas-Melgoza, Alejandro
Centro Tlaxcala de Biologia de La Conducta, México
Renton, K.
Estacion de Biologia Chamela IB-UNAM, México

The military macaw maintains homogeneity of a contact call across populations over a modified landscape in western Mexico

ABSTRACT Anthropogenic land-use change may create barriers that restrict the movement of individuals among populations, thereby disrupting population processes that would geographically homogenize culturally transmitted acoustic signals. This may lead to divergence in vocalizations, potentially creating behavioral barriers, and may be more severe for threatened species with reduced populations. However, few studies have evaluated the impact of habitat modification on geographic variation in acoustic signals of large-bodied, wide-ranging species. We evaluated two models for geographic variation in a contact call of the threatened Military Macaw (Ara militaris), among three populations in a modified landscape along the coast of Jalisco, Mexico. Under the vicariance and drift model we predicted a discrete pattern of divergence in calls between populations suggesting that habitat modification restricts movements of macaws, whereas in the isolation by distance model we predicted a gradual clinal pattern of similarity in calls, indicating no influence of habitat modification. We evaluated call features among sites and with distance by comparison of specific parameter measures using Principal Components Analysis with ANOVA, and similarity values obtained with spectrogram cross-correlations and Mantel tests. Acoustic parameter analysis found a significant difference in one principal component between the two furthest sites, while the spectrogram similarity analysis showed an association of calls with site, and decreased similarity in calls with distance. This demonstrates a clinal differentiation of acoustic signals with distance, supporting the Isolation by Distance model. Our results suggest that large-bodied non-oscines, such as the Military Macaw, may be able to maintain homogeneity of culturally transmitted traits in modified landscapes through population processes of dispersal and cultural diffusion. Therefore species-specific dispersal capabilities may drive the likelihood that habitat modification leads to call divergence in species with vocal learning capabilities.

FRIDAY | Sept 11th 17.00 – 17.15

Salvin, Pauline
Leboucher, G.
Amy, M.
Université Paris Ouest Nanterre La Defense, France

Functions of female signals: the copulation solicitation and the mate sampling aid hypotheses in the domestic canary

ABSTRACT Since Darwin, studies on the sexual selection theory mainly focused on male secondary sexual characters. For instance, studies on animal communication in songbirds have mainly focused on male song. Yet, female vocalizations in songbirds are growing in interest among behavioural and

evolutionary biologists because these vocalizations can reveal the female's preferences for male traits and may affect male display. Two studies were designed to test whether female domestic canaries (Serinus canaria) can signal their preferences and whether these different signals can incite males to display. In a first experiment, female canaries were daily exposed to three types of song performance, differing in the repetition rate of sexy syllables. This experiment revealed that females are engaged in multimodal communication during sexual interaction. Female used Female-Specific Trills as well as Copulation Solicitation Display to indicate their readiness to copulate. These results support the copulation solicitation hypothesis for the Female-Specific Trills. In a second experiment, still in progress, male canaries were daily exposed to visual and acoustic female canary signals: two different female calls (a simple call and a Female-Specific Trill) and a female in Copulation Solicitation Display (or not). The results will be discussed in light of the sexual selection framework.

MONDAY | Sept 7th 12.00 – 12.20

Scharff, Constanze
Free University Berlin, Germany

Molecular toolkits for control of vocal production

ABSTRACT Spoken language and birdsong share a number of striking parallels. Comparing the biologically tractable cognitive abilities necessary for language and for birdsong is a fruitful endeavor to identify, which properties are shared and which are unique to each. I will review evidence for the relevance of the FoxP2 gene and its associated molecular network for speech and its role in modulating variability in the songbird basal ganglia circuit relevant for the acquisition and production of birdsong. However, I will argue that the similarities between human language and songbirds are not limited to sensorimotor processes – but may extend to other structural and functional properties. Many questions regarding the similarities between spoken language and birdsong remain unanswered, but increasing evidence suggests that human and non-human communication systems may rely on conserved molecular toolkits that act as genetic modules. These may specify the neural circuits subserving these particular behaviors, and organize their function. Elucidating these genetic modules in different animal models may inform the evolution of language and other complex traits.

TUESDAY | Sept 8th 11.40 – 12.00

Schmidt, Arne K. D.
Römer, H.
University Graz, Austria

No evidence of acoustic signal divergence in a tropical cricket assemblage

ABSTRACT Efficient acoustic communication in multispecies assemblages will strongly depend on the degree of signal overlap. Masking interference and signal confusion of similarly structured signals can affect detection, recognition and localization, and thus might impose fitness costs. Therefore, it is widely believed that masking interference should drive signal divergence to reduce overlap in signal space and to promote intraspecific communication. In this study we examined the role of acoustic competition in a tropical cricket community and asked whether call structures of species that co-signal at the same time and place are more dissimilar than species that are spatially and/or temporally separated. Moreover, we examined whether species with higher spectral overlap of their calling songs show higher dissimilarity in their temporal call structures than those species that have low levels of spectral overlap. We used non-metric multidimensional scaling (NMDS) and pairwise comparison of acoustic similarity/dissimilarity and found no significant difference in acoustic signals for species pairs co-signaling or showing higher spectral overlap compared to species that were spatially/temporally segregated or had low levels of spectral overlap, respectively. Therefore, for the acoustic cricket community investigated here we found no evidence for the hypothesis that masking interference is a significant driver of signal divergence. Alternatively, we suggest that a suite of sensory/neuronal mechanisms, such as narrow filtering, spatial release from masking, or gain control processes play a more important role to ensure reliable communication under noise.

TUESDAY | Sept 8th 10.00 – 10.20

Schöneich, Stefan
Hedwig, B.
University of Cambridge, U.K.

Neurobiology of acoustic communication: Neural networks for singing and song pattern recognition in crickets

ABSTRACT From human language to birdsong and the chirps of insects, acoustic communication is the information transfer by sound signals. Male crickets use species-specific calling songs to attract conspecific females. They produce the genetically determined sound pulse pattern by rhythmic movements of their forewings. By intracellular recordings in the CNS of singing males I identified key neurons of the central pattern generator (CPG) that drives the motor pattern for sound production. The CPG is located in the anterior abdominal neuromers and comprises interneurons showing mutual inhibition and postinhibitory rebound (PIR). Recordings in females revealed a small network of auditory brain neurons that recognizes the species-specific sound pulse pattern and exhibits properties fundamental to a feature detection based on delay-line and coincidence-detection mechanism. An internal delay that matches the pulse period of the male calling song is provided by a non-spiking neuron. Upon acoustic stimulation it receives transient inhibition that triggers PIR. Direct and delayed excitations converge in a coincidence detector neuron, which responds best to the pulse pattern of the male song. The pattern selective output of the feature detector circuit closely matches the tuning of the female's phonotactic behavior. For effective communication the sender and the receiver need to be attuned to the same signal and the generation and recognition of the song pattern are genetically coupled in crickets. Modifications of the membrane conductance that set the time constants of the PIR are likely to adjust the phonotactic selectivity in species that use different pulse rates. Delayed excitation by PIR is not only crucial for song pattern recognition but also essential in the singing pattern generating network. Therefore, coupling at the level of membrane proteins that are controlled by the same genes seems to ensure concomitant changes of time constants in the networks for signal generation and recognition during speciation.

WEDNESDAY | Sept 9th 10.40 – 11.00

Slocombe, Katie E.
University of York, U.K.

Flexibility in chimpanzee vocal communication

ABSTRACT Non-human primate receivers have demonstrated considerable flexibility to learn associations between vocalisations and events and to integrate contextual information and existing knowledge with information extracted from vocalisations to respond to conspecific calls in an adaptive manner. In contrast, it has often been assumed there is little complexity or flexibility in the production of non-human primate vocalisations. Recent findings in chimpanzees are, however, beginning to challenge this assumption. Firstly, field experiments presenting wild chimpanzees with model snakes have shown that some of their alarm calls are selectively produced, directed at others and goal directed, rather than simply emotional responses to the stimulus. These alarm calls meet the same criteria previously used to identify first order intentionality in child and ape gesture production. Secondly, whilst chimpanzees, like other non-human primates, cannot generate new vocalisations, a recent study has shown that there is some flexibility for chimpanzees to alter the structure of their referential food calls to match those of close social partners, independently of their preference for the food. Together, these studies indicate that chimpanzees have more control and flexibility over both the structure and usage of their calls than previously assumed.

TUESDAY | Sept 8th 14.50 – 15.10

Stowell, Dan
Queen Mary University, London, U.K.

Classifying multiple bird species in crowdsourced smartphone audio

ABSTRACT Given an amateur sound recording from a smartphone app, it is challenging to automatically recognise the set of bird species that are active in the recording. I describe our method for multilabel classification of bird sounds, which was validated through the BirdCLEF challenge on 500 and 1000 tropical bird species, and then deployed as a popular smartphone app for UK birds. I discuss unsupervised feature learning and classifier configuration, and also illustrate some unexpected aspects of the „soundscapes“ captured on mobile phones.

FRIDAY | Sept 11th 15.10 – 15.30

ten Cate, Carel
Spierings, M.
Leiden University, The Netherlands

Linguistic rule learning in birds

ABSTRACT The ability to abstract a grammar rule that underlies strings of seemingly meaningless sounds is an important aspect of language processing. Rule abstraction allows infants to learn about regularities in their native language and to generalize these regularities to novel input. This ability is a core mechanism underlying the language faculty. But is it specific to humans and language learning? Birds provide interesting models to address this question. Like spoken language, songs of songbirds are characterized by rapidly produced, structured sequences of more or less stereotyped elements ('notes'). Birds might therefore also show some ability to abstract structural rules underlying strings of sounds. We present an artificial grammar learning (AGL) experiment examining the rule learning abilities of a songbird, the zebra finch, and a parrot species, the budgerigar. In particular we focus on these species' abilities to distinguish XYX from XXY strings (X and Y denoting different vocal elements), an ability demonstrated in human infants (with X and Y being speech syllables). Subjects were trained to discriminate between strings of sounds with either an XYX or an XXY grammar. After this discrimination was acquired, each subject received a number of test strings (intermixed with the training sounds) that followed the same grammar rules, but consisted of either elements not heard before, or new combinations of familiar elements. The responses of the zebra finches showed that they seem to discriminate the strings by attending to the ordinal positions of elements within the strings. However, the budgerigars generalized their discrimination to strings consisting of new sounds, thus revealing evidence of having formed an abstract representation of the grammar underlying the training strings. This implicates that although the ability to abstract and generalize structural rules is not readily found in the animal kingdom, there are species that share this mechanism with humans.

THURSDAY | Sept 10th 11.40 – 12.00

ter Maat, Andries
Poot, H.
Gahr, M.
Max Planck Institute for Ornithology, Seewiesen, Germany

Vocal learning in social groups of zebra finches

ABSTRACT Male zebra finches sing repetitions of unique song motifs that consist of 3 to 14 syllables, which are learned by imitation of adult tutors during a sensitive phase in early life. Experiments with single tutors or tape relays result in almost perfect copies of the tutor song. Therefore, it was assumed that juveniles learn the song of their fathers rather than that of others. However, wild zebra finches live and breed in large flocks with many potential song tutors. In our experiment we explored possible alternative scenarios where the social environment consisted of more than one possible tutor. We kept 10 zebra finch pairs in each of 4 aviaries and recorded the song of all adult males and of the subsequently generated male offspring. The juvenile males imitated song syllables rather than complete song motifs and the syllables were a mixture of exact copies, imitations, variations, elements and new developed syllables. Preferred tutors were not necessarily social or genetic fathers or dominant males. Tutor choice cannot be ascribed to one favoured tutor type, but seems to be a composition of convenient song parts of different tutors.

TUESDAY | Sept 8th 17.45 – 18.00

Thiebault, Andréa
Tremblay, Y.
Mullers, R.
Pistorius, P.
Nelson Mandela Metropolitan University, South Africa

Honking in traffic: use of calls in a foraging seabird

ABSTRACT Seabirds are known to be very noisy at their breeding colonies, when aggregated in high densities on land. Calls are used for individual recognition between partners and between parents and offspring. But when at sea, do seabirds communicate and for what reasons? We deployed 35 Cape gannets (Morus capensis) with GPS devices and video-cameras with microphones during the breeding season of 2010-2011 at Bird Island (Algoa Bay, South Africa) to study their foraging behaviour at sea. Group formation and size of aggregations were derived from the camera footage. During ~42h of video recordings, 89 gannet calls were recorded at sea. These were only made when conspecifics were observed in the surroundings of the equipped birds, and most of them when foraging in large groups (65 calls during 11 group events). Some of the calls in flight (9 out of 29) were concomitant with jerky camera movements, suggesting their use to avoid collisions with surrounding birds. In addition, 25 dives were directly preceded with one or two calls. We will discuss the use of calls in foraging Cape gannets.

FRIDAY | Sept 11th 16.45 – 17.00

Vernes, Sonja C.
Max Planck Institute for Psycholinguistics, Nijmegen, The Netherlands; Donders Centre for Cognitive Neuroimaging, The Netherlands
Rodenas-Cuadrado, P.*
Chen, X.S.*
Max Planck Institute for Psycholinguistics, Nijmegen, The Netherlands
Wiegrebe, L.
Ludwig Maximilians University, Munich, Germany
Firzlaff, U.
TU Munich, Germany

*These authors contributed equally to this work

A novel approach reveals first molecular networks in the bat brain: implications for vocal communication

ABSTRACT Bats are able to employ an astonishingly complex vocal repertoire for navigating their environment and conveying social information. A handful of species also show evidence for vocal learning, an extremely rare ability shared only with humans and few other animals. However, despite their obvious potential for the study of vocal communication, bats remain severely understudied at a molecular level. To address this fundamental gap we performed the first transcriptome profiling and genetic interrogation of molecular networks in the brain of a highly vocal bat species, P. discolor. To identify functional, biologically relevant gene networks, we utilized two contrasting co-expression network analysis methods with distinct underlying algorithms; WGCNA and MCLUST. These methods typically need large sample sizes for correct clustering, which can be prohibitive where samples are limited, such as in this study. To overcome this, we built on the WGCNA and MCLUST methods to develop a novel approach for identifying robust co-expression gene networks using few samples (≤6). Using this approach, we were able to generate tissue-specific functional gene networks from the bat PAG, a brain region fundamental for mammalian vocalization. The most highly connected of the networks identified in our study represented a cluster of genes involved in glutamatergic synaptic transmission. Glutamatergic signaling plays an essential role in vocalizations elicited from the PAG, suggesting that the gene network uncovered here is mechanistically important for vocal-motor control in mammals. These findings show that our innovative gene clustering approach can reveal robust biologically relevant gene co-expression networks with limited sample sizes. Moreover, this work reports the first gene network analysis performed in a bat brain and establishes P. discolor as a novel, tractable model system for understanding the genetics of vocal communication.

FRIDAY | Sept 11th 11.40 – 12.00

Vignal, Clementine
Boucaud, I.C.A.
Mariette, M. M.
Université Jean Monnet, Saint-Etienne, France

Vocal negotiation over parental care? Partners adjust their time spent incubating based on their acoustic exchanges at the nest

ABSTRACT Bi-parental care in birds occurs throughout an individual's adjustment of its workload to that of its partner. Communication within a pair might be crucial to achieve this adjustment. Zebra finches, Taeniopygia guttata, form life-long monogamous pair bonds, in which partners are highly coordinated and both incubate eggs. When relieving each other during incubation, partners perform a structured call duet at the nest. If this duet functions to coordinate incubation workload, disrupting the pair's usual nest-relief pattern by delaying the male's return to the nest should affect the structure of the duet. Using domesticated birds breeding in a large aviary, we found that delaying the male's return induced shorter duets with higher call rate. In addition, we tracked individuals' location with a transponder at the nest and the feeder, and showed that these accelerated duets were associated with increased haste of the partners to take turns incubating and foraging. Females also spent less time incubating during their subsequent shift, and females´ time off-nest was best predicted by their mates' calling behaviour in the previous duet. Taken together, these results suggest that duets may function as 'vocal negotiation' over parental care.

THURSDAY | Sept 10th 13.50 – 14.10

Wadewitz, Philip
Hammerschmidt, K.
Fischer, J.
German Primate Center, Göttingen, Germany

Advances in the quantitative analysis of graded vocal repertoires

ABSTRACT To identify the selective factors that shape the structure of a species' acoustic communication system, comparative analyzes between species are of crucial importance. A major challenge in this endeavor is to standardize analytical procedures to make different vocal repertoires comparable. Here we compare the vocal repertoire of chacma baboons (Papio ursinus) with the vocal repertoire of Barbary macaques (Macaca sylvanus). The two subsamples were selected from recordings that were taken from wild chacma baboons in the Okawango Delta, Botswana und from semi-wild Barbary macaques that live in an outdoor enclosure at Rocamadour, France. Both datasets were adjusted to similar sample size, age and sex composition. 38 acoustic features that describe the calls in terms of frequency and time dynamics were extracted from spectrograms. To quantify the graded structure of the datasets, fuzzy c-means clustering was applied. The results reveal a significant higher level of gradation in the Barbary macaque repertoire. However, even the chacma baboon repertoire which was formerly described as being rather discrete is showing an array of intermediate call structures between typical call types. Another finding is that the level of gradation differs not only between but also within the repertoires and some call types show more distinct boundaries than others. A big challenge that still remains unsolved is the determination on how many call types can be found for a given species. For graded systems, there does not necessarily have to be an optimal solution and subsequent analyzes should be understood as one possible solution amongst others. To describe and understand a repertoire in detail, different cluster solutions should be evaluated and compared.

FRIDAY | Sept 11th 16.00 – 16.15

Wojas, Lucyna
Osiejuk, T.S.
Adam Mickiewicz University, Warszawa, Poland

Social eavesdropping on acoustic cues in non-learning model bird species

ABSTRACT The social eavesdroppers are individuals that gather the information about the observed opponents based on interactions between them.

This behavior helps to adjust the defensive strategy to rival's capabilities and minimizes the costs of territory defense. In this study we've tested if corncrake males eavesdrop on vocal interactions taking place close to the boundaries of their territories. Corncrake (Crex crex) is a nocturnal species inhabiting wet meadows with dense vegetation. Males are territorial and the effective communication between conspecifics is limited to the acoustic channel. Corncrake's territorial call is loud (ca. 95 dB SPL at 1m) and reaches many conspecifics simultaneously. The rhythm of calling is a conventional signal of males' aggressive motivation and call characteristics are used by males for individual discrimination. All the mentioned features make corncrake an ideal model for studying the communication networks. To test our hypothesis we use two-stage experiment: (1) a simulated vocal fight played back with a set of four speakers, imitating the call exchange, approach, and a physical fight; (2) a simulated intrusion of either winner or loser of earlier interaction into the territory of the focal individual. In addition, we perform a control experiment where in the first stage there were not clear winner and loser. In each experiment (n=58), male's response was recorded by a microphone array. Males response differ both in behaviour and vocal reaction. Males respond stronger to the intrusion of aggressive individual than to the submissive and to the control. Corncrakes treated with control experiment increase their rhythm. Our results help to understand the relationships between territorial males of the non-learning rail species relying solely on vocal communication, and suggest that corncrake males eavesdrop on interaction taking place close to the boundaries of their territories. ■

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Poster number in left upper corner of abstract

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Adreani, M. Nicolás
D´Amelio
P., Gill, L.
Gahr, M., ter Maat, A.
Max Planck Institute for Ornithology, Seewiesen, Germany

Telemetric audio radio-transmitters: a powerful device for studies in vocal communication between group-interacting small animal

ABSTRACT One of the major challenges in the study of vocal communication is to record every acoustic signal that is performed by freely-behaving animals involved in a given interaction. So far, the most widely-used devices have been the classic dynamic or condenser microphones. However, except in few cases, these devices are generally insufficient to study individuals in a group because of the impossibility of identifying the signals of every sender. In recent years, data loggers and telemetric devices have increased their popularity and their development has improved surprisingly fast. Work on cetaceans (Deecke et. al., 2013) and big mammals (Lynch et. al., 2013) have shown the relevance of using such approaches. However, when it comes to studies in small animals such as songbirds, amphibians or small mammals, the main limiting factors of these devices are: portability, battery life, storage and synchronicity. In this work we present a wireless microphone transmitter of 0.6 grams (battery included), with a battery life of 14 days that allows for avoiding frequent handling of the animals and a recording distance of up to 15 meters. We show that it takes only 4 days for the birds to regain their normal movement and vocalizing behavior, after the transmitter is placed on the animal, and that they are able to perform normal behaviors while carrying the transmitters. Furthermore, we present data demonstrating the synchronicity between 8 transmitters recorded at the same time. Finally, we show some examples on the application and advantages of this device in the study of vocal communication in small animals. The performance of our device and its characteristics make it a great tool for studies in vocal communication between group-interacting small animals.

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Amaya, Juan P.
CRILAR (Centro Regional de Investigaciones Científicas y Técnicas de La Rioja), Argentina
Areta, J.I.
(IBIGEO-CONICET)
Basso, G.
Farina, A.
Universidad Nacional de La Plata, Argentina

Development of vocalizations in a fossorial rodent *(Ctenomys sp.)*

ABSTRACT Ctenomys are highly vocal subterranean rodents endemic to South America. Acoustic communication is an integral part of their behavior and they exhibit a remarkable vocal repertoire of airborne signals. The S-type vocalizations are territorial and/or warning long-range signals conformed by two parts: Part 1 consists on a variable number of series of two, three or four notes and Part 2 is a train of individuals notes. We analyzed the development of S-type vocalizations of one female and one male litter of Ctenomys sp. from La Rioja, Argentina. Litters were captured in the field and sound recorded in our laboratory during the next 5 months beginning one week after capture. We recorded 65 vocalizations from the male (initial/final weight 70/135g) and 15 vocalizations from the female (initial/final weight 30/120g). Peak frequency values decreased in both individuals through time approaching the adult values: in the male from 222±28.8 Hz [range 183-269] to 175±31.5 Hz [129-247] (n=3 in each case), and in the female

from 519±209 Hz [323-904] to 318±5.6 Hz [312-323] (n=3 in each case). Peak frequency in adult males (weight 240 g) is 181±8.4 Hz [161-193] (n=3), while we lack certain data on female vocalizations (weight 160 g). Litters gave only Part 1 which also had fewer series than in adults (maximum number of registered series were 6 in litter female, 17 in litter male and 98 adult males) and with longer silences between successive series than in adults (in litter male silences between series durations was 7.4±6.2 sec [1.9-27.5], in litter female 4.4±0.2 sec [1.6-11.4] in while in adults male was 0.7±0.1 sec [0.4-1.1]. This study is the beginning to understand the S-type vocalizations developed in this specie and allowed to observe how the peak frequency values of these two litters change during part of the period of growth.

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Anichini, Mariana
Lehmann, G.
Humboldt-Universität zu Berlin, Germany

Singing plasticity and signaling strategies in the bushcricket *Poecilimon ampliatus (Orthoptera: Tettigoniidae)*

ABSTRACT Males of several acoustically communicating insect species use these signals to attract a conspecific partner for mating. Song in most cases seems to be honest signals and song traits seems to be under sexual selection. In previous studies on the unidirectional communicating bushcricket species Poecilimon zimmeri (Tettigoniidae: Phaneropterinae), females prefer the heavier of two competing males (Lehmann & Lehmann 2008), which transfer the bigger nuptial gift during mating (Lehmann & Lehmann 2009). Using the congeneric bushcricket species Poecilimon ampliatus as a model, we investigated condition dependent song characters. Heavier males produce songs with higher duty cycles (number of syllables produced per time unit) and obviously signal their condition with the song. When placed in male-male competition trials, males speed up song production. However, matching males with a significant weight difference (heavy and light individuals) showed that heavier males outcompete their rivals in song characters. This song contest with heavier males as the winner was more severe the closer the distance between the competing singers was. Song competition seems to be strong in this species and should have consequences for the signalling strategy in the natural chorus, where more than two competitors sing simultaneously.

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Araya-Salas, Marcelo
Medina-Garcia, A.
Wright, T.
New Mexico State University, U.S.A

Does vocal learning accelerate acoustic diversification? Evolution of contact calls in Neotropical parrots

ABSTRACT Learning has been traditionally though to accelerate the evolutionary change of behavioral traits. We evaluated the evolutionary rate of learned vocalizations and the interplay of morphology and ecology in the evolution of these signals. We examined contact calls of 51 species of Neotropical parrots from the tribe Arini. Parrots are ideal subjects due to their wide range of body sizes and habitats, and their open-ended vocal learning that allows them to modify their calls throughout life. We estimated the evolutionary rate of acoustic parameters of parrot contact calls and directly compared them to those of morphological traits and habitat. We also evaluated the effect of body mass, bill length, vegetation density, and species interactions on acoustic parameters of contact calls while controlling for phylogeny. Evolutionary rates of acoustic parameters did not differ from those of our predictor variables except for spectral entropy, which had a significantly slower rate of evolution. We found support for correlated evolution of call duration, and fundamental and peak frequencies with body mass; and of fundamental frequency with bill length. The degree of sympatry between species did not have a significant effect on acoustic parameters. We demonstrate that parrot contact calls, which are learned acoustic signals, show similar evolutionary rates to morphological traits. This is the first study to our knowledge to provide evidence that change through cultural evolution does not necessarily accelerate the evolutionary rate of traits acquired through life-long vocal learning.

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Attia, Joel
Université Jean Monnet, St. Etienne, France

Acoustic playbacks elicit more responses in dim light than in daylight conditions in the cichlid fish Metriaclima zebra

ABSTRACT The Malawian cichlid fish Metriaclima zebra emits sounds. These sounds are produced in the same time as body quivers, behaviours that occur during aggressive interactions. Aggressive interactions notably occur during the territory defence. Playback experiments at Laboratory have put in evidence the attenuator role of the sounds on the aggressiveness. These results were obtained under daylight conditions, when visual perception is optimal. Nevertheless, aggressive interactions can occur during dawn, dusk, or night. Do low light conditions, disturbing the visual perception, modify the attenuator role of sounds on aggressiveness and/or the sound production? To answer to these questions, we have investigated the impact of acoustic playbacks on the aggressive behaviour of adult males defending their territory in very low light conditions ("dim light", 3.2 lx) and under daylight conditions ("daylight", 165.0 lx) for comparison. We also recorded the sounds emitted by the fish during the aggressive interactions under these two lighting conditions. We found that sound production is significantly higher in „dim light" than in „daylight" conditions. The acoustic playbacks make decreasing the aggressiveness of the receptor fish both in „dim light" and „daylight" conditions. But the decrease of aggressiveness is four times higher in „dim light" than in „daylight" conditions, for the same amount of sounds sent. Metriaclima zebra seems to react more to sounds when visual perception is disturbed. These results suggest that the environmental constraints can impact the multimodal communication of Metriaclima zebra.

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Aumann, Herbert
University of Maine, U.S.A.

The RF microphone: A new way of monitoring honey bee sounds

ABSTRACT A radio frequency (RF) microphone has been developed as a new tool for studying incidental and deliberate insect sounds. It was specifically designed to record the sounds produced by honey bees inside and outside a beehive without disturbing the bee colony. Acoustic methods of recording bee sounds are well known. However, acoustic microphones must be inserted into the bee hive. They have very little directionality and the measurements are corrupted by environmental noise.Optical sensors have also been used to study bee vibrations, but they require very precise pointing and visual access to the normally dark beehive interior. The RF microphone is based on an adaptation of a Doppler radar to measure vibrations of a dielectric object. It is not sensitive to airborne pressure waves. If the vibrational amplitude of the object is much less that the radar wavelength, the frequency of the mechanical vibration and the frequency of the phase modulated radar reflection are the same. The RF microphone derives its narrow beamwidth from the high directivity of the radar antenna. By operating in the unlicensed 5.8 GHz Industrial, Scientific and Medial (ISM) radio frequency band, the instrument can be implemented safely and inexpensively with readily available wireless RF components. The output of the RF microphone is an audio signal no different from the audio signal that might be recorded with a microphone on a laptop computer. As such the same data collection and processing techniques can be applied. Airborne sounds and vibrations produced by honey bees inside and outside an observation beehive are compared. The radar based RF microphone is shown to penetrate the opaque beehive wall and measure vibrations which are otherwise inaudible.

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Baier, Leonie
Ludwig Maximilians University Munich, Max Planck Institute for Ornithology Seewiesen, Germany
Goerlitz, H.
Max Planck Institute for Ornithology Seewiesen, Germany
Wiegrebe, L.
Ludwig Maximilians University Munich, Germany

Breaking the waves: spatial frequency in bat biosonar

ABSTRACT The concept of spatial frequency was instrumental in understanding how visual peripheral representations of objects are processed by the brain. In echolocation there is no direct correlation between an echo's acoustic features and the spatial layout of the environment. Bats must use the spectro-temporal and binaural echo cues to create an internal representation of their surroundings. We hypothesised that despite the fundamentally different peripheral representations of spatial frequency in vision and echolocation, both systems utilise the concept of spatial frequency to segregate objects from their surroundings. Here we quantified perceptual sensitivity to spatial frequency in a formal psychophysical detection experiment. Six bats of the species Phyllostomus discolor were trained to discriminate 3D-objects exhibiting wave patterns with spatial frequencies in the range of 4.4/m to 17.8/m from a reference object with a smooth surface. Our results show that wave amplitudes required for detection decrease with increasing spatial frequency, i.e. animals were much more sensitive to higher spatial frequencies than to lower frequencies. We argue that this perceptual high-pass filter is directly comparable to a visual or optical spatial high-pass filter that allows extracting the contours of objects in a complex scene. Ecologically, this is directly relevant to prey detection on water, as prey-induced disruptions in spatial frequency patterns of natural water surfaces may become more detectable. Consequently, the formal detection experiment is currently complemented with a field experiment using water specialists, Daubenton's bats. If our expectations hold to be true, this would identify spatial frequency as a cue for prey detection on agitated water surfaces and provide first insights into how a biosonar system solves this challenging task despite its lack of an explicit spatially arranged sensor array.

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Bakhturina, Daria
Klenova, A.
Lomonosov Moscow State University, Russian Federation

The structure, context and functions of duet displays in three auk species *(Charadriiformes, Alcidae)*

ABSTRACT A number of hypotheses explain the presence of duets in behavioral repertoires of some passerine birds. But suitability of such hypotheses for non-passerine birds is still unclear. Here we compared the structure and context of duet displays (so-called billings) in three auk species. The objects, namely crested auklet (Aethia cristatella), parakeet auklet (Cyclorrhynchus psittacula) and horned puffin (Fratercula corniculata), are closely related, monogamous, colonial breeding and highly socially active seabirds. They spend on duetting from 2 to 10% of their time during social activity on the colony. In 2010-2011 and 2013 years we observed duet behaviour of the species on the natural breeding colony of Talan Island, Sea of Okhotsk. We described the situational context of duet displays and found that it differ significantly among the species (Kruskal-Wallis ANOVA, $p<0.001$). Most frequently individuals of all species performed duets due to conspecific approach (47.2, 25.7 and 19.7% of cases in crested auklet, parakeet auklet and horned puffin, respectively) or in course of interactions between the pair mates (31.1, 50.5 and 74.2% of cases, respectively). The structural variables of duets, namely total duration and partners' postures, had significant interspecific differences; the duet intensity didn't differ among species (Kruskal-Wallis ANOVA). In all species the structure of duets was affected significantly by the number of conspecifics in the nearest environment (Spearman rank), but not affected by the situation that caused duet (Kruskal-Wallis ANOVA). Crested auklet's duets were the most attractive for conspecifics (they caused the largest number of approaches), while duets of parakeet auklet and especially horned puffin were less attractive (0.6±0.9, 0.2±0.5 and 0.1±0.3 conspecifics' approaches during duetting, respectively). We discussed the possible functions of duet displays in auks like mate guarding, signaling about quality and commitment to the partner. The study was funded by Russian Scientific Foundation (grant 14-14-00237).

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Blum, Christian
Pika, S.
Max Planck Institute for Ornithology, Seewiesen, Germany
Böckle, M.

Danube University Krems, Austria
Bugynar, T.
University of Vienna, Austria

Vocal ontogeny in common ravens *(Corvus corax)*

ABSTRACT Language clearly distinguishes us from the rest of the animal kingdom. To investigate the evolution of this ability researchers have been focusing on complex communication systems of other animal species. Bird song represents one of the most complex systems. It is characterized by an early critical period in communicative development, vocal production learning and individual recognition. However, little is known about the complexity underlying calls, which unlike song are short, flexible vocalisations and are produced by both sexes. They occur independent of season, are strongly related to specific contexts and can function as referential signal. Concerning usage, calls may therefore be more cognitively demanding than song, equalling the complexity of referential vocalizations of some nonhuman primate species (e.g. vervet monkeys). The aim of the present study was to investigate i) emergence and extinction of specific calls, ii) order of emerging call-contexts, such as affiliative and agonistic interactions and functional reference, iii) changes in physical parameters like chaotic parts of vocalisations, frequency and duration of calls in the course of vocal ontogeny. As study subjects we chose ravens, a species of songbird, whose vocal repertoire consists entirely of calls with varying degrees of acoustic complexity, featuring context specificity and functional reference. Our data was collected from 13 individuals during their first year of life, covering the time from fledging to vocal maturity. We recorded 45 minutes per bird per week (observational focal sampling) and analysed resulting data via a clustering method. Preliminary results, such as change in number of clusters over time and order of emergence of new call-groups are discussed.

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Bolaños Sittler
Pablo R.
University del Valle de Guatemala, Guatemala

Quetzal Echoes in Mayan Temples

ABSTRACT The species Pharomachrus mocinno (Resplendent Quetzal) is a very important bird for Guatemala, since ancient times. The Mayas represented it in their art and temples, and was considered a god. In modern culture the species is also very important and it is represented in textiles and Mayan art. The quetzal is the Guatemalan national bird, it is part of the flag shield, it is a freedom symbol and it is also the name of the national currency. At the Mayan cities it is possible to listen a phenomenon caused when a person claps in front of some temples, which cause a chirp echo very similar to the call of the bird. It has been discussed if this phenomenon was caused deliberately by the Mayas, or if this was only a causality. There are a few studies about this effect at Chichen Itzá (México), to elucidate how this happens, from an acoustic point of view, and a very simple comparisons of the sounds of the echo and the bird. It has been proposed that the temples could be the first sound preservation system made by humans; it has even been suggested that this echoes could be used to attract quetzales to the temples, as a kind of "play back". The major concentration of Mayan cities are located at Guatemala, as well as the tallest temples. One of the more important cities is Tikal, which means "City of Voices", and is considered as a capital for the Mayas at their heyday. For this research I did a comparison between the echoes of the temples, and the calls of the quetzal at their habitat. The obtained results show a great resemblance between the two sound types, and will be useful to support future studies to answer other important questions regarding this effect.

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Boucaud, Ingrid
Aguirre Smith, M.
Valere, P.A.
Vignal, C.
Université Jean Monnet, St. Etienne, France

Does vocal communication at the nest during incubation signal female's hunger in great tits?

ABSTRACT Although most bird species show monogamous pair bonds and bi-parental care, little

is known on how mated birds coordinate their activities. Acoustic communication between partners at the nest is a good candidate but as seldom been considered. The great tit (Parus major) represents an interesting study system to investigate intra-pair communication at the nest, as males are known to address songs to their female while she is in the nest cavity, and females have been shown to answer their male with calls. In a first study, we recorded the vocalizations and observed the behavior of great tit pairs around the nest at different breeding stages (laying, incubation and young nestlings). We observed vocal exchanges between the female inside the nest and her male outside in three situations with different outcomes: (i) the female left the nest, (ii) the male entered the box to feed the female, (iii) mates stopped calling but did not move out/in the nest. The comparison of the acoustic structure of these three situations of vocal exchanges suggests that one possible function of this communication is for the female to signal her need for food to her mate. To test for this hypothesis, we conducted a second study in which each pair was recorded on two days during incubation: one day without food supplementation and one day with a feeder of mealworms into the nest box. We found that females called less with food supplementation. This result confirms our hypothesis that females indicate their need for food in vocal exchanges with their mates. Males' response to this information remains to be determined.

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Bowling, Daniel L.
Garcia, M.
Fitch, T.W.
University of Vienna, Austria

Acoustic allometry in mammals: a comparative study of over 60 carnivore and primate species

ABSTRACT Understanding the information communicated by animal vocalizations is one of the main focuses of bioacoustics research. Vocal allometry seeks to determine what the acoustic characteristics of an animal's vocalizations can tell us about the size of their body. Despite considerable interest, there are only several studies in the literature that compare data across species, and their methods stand to benefit from the application of more modern and precise analytical techniques. The aim of this study is to empirically examine the relationship between acoustic properties of vocalization, body size, and larynx size, across a diverse sample of carnivore and primate species (n=60+) using rigorous methods. For each species in our study we obtained vocalization recordings, average body size measurements, a laryngeal specimen, and an associated femoral length measurement. Acoustic analyses are made and the results are compared to the anatomical data. In addition to traditional approaches that correlate acoustic properties with body size, we additionally examine how the same acoustic properties correlate with laryngeal anatomy (as assessed by measurements of 3D models derived from CT-Scan images). Given that the larynx is the organ of vocal production, we predict that its properties are likely to be more directly related to the acoustics of vocalization than body size.

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Brazao Protazio, J. Marcelo
Universidade Federal do Pará, Brazil; Max Planck Institute for Ornithology, Seewiesen, Germany
Leitão, A.
ter Maat, A.
Gahr, M.
Max Planck Institute for Ornithology, Seewiesen, Germany

Mathematical-statistical methods applied to bioacoustics – a case study applied to zebra finches *(Taeniopygia guttata)*

ABSTRACT The main objective of this work is create a methodology able to model the dynamic of the song learning process of the Zebra finches (Taeniopygia guttata) from his first vocalizations until the song crystallization. For that, we use mathematical-statistical methods to generate indices based on spectral properties of the sound to describe individual characteristics of the song. With these parameters, we developed a function based on similarity indices, to model the development of the individual's song in relation to its crystallized song and in relation to its tutor song. In the study, we apply the methodology to the Zebra finches, but the procedure can be used for any other object of study.

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Brumm, Henrik
Zollinger, S. A.
Max Planck Institute for Ornithology, Seewiesen, Germany
Templeton, C.N.
University of St. Andrews, U.K.

Traffic noise drowns out great tit alarm calls

ABSTRACT In the recent years, anthropogenic noise pollution has been receiving increased interest by bioacousticians and conservationists alike. Perceptual studies with birds in the laboratory have shown that high noise levels can constrain their call detection but the fitness consequences of these impairments are only poorly understood. Here, we investigated whether traffic noise impairs the communication of free-ranging birds in a task with important fitness consequences, alarm call detection. Birds use alarm calls to communicate about the presence the threat level of predators. Therefore, failure to immediately detect an alarm call may be fatal for a bird. We studied alarm call production and perception with a combination of lab and field experiments in great tits (Parus major), a common songbird that inhabits noise-polluted environments. First, we measured noise-related call changes in the lab and field and found that birds increased the amplitude of their calls in response to increased background noise. Based on these measurements we were able to construct realistic call playback stimuli that we tested in combination with realistic traffic noise playbacks in the territories of great tits close to country roads in Bavaria, Germany. Our data demonstrate that current levels of road traffic noise mask the alarm calls of this species at a distance of 20m, leading to markedly reduced responses to alarm calls in the presence of traffic noise compared to control trials with no noise. These results show that despite the vocal adjustments used to compensate for anthropogenic noise, great tits could not restore the active space of their calls. As a consequence, birds are likely to suffer from increased predation risk in noise, which could affect both their behaviour and population dynamics in noise-polluted areas.

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Budka, Michal
Kokocinski, P.
Adam Mickiewicz University, Poznan, Poland

Duet singing behavior in common crane

ABSTRACT Singing in duet is one of the most amazing communication strategy, both from behavioral and evolutional point of view. Researchers still have tried to explain wherefore such coordinated acoustic display, uttered by two individuals, have evolved. Despite these efforts, the function, causes and ontogeny of such joint acoustic display remains unclear, since too little species have been examined to make any generalization. Here we focused on duet singing behavior in Common Crane (Grus grus) - a large-size bird species, which inhabits northern parts of Europe and Asia. We analysed recordings of 39 wild-living pairs, collected in Poland in 2014 and 2015. We measured various temporal and spectral call characteristics to examine, (1) which of them could be responsible for identity coding and (2) body size signaling. Additionally, we performed experiment with song transmission in which we tried to show how signal is degraded during sound propagation for a long distance. We found that variation observed within-individual and within-pair in song characteristics is lesser than those observed between different individuals and different pairs. Thus, in this species, theoretically, song characteristics could be used both for individuals and pair discrimination. Moreover, we found significant differences in formant frequencies between individuals which sing in duet. This may suggest that formant frequencies could be acoustical body size signal, since in Common Crane sexual dimorphism in body size is observed – males are larger than females. We also showed how signal is degraded during transmission. We found that formant frequencies, especially those lower, are distinguishable and weakly distorted even in the distance 500 m from the speaker. This finding suggest that formants could be important acoustic information carrier. We hope that our study will be the first step to the better understanding the function, causes and ontogeny of singing in duet in Common Crane. This study was supported by the Polish National Science Centre (grant number 2013/09/N/NZ8/03214).

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Cardoso, Guilherme S.
Donatelli, R.J.
São Paulo State University, Brazil

Vocal performance of *Thamnophilidae (Aves, Passeriformes)* species in different biomes of South America

ABSTRACT The vocal performance refers to the ability to execute challenging vocalizations closer to the physical constraints of the birds. This feature provides information about male quality and may interfere with female choice for mates. The trilled vocalizations are limited by a performance tradeoff between the syllable repetition (trill rate) and the range of frequencies that the syllables can scope (frequency bandwidth). Birds of Thamnophilidae family are known to have species that produce trilled vocalizations. This study sought to determine whether different species of Thamnophilidae within the same geographic distribution show similar vocal performances. We surveyed 645 songs from 31 species. We clustered the vocalizations based on the geographic distribution of the species. We obtained three groups of species: the Amazonian, the Atlantic and the Central species. The trill rate (TR) and the frequency bandwidth (FB) were calculated for each song. We applied the Spearman correlation on each group separately. Then, a vocal performance limit was established based on an upper boundary linear regression between those two variables. We calculated the performance of vocalizations using the distance from the point to the upper boundary line. We conducted a Kruskall-Wallis test with Dunn-Bonferroni post-hoc test on the groups using the vocal performance, the trill rate and the frequency bandwidth of each song to determine the relationships between the biomes. The trill rate had significant correlation with the frequency bandwidth on the Amazonian and Central species. The three groups have vocalizations with low performance, but the Amazonian and Atlantic species present a considerable number of samples in which performance is closer to the limit. The Kruskall-Wallis test showed that the groups differ the trill rate and in the frequency bandwidth. According to the post-hoc test, the Amazonian and the Atlantic groups are more similar in frequency bandwidth than the Central one.

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Chabrolles. Laura
Thibault, T.
Attia, J.
Beauchaud, M.
Université Jean-Monnet, St. Etienne, France
Amorim, C.
Fonseca, P.
MARE, ISPA-Instituto Universitário, Lisboa, Portugal

Do personality and social status influence sounds production in Metriaclima zebra

ABSTRACT Many gregarious species have a social hierarchy (1). It is the case for Metriaclima zebra, a sounds producer cichlid's fish. In this species, dominant fish have favored access to resources because of their social status. Social status is therefore a very important criteria to qualify an individual. Otherwise, individuals from a same group can show different levels of locomotor activity, attractiveness for novelty, willingness or avoidance for fights with fellow creatures (2). All of these behavioral expressions form what we call «temperament» or «personality» in animals (3). But the link between social status and temperament is not always so obvious. Moreover, even if we begin to understand the role of acoustic signals during interactions between two individuals, we do not know yet the impact of the social status and the temperament on the sounds production for Metriaclima zebra. Firstly in this study we used neophobic device to test fish personality. Then we performed dyadic interactions between fish showing different status and personality. All behaviors and sounds emitted during the fights have been recorded and analyzed. First results showed that the dominant fishes were bolder and more aggressive than the dominated fishes. But now remains the question about a correlation between the sounds production and the protagonist's status. Is there any difference in sounds production between a fight among two dominant fishes and another fight among two dominated fishes? (1) Jameson et al., 1999 (2) Gosling, 2001 (3) Réale et al., 2007

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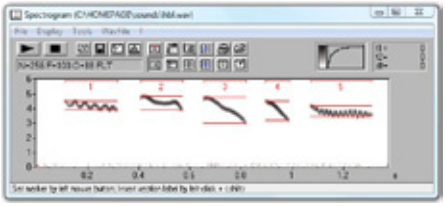

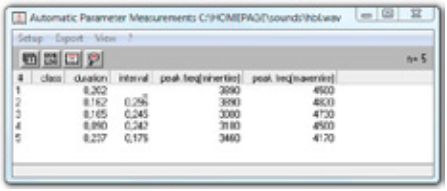

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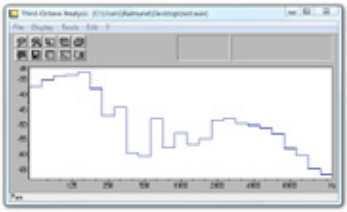

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Chivers, Benedict
Jonsson, T.
Jackson, J.
Windmill, J.
Montealegre-Z., F.
University of Lincoln, U.K.

Bilateral asymmetry in the distribution of sound pressure levels around a singing cricket

ABSTRACT Male field crickets generate mating calls to distant females through tegminal stridulation (the rubbing together of the overlying right wing which bears a file of teeth against a plectrum on the underlying left wing). Specialised areas of membrane on each wing oscillate together to produce acoustic radiation. Maximum transmission effectiveness will be facilitated by omnidirectional propagation at high intensities as the location of the females in the environment is unknown to the calling males. However, producing an omnidirectional sound field of maximum sound pressure levels may be problematic due a mechanical asymmetry found in the cricket sound generation system. Mechanical asymmetry occurs by the right wing coming to partially cover the left wing (and the left wing membranes) during the closing stroke, the effective stage of sound production. As such it is hypothesised that the sound field on the left-wing side of the animal will contain lower sound pressure components than on the right-wing side as a result of this coverage. This hypothesis was tested using a novel method to accurately record a high resolution, three dimensional mapping of sound pressure levels around restrained field crickets in which stridulation had been elicited by pharmacological brain stimulation. Acoustic recordings were made through the use of a robotic arm, which is capable of moving a condenser microphone across a mesh of points around a central position whilst maintaining a consistent distance and aspect to the source. The results indicate that across individuals, a bilateral asymmetry is present, with greater amplitude components being present in the right-wing side of the animal, the uncovered wing. Individual variation in the focus of sound pressure to either the right or left-wing side is also observed.

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Codarin, Antonio
ARPA FVG - Regional Agency for Environmental Protection of Friuli Venezia Giulia, Palmanova, Italy

An inexpensive Arduino-based autonomous recording unit: open source tool for remote acoustic studies

ABSTRACT Autonomous acoustic recorders are very important and increasingly popular tools for acoustically and bioacoustically characterization of specific environments over a long period, both terrestrial and aquatic. Often, however, their excessive cost inhibits their use. During the course of my work I have designed and built a water-proof recorder, driven by Arduino UNO board programmed to record, continuously or at specific intervals, the noise present in a certain area, for the cost of about 300 Euros. The recorder is built with readily available materials and can easily be assembled, by anyone, with maintenance costs of only the internal batteries. It provides high-quality audio data (up to 96kHz, 24-bit) in .wav format saved on a SD card and can be used both in terrestrial and aquatic environments, connected to an external microphone or a hydrophone, and fixed to a suitable support. The recorder has been tested to assess the acoustic environment, as required by the Marine Strategy European Directive, in the Gulf of Trieste, an area with intense vessel traffic (north Adriatic Sea, 25 meters depth). Results of one minute recordings made every 15 minutes, 24 hours a day, will be reported. The low cost, flexibility and increasing popularity of systems based on Arduino should provide biologists, teachers and students with a tool which is easily customized for studies in a wide range of environments. For this purpose possible changes to the recorder will be discussed in order to extend the recording time and the maximum amount of recordable data, and make it completely submersible to a medium depth.

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Collier, Katie
Townsend, S.W.
Manser, M.B.

University of Zurich, Switzerland
Radford, A.N.
University of Bristol, U.K.

Dwarf mongoose alarm calls: a complex system

ABSTRACT Dwarf mongooses (Helogale parvula) produce a large number of alarm calls to warn conspecifics of danger. Whilst previous work has suggested the function of these calls is to refer to different predator types (Beynon and Rasa, 1989) these observational data have not been verified with playback experiments demonstrating receiver comprehension. We revisited the alarm call system of dwarf mongooses living on Sorabi Rock Lodge, Limpopo, South Africa. Through recording calls given during natural predator encounters as well as experimental predator presentations, we concur that dwarf mongooses produce structurally distinct alarm calls to different types of predators: aerial and terrestrial. Playback experiments further demonstrated distinct predator-specific responses to the playbacks of these two alarm calls, suggesting these alarm calls are functionally referential. Dwarf mongooses also produce a third alarm call that is the combination of the two other calls, though its production does not seem to be tied to a specific predator type. Instead, this call combination seems to be given when a predator of either type is present but not an immediate threat to the mongooses, conforming with the hypothesis that call combinations are more likely to happen in less dangerous situations. Furthermore, behavioural observations and playback experiments indicate receiver response to this third alarm call varies in both quality and intensity depending on the context it is produced in; namely, whether it is produced alone or is preceded by predator-specific alarm call. Our data indicate dwarf mongooses have a complex alarm call system with both functionally referential calls and call combinations whose importance seems to be context specific.

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Coquereau, Laura
Grall, J.
Chauvaud, L.
Institut Universitaire Européen de la Mer, Brest, France

Di Iorio, L.
Fondation of Grenoble Institure of Technology, Grenoble, France

Acoustics as a potential tool to monitor variabilities under anthropogenic pressure in a marine biogenic habitat

ABSTRACT Maerl beds are a marine biogenic substrate, which has been the subject of increasing attention in recent decades because of its high importance as reservoirs of diversity, often called “temperate waters reefs”. However, human activities, such as maerl extraction, fishing and eutrophication, continue to degrade beds worldwide. Acoustic monitoring of invertebrate sounds may be indicative of ecosystem health since changes in biodiversity as a result of degradation likely change the acoustic features of underwater soundscapes. However, limited records of sound production by invertebrates have restrained the application of acoustic monitoring at the individual and the community level in benthic habitats. The first step of our work was to identify and characterize sound-producing invertebrates in maerl beds. Aquarium recording sessions of twenty invertebrates from Atlantic maerl beds revealed fifteen different sound types. The behaviors corresponding to these sounds were feeding, moving, snapping, and probably communication. These soniferous species included three species of sea urchins, one species of snapping shrimp, one of spider crab, and the invasive slipper limpet. These species play key ecological and economic roles but their sound production has not been described previously despite its potential for ecological monitoring. Ongoing work conducted in poorly and heavily dredged maerl beds suggests variabilities between both habitats in seasonal sound production. Acoustics might help in monitoring maerl beds health state, and more generally benthic habitats.

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Curé, Charlotte
Dutilleux, G.
Cerema, Dter Est, Laboratoire Régional de Strasbourg, France

An automatic acoustic recognition system for

monitoring an endangered amphibian species, the common spadefoot *Pelobates fuscus*

ABSTRACT Acoustic recordings of animal sounds provide an effective tool for monitoring acoustically active species and species which are difficult to observe in the wild. Automated acoustic recordings allow to collect sounds for extended periods, increasing the probability of detecting a given species with little disturbance to the vocalizing animals. This method implies the processing of a huge acoustic dataset. Although it can be done manually by listening to the collected acoustic recordings, it represents a very long and tedious work. The aim of our study was to get rid of this operator-dependent processing of the acoustic data and to develop an automatic acoustic recognition system for monitoring the common spadefoot toad (Pelobates fuscus), an amphibian species threatened in France. Automated acoustic recordings were carried out in pools of different locations throughout four successive annual breeding seasons. A routine was developed in Scilab to automatically detect the spadefoot calls in the collected acoustic recordings. The recognition system was based upon i) inspection of the frequency band corresponding to spadefoot call frequencies carrying the highest amplitudes and ii) difference of sound levels between this frequency band and the background noise. Best configuration of the system retained a signal as being a common spadefoot toad call if the maximum sound level, calculated in the octave for which the center frequency is 800 Hz, exceeded the average sound level of the background noise of +14dB. This system showed 52% of true positives and 5.4% of false positives, providing a reliable method compared to existing anuran automatic detectors. Using this system, we explored temporal variation in the spadefoot calling activity throughout the breeding season and found that beside the typical and expected nocturnal vocal peak activity of the species, a diurnal period of calling was also present.

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Crisostomo Valdoria, Ciara M. C
Ramos, A.
Lam, M.K.
Vasconcelos, R.O.
University of Saint Joseph, Macau, SAR China
Chaves, P.
University of Saint Joseph, Macau, SAR China and MARE, ISPA, Lisboa, Portugal
Amorim, C.P.
MARE, ISPA-Instituto Universitário, Lisboa, Portugal

Early multimodal communication in the territorial Lusitanian toadfish

ABSTRACT Ontogenetic development of acoustic communication has been widely reported in birds and mammals but scarcely investigated in other vertebrates such as fish. Certain species as the Lusitanian toadfish (Halobatrachus didactilus) start producing sounds (grunts) and visual displays remarkably early in development, suggesting that these signals may convey important information for social communication. The biological function of such multimodal communication in early fish development has never been properly investigated. We investigated the social role of acoustic and visual signaling among early juveniles H. didactilus (3-6 months old; 2-3 cm total length). Our goals were: 1) determine how social context affects acoustic and visual signaling; and 2) verify whether signaling is related to territory ownership (social status). Six groups of four similar-sized juveniles were isolated in small tanks provided with two shelters to promote territorial competition. Two fish were initially placed in each tank to become "residents"; 24h later two other individuals were introduced. Audio-video recordings were carried for 1h, twice a day, over 4-12 days. Data was analyzed per individual regarding number of sounds and visual displays, and social context of signal production. Most juveniles firstly introduced in the tanks readily occupied the available shelters becoming residents and defending the territory throughout the whole observation period. Juveniles relied on both visual and acoustic signals that were often exhibited as a multimodal display. The most common visual signal was attack. Visual signalling was equally observed during territorial defense and other social interactions, but frontal and lateral displays were also exhibited. The social context had a significant effect on sound production, with the feeding context evoking the highest number of sounds. Residents, or dominant individuals, revealed higher visual and acoustic signaling rates compared to non-residents. We

provide evidence that multimodal communication plays important role in the social communication of a vocal teleost species.

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Dadwal, Navjeevan
Bhatt, D.C.
Sethi, V.K.
Gurukula Kangri University, Haridwar, Uttarakhand, India

Examination of parental investments in the nest defense and anti-predator behavior of a tropical songbird, the Pied Bush Chat

ABSTRACT Most of the avian species expend considerable efforts in nest defense through different strategies including use of acoustic signals in the form of threat/alarm calls. In the present study, an attempt was made to examine the parental investments in nest defense behaviour by the Pied Bush Chat (Saxicola caprata). We quantified the alarm and territorial calls in the presence of the decoy avian predator in the territories of 12 males. Results revealed that the nest protection intensity increased with the progression of the nesting cycle i.e. the parental aggression was more intense to protect the nestling than that of the eggs. Also, significant difference was noted for the usage of the threat calls over the territorial calls during this experiment. The assessment of the individual parental aggression between male and female put the male on the winning side i.e. for the most cases, males were found more aggressive than that of the females (on the basis of the calls rates they uttered). It was interesting to note that consistent use of the same predator throughout the study did affect the parental aggression behaviour. Thus, this study does not support the prey- predator familiarity hypothesis.

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Davis, Jordon
Sieving, K.
University of Florida, Gainesville, U.S.A
Lucas, J.
Purdue University, West Lafayette, U.S.A.
Freeberg, T.
University of Tennessee, Knoxville, U.S.A.

Experimental assessment of distance-from-source effects on spectral classification of bird vocalizations recorded in natural environments

ABSTRACT Propagating sounds degrade with distance from their source. Animal signal degradation can influence information content, value and, in turn, organismal responses; therefore it is of conceptual importance in ecological acoustics. However, acoustic degradation also influences accuracy in detecting and classifying animal signals, and may be especially problematic in the interpretation and effectiveness of spectral analyses using automated recordings. We take a robust experimental approach to determining the effects of distance-from-source on acoustic signal detection using spectral tags and automated searches (Avisoft SAS-Lab Pro). We broadcast replicated and calibrated high fidelity recordings containing > 20 vocal elements produced by 2 species of birds in family Paridae in natural habitats within the species' ranges. Broadcast sounds were then recorded at 1m and at all 10m increments up to 100m away from the sound source. Experiments with identical procedures were conducted in FL, IN, and TN, USA in the same months. Spectral tags were created for each vocal element from both the high fidelity and field recordings across the distance gradient and are being used in tag sets containing different titrations of classifiers made from degraded and un-degraded vocal elements. Statistical models will evaluate, for each vocal element, the relationships between detection accuracy, distance-from-source, tag set composition, spectral model parameters, background noise, habitat type, and region. Results will be discussed in light of the most common objectives and strategies for automated biophonic recording and signal detection (e.g., community surveys vs. species-centered behavioral outputs).

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Diniz, Pedro
Rech, G.
Ribeiro, P.
Macedo, R.

Universidade de Brasília, Brazil

Vocal response by social pairs to playbacks of solos and duets varies with the presence of juveniles in a Neotropical ovenbird

ABSTRACT Duets may occur between breeding pairs due to conflict (e.g., when an individual answers its partner's song to acoustically mate-guard partner) or as a cooperative behavior (e.g., if the individuals share territory defense benefits by coordinating their songs into duets). The presence of juveniles, however, may affect the relative cost for territorial birds, of either losing a partner versus losing a territory, thus contributing to how duetting functions. We studied the Rufous Hornero, a year-round territory defending species with delayed juvenile dispersal. We hypothesized that the cost of losing a territory is higher for pairs with juveniles than for those without, because territory loss may affect both juvenile and adult survival. To test this hypothesis, we played back (1) duets, (2) male solos, (3) female solos, and (4) a control heterospecific duet to social pairs, with and without juveniles, in the non-breeding season. Both male and female adults sang promptly after conspecific playbacks (57 times faster compared to control), independently of juvenile presence. Most of the song response (94%) to conspecific playbacks consisted of duets, of which 69% were male-initiated. Pairs with juveniles responded faster to the playback of duets and female solos than pairs without juveniles. Pairs without juveniles responded faster to male solos than to any other playback treatment. Playback treatments did not influence male and female song duration, duet duration, and probability of males initiating a duet. Our results suggest that duets are cooperative displays in the Rufous Hornero. Territory seems to be more valuable for pairs with juveniles than pairs without juveniles, and social pairs with juveniles seem to coordinate their songs to defend their territory. In contrast, male intrusion seems to be more threatening to territorial males without juveniles, though females seems to cooperate to prevent their partners from being overthrown.

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Dorado Correa, Adriana
Zollinger, S.A
Brumm, H.
Max Planck Institute for Ornithology, Seewiesen, Germany

Vocal plasticity in mallards: multiple signal changes in noise and the evolution of the Lombard effect in birds

ABSTRACT Acoustic communication is crucially constrained by environmental noise. As a response, many animals adjust the properties of their vocalizations in noise to maintain signal transmission despite interference. A particular form of this noise-dependent vocal plasticity is the Lombard effect, in which a signaler increases its vocal amplitude in response to an increase in the background noise. The Lombard effect is a well-studied feature of human speech. It has also been reported in other mammals as well as several bird species. However, the evolution of the Lombard effect and other related vocal adjustments in birds is still unclear. Thus far only three of the five major avian clades have been studied. We report the first evidence for the Lombard effect in an Anseriform bird, the mallard (Anas platyrhynchos). Besides the increase in call amplitude, the birds also raised the peak frequency of their calls in noise. However, in contrasts to the increase in amplitude the observed increased in call frequency did not yield any release from masking because we used white noise in our experiment. Therefore the frequency change is unlikely to be adaptive in the context of noise mitigation. Our findings support the notion that all extant birds use the Lombard effect to solve the common problem of communication in noise, i.e. it is an ancestral trait shared among all living avian taxa, which means that it has probably evolved more than 100 million years ago within that group.

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Duarte, Marina H.L.
Pinto Viana Pontificial Catholic, Y., Federal University of Minas Gerais, Brazil

Mining noise affects acoustic communication by the rofous-collared sparrow *(Zonozhichia capensis)* in a tropical forest

ABSTRACT Several species depend on acoustical

signals for communication, and many studies have shown that noise can affect communication by masking vocalizations, preventing animals from communicating effectively. An important part of the Brazilian economy is based on mining, which produces noise from heavy machinery, explosions, sirens, and road traffic. Mining is often conducted close to biodiversity hotspots, but studies on the effects of mining noise on animals are lacking. The rufous-collared sparrow is a passerine found in Atlantic forest areas in Brazil. The aim of this study was to analyze the effect of noise from mining trucks on vocalizations of Zonothichia capensis. Data were collected in an Atlantic forest fragment located close to a mine at Peti Environmental Station in Southeast Brazil. Two digital field recorders (SM2, Wildlife Acoustics) were installed 150m from each other and 25m from a mining road. The SM2 were set to record at 44.1kHz from 05:00 to 09:00 am during 7 continuous days in October 2012. The data analysis was done using Raven Pro 1.4 software according to the following steps: 1) Manual search for truck noise; 2) Check for presence of Z. capensis vocalizations in intervals of 1 minute before the truck transit; 3) Analyze the spectral characteristics of the truck noise (duration, maximum and minimum frequencies, and bandwidth); and 4) Analyze the spectral characteristics of the vocalizations 1 minute before and during and 1 minute after the truck transit (duration, maximum and minimum frequencies, number of notes, interval between the calls, and latency period after the truck transit). Results showed that the species stops calling or decreases the duration and number of notes during truck transit. These results indicate that mining noise can affect a species' vocal behavior, which is important for the development of conservation strategies in natural areas close to mining operations.

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Eckenweber, Maria
Knörnschild, M.
University of Ulm, Germany

Individual recognition in wild greater sac-winged bats *(Saccopteryx bilineata)*

ABSTRACT The ability to recognize conspecifics individually plays a crucial role in shaping animal societies. Under natural conditions, vocal individual recognition has predominantly been studied in primates, despite its importance for other mammalian taxa. Here, we present experimental evidence that wild bats, Saccopteryx bilineata, can recognize individual group members using voice cues in distress calls. Bats produce distress calls when being caught by a predator, and distress calls often attract conspecifics. We conducted two distress calls playback experiments to simulate predation events in the vicinity of the bats' day-roost. In the first experiment, roosting bats approached the speaker broadcasting distress calls of group members only when the simulated scenario was plausible (when the stimulus donor had just left the roost), but never when the simulated scenario was physically impossible (when the stimulus donor was still perched among the focal bats). The lack of responsiveness when conflicting information was presented (i.e. the physical presence of an individual in one place and its voice in another place) strongly suggests that S. bilineata is capable of recognizing individual conspecifics based on voice cues in distress calls. Since a simulated predation event at the day-roost likely represents a highly relevant but nevertheless rare scenario, we conducted a second experiment to test the bats' responsiveness to distress calls of unfamiliar conspecifics at different distances to the day-roost. Focal bats reacted to the broadcasted distress calls when the speaker was placed directly at the day-roost or in close proximity to it, but not when it was placed at a nearby foraging site, suggesting that foraging S. bilineata are not particularly attracted to conspecific distress calls. Thus, the bats' degree of responsiveness to distress calls apparently depends on the perceived social relevance of a given situation, and distressed group members calling at the day-roost elicit the strongest response.

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Emam, Tariq
Mackay, R.
Barnard, M.
University of Hull, U.K.

The Yorkshire Soundscape Project: a case study in soundscape comparison and composition

ABSTRACT Recent developments in the field of ecoacoustics have yielded different approaches to environmental monitoring through the use of sound recording, including the capturing and analysis of entire soundscapes, rather than individual species (Pijanowski 2011). May 2015 has marked exactly forty years since the World Soundscape Project (from Simon Fraser University, Vancouver) visited places within Europe in order to produce Five Village Soundscapes and the accompanying European Sound Diary (both Schafer 1977). This project focuses on the capturing and analysis of a range of soundscapes using rural Yorkshire as its study area, developing effective sound recording and analysis techniques in order to enhance environmental monitoring; taking an interdisciplinary approach, combining practices in sonic arts and ecology. It begins with a comparative analysis of archived sound recordings from 1975 as part of the World Soundscape Project database at Simon Fraser University. This paper will present the first year of study and results that have put into effect relevant field and compositional techniques to fuse methodologies on theoretical and practical levels. These include field recording, ecoacoustics composition, spectral analysis, working with aural archives and their philosophical challenges. Composed sonic material will be previewed accompany the writing. The aims of this paper are in line with the growing focus on ecology and contemporary composition; together, arts and sciences have seen, and continue to see, a convergence of human feeling and ecological concern (e.g. from Payne 1970 to Krause 2014). Soundscape recording and ecoacoustic composition 'could be a powerful means of raising awareness of acoustic biodiversity and its heritage.' (Monnachi 2013).

23

Español Jimenez, Sonia
Hucke-Gaete, R.
Austral University, Argentina
van der Schaar, M.
Universitat Politecnica de Cataluña, Spain

First study of presence of humpback whales vocalizations in a feeding ground of the Southern Chile

ABSTRACT Humpback whales, Megaptera novaeangliae inhabit all major ocean basins and undertake long-distance seasonal migration between productive high-latitude areas where whales feed in the summer and fall, and low-latitude tropical waters where mating and calving occur during winter and spring. Southern Chile, especially the Chiloense Ecoregion, have been recognized as an important summer feeding ground for the southeastern Pacific humpback whale. The song of humpback whales is a loud, complex series of sounds repeated over and over. It occurs primarily (although not exclusively) during the breeding season, is sung only by males, and its composition changes as it is being sung with all singers in a population singing the same version at any one time. In this investigation, we used the songs of humpbacks whales to study the seasonal patterns in the presence of humpback whales in this area. We deployed one marine autonomous recordings unit (MARUs) during six months (January to June 2012). We used SONS-DCL software to automatically extract acoustic events from this unit. Our results indicated that there was a constant presence of humpback whale in the south of Chiloense Ecoregion, but there were an increases in the presence in the last months studied. So, in June we found the maximum presence of humpback whale vocalizations. In addition, we studied the diary or circadian pattern of these vocalizations for understanding more of the activities they were doing in these months over this area. In this context, our results showed that were more vocalizations in periods with low light or in dark (at night). These are the first recorders of humpback whale in this area, so for complete this investigation, we continue studying these vocalizations, as well as other sounds and biology variables that maybe will be influenced in humpback whale behavior.

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Ey, Elodie
de Chaumont, F.
Olivo-Marin, J.-C.
Bourgeron, T.
Institut Pasteur, Paris, France

New insights into spontaneous ultrasonic vocalisations in mice

ABSTRACT Rodent ultrasonic vocalisations are currently broadly used as proxies for communicative abilities in the behavioural characterisation of models for neuropsychiatric diseases. These communication signals are recorded in experimental contexts in which the motivation of the animals is manipulated. This artificiality in the contexts does not allow mice to express their complete natural behavioural repertoire and might lead to biases in interpreting data and difficulties in reproducing results. We now aim at defining more ethologically relevant conditions to test mouse models of neuropsychiatric disorders, and more specifically to evaluate social communication. As a first step, we concentrated on the contexts of emission of spontaneous ultrasonic vocalisations. We followed continuously several groups of 3 adult female mice during 3 days and 4 nights. Ultrasonic vocalisations were recorded automatically, and simultaneously the corresponding video recordings were triggered. Spontaneous isolated ultrasonic vocalisations were emitted when mice were foraging or resting without any contact. In contrast, sequences of complex ultrasonic vocalisations were emitted mostly during social interactions of at least two mice. It appeared that the most complex sequences were emitted when all three mice were sniffing each other when arousal appeared to be high. Such approaches will deepen our understanding of rodents as such, and therefore lead to more reliable characterisation of behavioural phenotypes in rodent models of neuro-psychiatric diseases. This information on mouse vocal communication needs to be complement but it will be of high interest in mouse models of social communication deficits such as autism spectrum disorders.

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Faragó, Tamás
MTA-ELTE Comparative Ethology Research Group, Budapest, Hungary
Marx, A.
Eötvös Loránd University, Budapest, Hungary

Non-linear phenomena in dog whines as potential indicators of separation anxiety

ABSTRACT Although nonlinear phenomena are often present in healthy vocalizations, their communicative functions are still unclear. Fitch at al. in 2002 suggested several adaptive functions of these irregularities. Later the 'unpredictability hypothesis' was tested in several species (meerkats, prairie dogs) providing support for the attention evoking function, but we still have little knowledge about whether the NLP provide information about the caller's identity, quality or its inner state. Blumstein and Récapet suggested that nonlinearities can act as honest signals of the level of arousal and several indirect evidence suggest a link between the arousal of the individual and the harshness of their sounds. However, to our knowledge no studies attempted to test this link directly so far. Dog whines can provide an excellent model for this, as NLP is often present in them, and we can collect and compare whines from dogs experiencing different level of stress during separation from their owner. Thus in this study with using questionnaires about separation and vocal behaviour, we recruited family dogs that whine during separation, and according their owners have or lack separation-related stress. We recorded their whines and measured the occurrence of NLP. We compared the number of nonlinear events and biphonations between dogs reported to have separation problem and not. Our preliminary results from the data of 50 subjects showed that there were difference only between the occurrences of nonlinearities in the first fundamental frequency. Significantly more nonlinear phenomena were found in the whines of the stressful subjects. Additionally we are currently running quantitative acoustical analysis and behaviour coding to find additional associations between the inner state of the subjects and the acoustical parameters of their whines. Our preliminary results are promising, suggesting that nonlinear phenomena in whines are possibly act as indicators of stress level in dogs.

3

Favaro, Livio
Gamba, M.
Fissore, C.
Gnone, G.
Pessani, D.
University of Turin, Italy

Acoustic cues to individuality and species in Spheniscus penguins: a source-filter theory approach

ABSTRACT The diversity of colonial lifestyles displayed by penguins presents different challenges for vocal production and recognition. Banded penguins (Spheniscus spp.) are unusual as they are highly territorial, and build nests in underground burrows. Banded penguins also have complex vocalisations (display songs), which are relevant for mate and parent-offspring recognition. Moreover, they produce contact calls to maintain social relationships and group cohesion. We collected acoustic recordings from two large ex-situ colonies of African penguins (Zoom Torino, Italy) and Magellanic penguins (Acquario di Genova, Italy) between 2012 and 2014. To determine which acoustic proprieties of vocalisations have the potential to discriminate between different individuals, sexes, and species, we measured temporal (e.g. duration), source-related (fundamental frequency, F0), and filter-related (formants) acoustic features of each vocal signal. The acoustic parameters were used to carry out a series of stepwise, permuted discriminant function analysis (with cross-validation). Our results showed that vocalisation could be classified according to the emitter, in a manner shown to be far greater than that attributable to chance. Moreover, we were able to determine the acoustic features that are potentially relevant for individual vocal recognition in both species. We also showed that species discrimination by calls is possible, despite the limited genetic distance between the African penguin and the Magellanic penguin. However, we failed to find sex-related vocal distinctiveness. Overall, we demonstrated that penguin calls can be studied by considering independent contributions from three different parts of the respiratory apparatus, namely lungs (temporal patterns), vocal production organ (source, determining the F0) and vocal tract (filter, responsible for formant peaks). Our results provide the first evidence that the source-filter theory can lead to a far better understanding of biologically meaningful information contained in nesting penguin calls. We suggest that this approach should be adopted to study vocal communication in other penguin species.

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Feng, Ni
Ahn, G.
Yip, F.
Liao, C.
Bass, A.H.
Cornell University, Ithaca, U.S.A.

The circadian vocal rhythm of a singing fish

ABSTRACT Biological rhythms enhance animal survival and reproduction by synchronizing behavior and physiology to cyclical changes in the external environment. The hormone melatonin is the chemical expression of darkness in vertebrates, and plays a central role in entraining daily activity to the day-night cycle. Although regulation of cyclical locomotion and feeding behaviors has been well characterized, circadian and melatonin regulation of vocal behavior is not well understood. Knowledge of nocturnally vocal species is especially lacking, as diurnal songbirds are the predominant models for studying vocal behavior. We investigated the nocturnal courtship vocalization ("hums") of a highly vocal fish, the plainfin midshipman (Porichthys notatus). To test the hypothesis that hums are under circadian control, we recorded them from individual males held under normal light-dark (LD, 15:9) and constant dark (DD) cycles in artificial habitats mimicking natural conditions. The results strongly suggest that the daily cycle of midshipman vocalization is controlled by a circadian clock, although the strength of the clock varies across individuals. To test the hypothesis that melatonin stimulates midshipman vocalization, males who had been humming under LD were transitioned to constant light (LL) to suppress endogenous melatonin levels. On the day of transition to LL, one group was implanted with 2-iodomelatonin (2-Imel; potent melatonin receptor agonist) and another with vehicle control. Preliminary data suggest that humming activity decreases under LL in control-implanted and non-implanted males, but persists in 2-Imel-implanted males. Together, our results demonstrate for the first time a circadian rhythm in fish vocal behavior, and that melatonin action stimulates nocturnal vocal behavior. Knowledge of circadian and melatonin control of nocturnal vocalization in midshipman fish will complement investigations in diurnal birds and inform comparative investigations in other nocturnally vocal vertebrates. Support from NSF IOS1406515 and IOS1120925.

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Ferhat, Allain-T.
Ey, E.
de Chaumont, F.
Institut Pasteur, Paris, France

Contexts of emission of ultrasonic vocalisations during social interactions in mice

ABSTRACT Social communication is heavily affected in patients with neuropsychiatric disorders. Accordingly, mouse models designed to study the mechanisms leading to these disorders are tested for this phenotypic trait, especially for ultrasonic vocalisations during social interactions. Nevertheless, little is currently known on the precise contexts of emission of these ultrasonic vocalisations during social interactions. Therefore, in the present study, we aimed at synchronising the analyses of ultrasonic vocalisations and specific events in social interactions during male-male interactions in freely moving animals (occupant / new-comer). We tested 8 pairs of male mice in free dyadic social interactions, in three cage formats (rectangle, round, square). Under these conditions, we examined the emission of ultrasonic vocalisations during the different types of social contacts, approach-escape sequences, follow behaviour, and the time each animal spent in the vision field of the other one. We did not highlight any significant effect of cage shape / size on the number of ultrasonic vocalisations recorded as well as on the behavioural events examined. In contrast, we showed that vocalisations were emitted during specific behavioural sequences, especially during close contacts or approach behaviours. A large proportion of these vocalisations (30- 50%) occurred when the occupant was behind the new-comer. The types of ultrasonic vocalisations emitted also varied according to the behavioural events in which they were emitted. The present study provides new information about the context of emission of ultrasonic vocalisations in a protocol reliably eliciting social contacts in adult male mice. This knowledge will be valuable in standardizing investigation of social interactions in mouse models of neuropsychiatric disorders.

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Florentin, Juliette
Kouroussis, G.
Verlinden, O.
Université de Mons, Belgium

Wildlife presence in a rural soundscape near a wind turbine

ABSTRACT Studies of wind turbine noise yield generous amounts of low quality sound data in various environments. In the present context, audio recordings near a turbine in the rural setting of Chevetogne, Belgium, are exploited to highlight wildlife presence. Two weeks of 12000 Hz continuous sound data were measured at three positions around the turbine, at distances of 100 and 200 meters. Upon inspection, the audio records were found to contain elements of anthropophony (the turbine, various vehicles, voices, church bells), geophony (wind) but most interestingly a rich biophony (birds, insects and mammals). The detected bird species are common in the area. Color-composite spectrograms, assembled from acoustic indicators that target wildlife detection, allow a direct visualization of 24 hours of sound data at once. The acoustic complexity index (ACI) excels at highlighting the contributions of passerines, while a modified spectral entropy (Hs) captures the voices of birds with more monotonous songs. A third dimension, derived from the sound pressure level, gives a sense of the weight of human activities on the soundscape, namely through road traffic and agricultural work. The final spectrograms display the musical score of the day, showing birds singing on and off in succession or simultaneously but in different frequency ranges. Observations related to the coexistence of birds and the wind turbine are in line with existing knowledge; common passerines are heard at short distances from the turbine and limited raptor presence on site is captured (Buteo buteo).

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Florentin, Juliette
Kouroussis, G.
Verlinden, O.
Université de Mons, Belgium

Acoustic characterization of woodpecker drumming in view of European species identification

ABSTRACT Recent studies on bird song identification have primarily used mean spectral content to describe vocalizations. This strategy is certain to fail for some species, for example when the temporal structure of the song is critical. The drumming of woodpeckers falls into this last category. For woodpeckers, drumming achieves territory defense and partner attraction to such an extent that some species have no song (Dendrocopos major, Dendrocopos leucotos). Hence drumming sounds bear species markers and their acoustic description is a necessity. For that purpose, a database of 361 drumming recordings is assembled from the online archives Xeno-Canto (the Xeno-Canto Foundation) and Tierstimmen (Museum für Naturkunde Berlin) with samples from the nine European woodpecker species that drum. Our objective is the recognition of drumming in a continuous sound flow and the identification of woodpecker species through a generic supervised classification algorithm such as KNN. 2666 drumming rolls are thus extracted from the Xeno-Canto and Tierstimmen sound files using a characterization of drumming as the repetition of a brief signal with a beat between 30 ms and 120 ms and with the bulk of the spectral components lying below 1500 Hz. The drumming rolls are also sorted in series of the same bird hitting on the same tree; this allows taking into account the possible duets between different birds or the potential tree changes. On that basis, the characteristic time interval between successive drumming rolls of the same bird is evaluated. Other acoustic features used in the classification are the duration of drumming rolls, their time structure (acceleration or deceleration while hitting) and a rough spectral description. The final feature ranges are compared to existing literature data.

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Frommolt, Karl-Heinz
Museum für Naturkunde - Leibniz Institute for Evolution and Biodiversity Science, Germany

Information obtained from bioacoustics monitoring – lessons from systematic acoustic monitoring during the breeding season

ABSTRACT Using a four-channel recording setup we provided a bioacoustics monitoring in a wetland restoration in Mecklenburg-Western Pomerania in northeastern Germany. Here we present the results of the first year of systematic evaluation of species composition during the breading time. Recordings were made in 2012 from March 29th until May 30th with a focus on nocturnal birds. Six sound snippets of 15 min duration were recorded daily, starting at 3 a.m., 5 a.m., 7 a.m., 8 p.m., 10 p.m. and 12 p.m. In total 372 sound snippets (93.5 hours of four-channel recordings) were obtained. All recordings were evaluated by listening to the recordings supported by spectrographic visualization. Vocalizations of 62 bird species could be detected. There was no recording with absolute silence. The number of bird species detected on the sound snippets varied from 3 to 22 (median 12). The temporal distribution patterns allowed an assessment of the status of the species. A regular presence can be used as an indicator of breeding. Applying pattern recognition techniques, the temporal patterns of vocal activity could be described on the example of the Eurasian bittern (Botaurus stellaris). Also the number of calling birds of this species could be estimated based on the evaluation of four-channel recordings. The bioacoustic monitoring revealed the occurrence of rare nocturnal birds such as Little Crake (Porzana parva), Spotted Crake (Porzana porzana) and Short-eared Owl (Asio flammeus). However, some species which are known as common breeding birds in the study area could not be found on the recordings. The potential of bioacoustic methods for long term monitoring of bird populations will be discussed.

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Gervaise, Cédric
chair CHORUS, Fundation of Grenoble Institute of Technology & GIPSA LAB, France
Lossent, J.
France Energies Marines, Brest, France
Di Iorio, L.
Fundation of Grenoble Institute of Technology, France

3D imagery of the marine biophony with compact sensor array

ABSTRACT In this communication, we address the development of protocol (instrumentation,

algorithms to process the data) to localize and characterize the marine biophony in 3D for coastal environment in a 100 m x 100 m x 15 m volume of water. For the biophony, we focuss on the impulses ([1 ms, 20 ms] duration range, [2 kHz, 50 kHz] bandwidth) produced by a large range of marine species (snapping shrimps; sea urchin, bivalves, noise from s. To localize these impulses, we use a small compact array of 4 hydrophones located within a 2 m x 2 m x 2m cube with a ad hoc geometry, for each impulse several features are extracted (peak frequency, SPL, etc) and then the distribution of the features in space may assessed and may help for the identification of species, behaviors or activities. We will present in detail the processing of the data (detection of impulses, estimation of tdoa, estimation of positions) and study the accuracy of localization both with theoretical argument and in situ calibration using synthetic emitters. Then we present the result of our 3D imagery of marine biophony for two 7 days at sea experiments ran in 2014 and 2015 to study via passive acoustics monitoring the marine fauna and its dynamic at artificial reefs (hosting rich marine biodiversity) on a soft substrat (hosting poor biodiversity). The first site is the artificial reef of Prado (Marseille, France) developed 6 years ago to mitigate the negative impact of Marseille of marine life. The second site is an unassigned petroleum terminal at Lanveoc (Rade of Brest, France) where several pylons (10 m diameter) are settled by marine life. In each case, the ground truth for the distribution of marine fauna is performed with divers.

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Gessinger, Gloria
University of Ulm, Germany
Tschapka, M.
University of Ulm, Germany and Smithsonian Tropical Research Institute, Balboa, Panama
Surlykke, A.
Syddansk Universitet, Denmark

Nasal and oral echolocation call emission in phyllostomid bats

ABSTRACT The phyllostomids form the ecologically most diverse neotropical bat family. Although they show a huge range of feeding habits, most of them are narrow space gleaners and utilize on first glance very similar echolocation calls. Foraging style demands for special adaptations of call parameters such as intensity, frequency, call duration, beam shape and bandwidth. Phyllostomid bats use typically rather short multi harmonic and steeply frequency modulated calls. Preliminary observations showed some phyllostomid species flying mostly with opened mouth, whereas others have their mouth closed during flight. We hypothesized that open versus closed mouth might be used to modulate call parameters. We therefore recorded flying individuals of different species with a multi microphone array (four microphones, three CM16, Avisoft Bioacoustics, and one calibrated ¼" G.R.A.S. type 40BF) and a high speed camera (frame rate 500 fps). All experiments were performed in Panama under standardized conditions in a flight cage using animals captured on Barro Colorado Island and the surrounding islands. The multi microphone array allowed calculating distance and direction to the bat and hence call intensity, whereas frequency, call duration and bandwidth were determined from single microphone recordings. We plan to test for correlations of call parameters with type of emission and the life history of the species animals. Bats having their mouth closed during flight emit calls exclusively through the nostrils, while bats with an open mouth may emit calls through the mouth and/or the nostrils. Preliminary results show that the type of emission varies distinctly between the subfamilies: Frugivorous Carolliinae and sanguivorous Desmodontinae fly with an open mouth. So do the animalivorous Phyllostominae with the exception of the omnivorous genus Phyllostomus, which flies with mouth closed. Frugivorous Stenodermatinae have their mouths closed during flight and emit the echolocation calls exclusively through the nostrils.

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Gifford, Toby
Linke, S.
Karakonstasis, C.
Barclay, L.
Griffith University, South Brisbane, Australia

Vocalisation characteristics of the soniferous catfish species *Neoarius graeffei*

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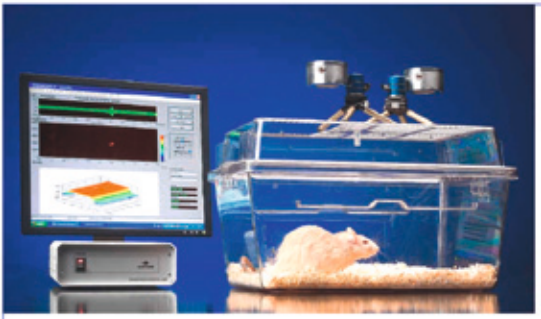

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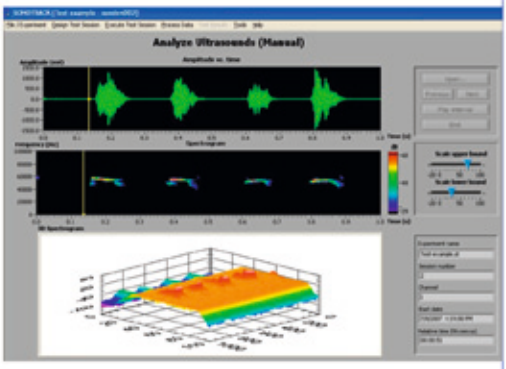

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Rats and mice produce ultrasonic vocalizations in a variety of situations, for instance in response to stress, anxiety and pain (22 kHz) or during social interaction like sexual behavior (50 kHz). Mouse and rat pups emit ultrasounds in response to separation from their mother and litter mates. These ultrasonic vocalizations can be used as an indicator of emotional and motivational status. In animal models of stress, anxiety, pain or sexual behavior, but also in studies of well-being of animals, USV is an accepted and sensitive parameter.

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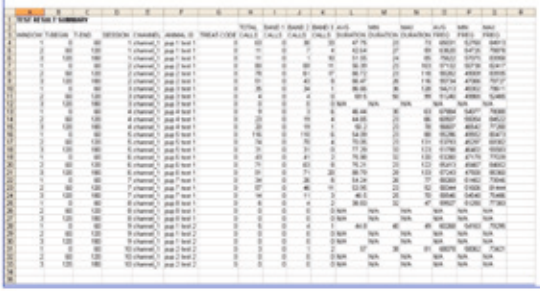

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ABSTRACT The Blue Catfish is an introduced soniferous fish abundant in the Brisbane River which emits a distinctive grunt, suggesting the possibility of automated passive acoustic population monitoring for this species. We have made in-situ field recordings and analysed the acoustic characteristics of Blue Catfish daytime vocalisations. During periods of high activity vocalisations are common - on the order of 1000 per hour for a school. We found typical grunts to be 50-100ms in duration, with 3-8 spectral bands with a falling contour of between 40-120Hz drop over the length of the grunt. There is a clear harmonic structure, with absent fundamental implied between 165-190Hz, commonly 3-4 strong harmonic overtones, weak second and fifth harmonics, and strong third and fourth harmonics. We report on algorithmic detection of grunts from a stereo hydrophone array based on this heuristic characterisation.

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Gill, Lisa
Goymann, W.
ter Maat. A.
von Bayern, A.
Gahr. M.
Max Planck Institute for Ornithology, Seewiesen, Germany

Who ya gonna call? Individual recognition in jackdaw *(Corvus monedula)* contact calls

ABSTRACT The ability to recognise familiar individuals underlies most animal societies, to maintain social networks and ensure investment in closely related individuals (e.g. parental care towards own offspring). To communicate, many species use vocalisations that may show inter-individual variation reflecting differences in the anatomy of vocal organs. Some animal species have been shown to use such individual signatures at the receiver‘s end to differentiate between individuals. But only very few species have been reported to use this information at the sender‘s end – to “address” specific individuals. Jackdaws (Corvus monedula) are highly social, long-lived birds that nest in colonies and share nest defence and parental care with their life-long partner, and utter various, not yet well-studied vocalisations. Contact calls are often used to maintain group cohesion, and seem to differ between individuals, even to the (trained) human ear. Whether the birds use this information to communicate specifically is, to date, unknown. We performed a two-level playback study with a captive population in which focal individuals were held in short-term acoustic and visual isolation from their conspecifics. We played back stimulus calls of the partner and of other familiar group members, and, due to the pair’s crucial role in the colony, expected different reactions if partners could be vocally distinguished (level 1: recognition). In addition, these stimulus calls had been recorded previously, while stimulus birds were listening to calls of our focal or of a different individual (level 2: addressing). Preliminary results suggest that jackdaws respond more strongly to their partner’s calls and even more so when “addressed” by the partner. We conclude that jackdaws are able to use vocal cues to distinguish between individuals, and that their contact calls mean more than merely eliciting group cohesion, but have the potential to be used in communication between specific individuals.

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Glotin, Hervé
Université Toulon, France
Pavan, G.
University of Pavia, Italy

Scaled soundscape automatic annotation - evidences from the Sabiod EADM challenge

ABSTRACT This talk presents the SABIOD EADM (Environmental Acoustic Data Mining) challenge on the categorization of terrestrial soundscapes applied to 40 days of recordings made in SABIOD-Italy. The task consists into the classification in 11 categories and the maximisation of the mean average precision metrics computed from the similarity scores. Six of the classes are biophony: insects, low song (at least 10 continuous seconds with structured patterns of different notes below 1.5 kHz), high song (as before, but higher than 1.5 kHz), low call simple note (eventually in series) below 1.5 kHz (may be by birds or frogs), high call (as before, but higher than 1.5 kHz), mammals (low frequency sounds, tonal or harsh). Other categories are anthropophony (planes), geophony (rain, wind, thunder), and an “other” event class. We summarize and discuss the performances

of the challengers, the used signal representation, classification method, and the requested CPU time. Metrics to describe soundscapes will be discussed. EADM workshop will take place at the IEEE ICDM 2015 conference. http://sabiod.univ-tln.fr/eadm/#challenge

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Goerlitz, Holger R.
Max Planck Institute for Ornithology, Seewiesen, Germany
ter Hofstede, H.M.
Dartmouth College, Hanover, U.S.A
Holderied, M.W.
University of Bristol, U.K.

Linking lab physiology to behaviour in the wild: the multi-species predator-prey interaction of bats and moths

ABSTRACT The ears of many insects are a classic example for predator-mediated selection. Eared moths possess ears to detect and evade bats. However, while the neurobiology of moth hearing is well studied, the escape behaviour is much less understood, despite being the predator-mediated phenotype. Here, we aim to close this gap by, first, establishing lab-derived neural audiograms as a tool to estimate predator detection distances in the wild and, second, to test the function of the seemingly exaggerated neuronal detection distances for predator escape behaviour. For our first aim, we recorded neuronal audiograms of twelve species of noctuid moths in the lab, and additionally measured their detection thresholds for bat calls in the lab and field, and furthermore their detection distances for free-flying bats in the field. Next, we predicted neuronal call detection thresholds and -distances based on these audiograms and compared them to the measured lab and field data, showing that the predicted data were similar or slightly larger than the measured one. Thus, neuronal audiograms, which can be readily measured in the lab, allow to predict predator detection distances in the wild, which are the ecologically and evolutionary relevant behavioural parameter that determines the distance and time available for moths to escape from an attacking bat. In our second approach, we hypothesized that the frequency-dependant hearing of moths is a functional adaptation for detecting bat species calling at different frequencies at distances where they pose a similar threat. Combining neuronal measurements, bat call recordings and bioacoustic modelling, we show that bat call frequencies predict bat threat predation threat. that moth auditory cells detect bats long before bats can detect the moth, and that this neuronal activity translates into similar temporal safety margins for initiating escape flight across all sympatric bat species.

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Gogala, Matija
Trilar, T.
Slovenian Museum of Natural History, Ljubljana, Slovenia

Differences in song parameters and taxonomy of singing cicadas *(Hemiptera, Cicadidae)*

ABSTRACT During the last few decades it became obvious that by differences in song parameters most species of close related cicadas can be easily distinguished in contrast to morphological comparison. In many cases acoustic differences are very clear and easily definable (e.g. Cicadetta montana, C. brevipennis, C. cantilatrix - sympatric and syntopic in Slovenia). However, recent detailed studies of the complex of mountain cicadas and some other groups of close related species of Tibicininae show in many cases much subtler differences between the songs of certain populations like C. olympica from Mt. Olympus and related population from Mt. Taygetos in Greece. Another example are close related species of Cicadivetta from Southern Greece. The question is, how big must be differences in acoustic signals to prevent cross mating in the field. Behavioural tests in such animals are almost impossible. Therefore differences must be statistically validated and compared with possible zoogeographical, morphological and molecular differences. But even DNA analysis of COI and COII does not always show clear results in distinction of putative species.

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Goncharova, Maria
Klenova, A.V.

Lomonosov Moscow State University, RUS

Acoustic call variables indicate hunger level in Siberian crane chicks *(Grus leucogeranus, Gruidae)*

ABSTRACT It is well known that chick calls can convey information about the physiological state. However the vast majority of studies have focused on chick' vocal activity in connection with hunger level, and they agreed that it was a good indicator of chick's needs or condition. Fewer researches were devoted to the temporal-frequency variables of the begging calls and different studies showed opposite results. Here we experimentally tested whether vocal activity and temporal-frequency variables of the begging calls of human-raised Siberian crane chicks are related with their hunger level. The study was conducted in 2012 in Oka Crane Breeding Centre (Russia). We recorded calls of 9 individual chicks in two conditions: after experimental food deprivation (hungry chicks) and than during additional feeding (replete chicks). Each recorded session lasted 5 min. We measured 9 variables in first 20 calls in each recording session (360 calls in total), as well as total time spent on vocalization in each session. We found that all measured frequency variables (except minimum fundamental frequency and second energy quartile) in hungry chicks were significantly higher than in replete ones (e.g. maximum fundamental frequency in hunger chicks: 3.41±0.53, in replete: 3.34±0.53; $F1, 350=5.80$, $p<0.05$). Calls of hunger chicks also were longer, noisier and followed each other through smaller gaps. The total time of vocal activity in hungry chicks was also greater than in replete chicks, though this difference was insignificant. Thus the level of vocal activity, according to previous studies of bird begging behaviour, is quite universal indicator of hunger level in chicks. At the other hand, we found that temporal-frequency variables of Siberian crane chick calls also related with hunger level. We discuss how the way of vocal hunger level expression is related with ecological traits of different species. The study was funded by Russian Scientific Foundation (grant 14-14-00237).

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Gonzalez-Terrazas, Tania P.
University of Ulm, Germany
Simon, R.
Friedrich-Alexander University Erlangen-Nuremberg, Germany
Schnitzler, H.-U.
University of Tübingen, Germany
Tschapka, M.
University of Ulm, Germany; Smithsonian Tropical Research Institute, Balboa, Panama

The sound of cactus: a flower-visiting bat's perspective

ABSTRACT Bat-pollinated plants present specialized characteristics that attract and guide their pollinators towards the flowers. Recent studies have shown that some of these flowers evolved characteristic acoustic features that facilitate their detection by echolocating bats. Many species of cacti depend on bats for pollination, however, the echo-acoustic properties of their flowers are largely unknown. For assessing what acoustic cues are available to bats for finding open cactus flowers we used a biomimetic sonar head to measure echo impulse responses of an empty cactus branch of Pachycereus pringlei, as well as branches with a bud and an open flower, respectively.Additionally, in order to identify the floral structures relevant for acoustic localization of the flower opening we measured echo impulse responses of an intact cactus flower and four cactus flowers that had been modified in different ways. We found thatechoes reflected by a plain cactus branch differed substantially from those reflected by one with an open flower. Flowers reflected echoes of higher intensity and over a wider angle than a plain cactus branch, which makes them acoustically highly conspicuous to the bats. Flowers without petals showed the weakest echo of all targets and the most different reflective pattern. Our results show that the petals are the acoustically most perceivable structures that may help bats to locate the opening of the cactus flowers. Additionally, our result suggest that the distinct reflections of cactus flowers may allow the bats to distinguish between cactus branches with or without flowers by just using echolocation.

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Grison, Matthieu
Sèbe, F.

Grison, J.
Mazagol, P.-O.
Mathevon, N.
Université Jean Monnet, St. Etienne, France
Aubin, T.
Huetz, C.
Université Paris Sud, France
Quispe, R.
Max Planck Institute for Ornithology, Seewiesen, Germany
da Silva, M.L.
Universidade Federal do Pará, Belém, Brazil

Spatial and temporal dynamic in a lek of a tropical bird: the *Lipaugus vociferans*

ABSTRACT In some bird species, males use communal area, known as "leks", to perform courtship displays. Leks are generally restricted to a mating season and are of primary importance for females' mate choice. In some species however, leks remain active all year-round and the dynamics of their social organization remain poorly explored. One functional hypothesis is that these leks could constitute social networks where males compete for both spatial and temporal resources to establish long-term and possibly stable hierarchies. Here we focus on the Screaming Piha Lipaugus vociferans, where males use to form permanent leks of 10 or more individuals. They produce one of the loudest songs, which consists in two parts: one introductive bass roo-roo followed by loud syllables pee-peeyo. We studied the acoustic and social networks of Screaming Piha's leks during a whole year, providing the first description of the spatial and temporal dynamics of a permanent lek in a non songbird species. 44 individuals from 4 leks have been recorded and localized during three recording sessions between April 2011 and April 2012. By analyzing the acoustic structure of males' song, we found an individual signature and characterized its coding features. We showed that this signature remains stable enough during one year to survey each male by its vocalizations only. Using microphone arrays, we thus investigated the year-round dynamics of the lek's acoustic network. We found that individuals are faithful to the same lek all year, and the lekking place in the center of the lek is more stable than the fringes. Our study gives interesting insights of the functional dynamics of lek in tropical forest, and supports the hypothesis that, at least in the studied species, leks constitute permanent social networks with stable and long-term hierarchies, and that this social structure primarily results from signaling interactions between males.

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Hallerberg, Sarah
Meigel, F.
Dahlkemper, M.
Timme, M.
Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany
Vester, H.
Ocean Sounds e.V., Germany
Hammerschmidt, K.
German Primate Center, Göttingen

A bag-of-coefficients approach towards call categorization

ABSTRACT Technical advancements in bioacoustics: From sound analysis to telemetry. Besides humans, several marine mammal species exhibit prerequisites to evolve language: high cognitive abilities, flexibility in vocal production and advanced social interactions. Here, we describe and analyse the vocal repertoire of long-finned pilot whales (Globicephalus melas) recorded in northern Norway. Observer based analysis reveals a complex vocal repertoire with 140 different call types, call sequences, call repetitions and group-specific differences in the usage of call types. Recently, the bag-of-calls approach has been proposed to distinguish ensembles calls recorded from different groups of pilot whales. In this contribution we test in how far a similar concept, the bag-of-coefficients approach is sufficient for distinguishing different call types within the recordings of one group.

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Hoebel, Gerlinde
University of Wisconsin- Milwaukee, U.S.A.

Does audiovisual integration change leading call preferences in treefrogs?

ABSTRACT Humans perceive two sounds in

close temporal succession as a single event originating from the location of the leading sound. Surprisingly, a visual cue associated with the leading sound enhances sound localization, while a visual cue associated with the lagging sound inhibits it, indicating that auditory spatial perception in humans is a fundamentally multisensory process. Many animals also attend to the sequence at which mating displays are perceived. For example, females of many frog species will approach the leading of two calls in close succession, resulting in higher mating success for the leading male. Combining techniques used to study communication in frogs with those used to study perception in humans, I investigated whether audiovisual integration affects leader preferences in treefrogs. If so, addition of a visual cue to the leading call should induce or strengthen a leader preference. Conversely, addition of a visual cue to the lagging call should reduce a leader preference. I examined this phenomenon in two species of treefrogs that differ in their leader preferences: Gray treefrogs have calls comprised of a series of pulses – they do not have a preference for leading calls in general, but they do prefer leading pulses. Green treefrogs have tonal calls, and they have a preference for leading calls. I found that addition of a visual cue affects leader preferences under some circumstances, but that audiovisual integration is not a general feature of treefrog sensory perception: addition of a visual cue does not change existing leader preferences (i.e., leading call preference in green treefrogs and leading pulse preferences in gray treefrogs remain unchanged), but it can induce a slight leader preference where there initially was none (i.e., induce a leading call preference in gray treefrogs). I discuss the implications of these findings in light of sensory perception and mate choice.

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Hoier, Svenja
Von Merten, S.
Pfeifle, C.
Max Planck Institute for Evolutionary Biology, Plön, Germany

Context specific ultrasonic vocalizations in wild female mice *(Mus musculus)*

ABSTRACT Mice (Mus musculus) produce complex vocalizations in the ultrasonic range (ultrasonic vocalizations = USVs) that remind of high pitched birdsong when shifted into the human hearing range. Male USVs show signs of individuality as well as family and population membership and could be a signal that is evaluated by females during mate choice. USVs are however not restricted to the mating context, suggesting that they serve a more general function in social communication of mice. We investigated the vocalization behavior of partially interacting female mice under semi-natural conditions over an extended time course. We analyzed whether certain features of their USVs were specific to environmental stimuli (food, water, nesting site, male cues) or to two types of social interaction (direct and indirect). Our results support the idea that female USVs are mainly used as social signals and that they play a role during hierarchy establishment and familiarization. We found that female mice use their USV differently depending on the type of social interaction. Females emitted less complex vocalizations at lower frequencies when they encountered another female, as opposed to high pitched complex vocalizations when they encountered another female's urine and deposited their own. The two vocalization types seem to resemble what is known from birdsong as directed and undirected song and are likely to serve distinct functions in mouse communication.

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Honaiser Rostirolla, Tomás
de Araújo, G.F.
Barboza Capella, D.
Teixeira Moreira, A.P.
Universidade Federal de Santa Catarina, Brazil

Model reliability for automated bioacoustic recognition through Arbimon

ABSTRACT With the recent development of better software recognition technology, perspectives for bioacoustic monitoring arise as a reliable source of data regarding studies in biodiversity, environmental policies, restoration initiatives and so on. This work investigate the efficiency of Arbimon-acoustic Web Aplication for automatic recognition models on three bird species found at Santa Catarina, Brazil.

The recordings belong to Arquivo Bioacústico Catarinense, where we selected 178 sound samples of Attila rufus, Basileuterus culicivorus and Setophaga pitiayumi. Analysing song's characters presence stabilit, we created two range models for each species: whole song (WS) and stable song elements (SSE), calculated through a χ^2-distribution ($p > 0,95$). Samples were uploaded at the Arbimon II platform and used to create the range models, each with 5 random samples, tested with fitting of 20 present and 20 absent sound samples. The successful detection rate of species presence on the whole list, for each range model was: A. rufus: WS = 62% and SSE (GL=4) = 57%; B. culicivorus: WS = 73% and SSE (GL=3) =63%; and S. pitiayumi: WS = 66% and SSE (GL=13) = 89%. In most cases, whole song range models made the most reliable models for automatic recognition, a good perspective for monitoring works started from scratch. Stable song elements range model got promising results, although it requires a prior library of song samples for modeling, available at Arquivo Bioacústico Catarinense and other sound libraries. From further work with other species and false-positive detection more accurate models should come. At last, our belief is that Arbimon represent a great breakthrough in biodiversity monitoring and automated analysis tool, and because of its global range for biodiversity analysis at long term, and we strongly suggest that monitoring initiatives consider the possibility of joining this network and also have a sound library supporting them.

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Hrouzková, Ema
Matêj, Šklíba J.
Šumbera, R.
University of South Bohemia, Ceské Budêjovice, Czech Republic

Vibrational communication of blind mole rat *(Spalax ehrenbergi)* superspecies

ABSTRACT The blind mole rat (Spalax ehrenbergi) superspecies comprise four chromosomal species in Isreal. Their habitat vary in degree of aridity in temperature, with S. judaei inhabiting dry and hot southern deserts and S. golanii living in humid and relatively cold Golani heights. The S. ehrenbergi superspecies have been widely studied also regarding vibrational communication. The four chromosomal species differ in their courtship calls as well as in seismic signals.We studied the whole repertoire of all four species of S. ehrenbergi superspecies. The repertoire consists of six true vocalizations (courtship, cheep, chirp, snort, squeak and squeal) and two mechanical sounds (teeth grinding and seismic signal). The four species differ in use of the calls probably in accordance with their diverse degree of aggressiveness.

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Hügel, Theresa
Max Planck Institute for Ornithology, Seewiesen, Germany and Julius Maximilians University Würzburg, Germany
van Meir, V.
Clarin, B.-M.
Siemers, B.M.
Goerlitz, H.R.
Max Planck Institute for Ornithology, Seewiesen, Germany

Acoustic and ecological similarity: eavesdropping on heterospecific echolocation calls in Myotis bats

ABSTRACT The heterospecific recognition hypothesis predicts that animals recognize heterospecifics and respond with species-specific adaptive behaviours. This ability should be adaptive, provided that species-specific reactions to interspecific encounters are advantageous, for example by following foraging individuals that occupy a similar ecological niche. Increasing evidence shows that bat echolocation calls, primarily used for orientation and foraging, also enable communication between individuals within a species. However, data about the role of echolocation calls for interspecific information transfer is scarce. In contrast, the acoustic similarity hypothesis predicts that animals simply react to heterospecific calls with similar spectro-temporal structure, without explicitly distinguishing between con- and heterospecific calls. Here, we tested if bats are attracted to the echolocation calls of species that occupy the same foraging niche, independent of the calls' spectro-temporal structure. We conducted three different playback expe-

riments with one focal species, Myotis capaccinii, a European insectivorous trawling bat, testing its reactions to its own calls and those of four different playback species with similar or dissimilar foraging ecology and call structure. In a flight room (EXP. 1), which was separated into two compartments, we measured individual flight duration in the playback compartments as a measure of attraction. In the field, we evaluated the effect of playback type on individual flight behaviour using acoustic tracking of individual flight trajectories (EXP. 2), and on overall group activity by counting the number of flight passes (EXP. 3). Results differed between experiments: M. capaccinii was attracted to the calls of M. capaccinii and M. daubentonii (EXP. 1), only to M. capaccinii (EXP. 2) or none at all (EXP. 3). These results support neither hypothesis, but suggest that that both conditions, ecological and acoustical similarity, are required for information transfer across species boundaries, yet also highlight the difficulty of assigning degrees of "similarity" to different sympatric competing species.

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Hügel, Theresa
Goerlitz, H.R.
Max Planck Institute for Ornithology, Seewiesen, Germany

Behavioural audiograms to study anti-predator adaptation in eared moths

ABSTRACT Animal prey exhibit many different adaptations to predation threat. One common adaptation is unpredictable movement known as "protean behaviour". The defence behaviour of eared moths´ consists of two stages, directional flight in reaction to a distant bat, and erratic flight, which moths exhibit to escape attacking close-by bats, a classic example for protean behaviour. While the neurobiology of moth hearing is well studied, the escape behaviour is much less understood, despite being the predator-mediated phenotype. Since the predator-prey interaction between echolocating bats and eared moths is solely mediated by sound, it is a powerful model system to study the function, ecology and evolution of auditory-guided behaviour. Our first aim was to establish a sensitive computer-controlled force-transducer system, enabling us to effectively measure the flight of tethered moths in a standardized way and in response to different acoustic stimuli. Our second aim is to use this system to obtain behavioural audiograms of different moth species differing in neurobiology, ecology and additional anti-predator strategy. We therefore stimulated moths with pure tones of different frequencies and increasing intensities to obtain the threshold intensities at which their flight behaviour changes. These behavioural audiograms will first be compared to existing neuronal audiogram to establish a link from neuronal activity to elicited flight behaviour. Second, audiograms will be compared across species to test the hypothesis that due to a higher detection risk, larger moths initiate evasive flight at larger distances than smaller moths. Third, audiograms will be compared across species to test the hypothesis that moths that are protected by additional passive or active defence mechanisms possess higher thresholds than moths without such additional mechanisms.

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Ilina, Irina
Marova, I.I.
Moscow State University, Russian Federation

Comparative analysis of the song variation across the ranges of Chiffchaff *(Phylloscopus collybita)* and Willow Warbler *(Ph.trochilus)*

ABSTRACT We studied song variations across the ranges of two closely related species: Common Chiffchaff and Willow Warbler. In Willow Warbler 3 poorly differentiated subspecies are normally recognized. By contrast, Chiffchaff is treated recently as superspecies including 12 races 4 of which have status separate species. In order to estimate the extent of intraspecific differentiation in vocalization of both species we studied 10 geographical populations of 8 subspecies of Chiffchaff: Ph.c.collybita (W Europe), Ph.c.abietinus (Moscow, Kiev, E Ukraine), Ph.c.tristis (Central Siberia), Ph.c.menzberii (W Kopetdag), Ph.s.sindianus (Pamir-Alai Mts), Ph.s.lorenzii I Ph.c.caucasicus (Caucas), Ph.brehmii (Iberian p-la) as well as 8 population belonging to 3 subspecies of Willow Warbler: Ph.tr.trochilus (W Europe), Ph.tr.acredula (Moscow, Kostroma, North and South European

Russia, South Ural, Mirnoe), Ph.tr.yakutensis (Eastern Siberia). We use canonical discriminate analysis of a number of characteristics of songs: maximum and minimum frequency, bandwidth, number of notes and note types per one song, etc. Acoustic differences between different populations of Chiffchaff (Wilks Lambda =0.00357; p<0,001) were found to be better expressed then between populations of Willow Warbler (LW = 0,042; p<0, 001). The Chiffchaff subspecies fall into two major groups: Europe green races and Asian brown races by complex genetic and bioacoustic parametries. Difference between brown races are greater (LW=0,00669, p<0.001) then between green races (LW=0,08843, p<0.001). The taxonomic structure of Willow Warbler is not clear so far, different researcher separate from 3 up to 5 subspecies at the different areas. According to our data only westernmost and easternmost geographical populations of that species show reliable bioacoustic differences from other population (LW = 0,144; ɪ<0,001) .It's possible that different taxonomic and bioacoustic structure of these two closely related species of leaf-warblers could be explained by different history of dispersion which was connected with the Glacial epoch.

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Jakubowska, Aleksandra
Osiejuk T.S.
Adam Mickiewicz University, Poznán, Poland

Song duration mediates response of territory owner during simulated intrusion in a songbird species with small song repertoire

ABSTRACT Song duration is an important dimension of bird song variability affecting response of signal receivers. In discontinuous singers males increase singing effort rather by increasing song rate than by elongating phrase duration, however, often they also change song phrase duration and it could be meaningful too. In Emberiza buntings dominates relatively short songs birds often produce song phrases with reduced duration but the meaning of such behaviour is not well understood. We tested experimentally whether elongation and shortening of neighbour song in the ortolan bunting (Emberiza hortulana) affects response of rivals. We considered two scenarios: (1) song duration conveys information about male identity and males should respond stronger both to elongated and shortened song phrases in comparison to natural duration neighbour songs; (2) song duration changes are associated with aggressive motivation, thus elongation and shortening should affect response of rivals in opposite directions. We tested 18 and 17 different males in two paired experiments (response to natural vs. elongated or natural vs. shortened songs). We found no support for the first hypothesis. The way of response to different treatments reflected motivation hypothesis. Shortened songs did not evoke such immediate and strong response as normal duration song did, and response to shortened songs was weaker than to elongated songs. We also found that the order of treatments affected response significantly. If birds were first responding to normal duration songs, they approached loudspeaker faster in treatment with shortened song. Our results suggest that song phrase duration is used for mediating escalation level of territorial conflicts. (Financial Support: National Science Center, Poland, grant no. NN303807340).

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Jansen, Martin
Masurowa, A.
O´Hara, R.B.
Senckenberg Research Institute and Natural History Museum, Frankfurt, Germany

Individuality in face of plasticity: signal variation during sustained calling in frogs

ABSTRACT Recent developments in passive acoustic monitoring and acoustic pattern recognition now enable us to comprehensively record and analyze acoustic events over longer periods of time. In this project we studied the call variation of several individual white-lipped frogs (Leptodactylus) over several nights. We tested the potential of individual coding (PIC), i.e. if calls were statistically discriminated between each individual. In contrast to other studies where the test of PIC is usually based on a rather small sample size, our analysis is based on the whole nightly calling activity of individuals (usually more than 10.000 calls of one individual per night), and thus, it takes into account an

unexpected high intra-individual variation in spectral call traits which are usually suggested to be responsible for individual recognition in other frog species. We report on variation in several other call traits including calling effort during and between nights, and we ask if the markedness of the potential individual signature varies during the night.

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Jayasena, Nilmini
Galappaththi, H.G.S.S.
Alahakoon, A.A.C.B.
University of Peradeniya, Sri Lanka
Sieving, K.
University of Florida, Gainesville, U.S.A.

Interspecific communication for predator awareness between yellow-billed babblers and common palm squirrels

ABSTRACT In multi-species associations, animals may gather information from heterospecifics as well as from conspecifics. We hypothesise that the common palm squirrel (Funambulus palmarum) forms foraging associations with flocks of yellow-billed babblers (Turdoides affinis) to acquire information on predators. We predict that babblers would respond with alarm calls to predator presence more frequently than squirrels and that squirrels would change their behaviour in accordance to babbler alarm calls. We also hypothesise that each species would respond to the other's alarm calls indicating the ability to gather information from heterospecific vocalisations. We are testing these hypotheses by conducting playback trials of predator calls with presentation of predator models using predators common to both species (shikra and domestic cat). We are conducting similar trials on squirrels and babblers foraging alone to investigate whether presence of either species influences vocalisation. We are testing for interspecific communication between the two species by playing back heterospecific alarm calls to each species when foraging alone. In squirrel-babbler associations, babblers responded with alarm calls to predators in all of the trials (n=19). In 95% of the trials the initial squirrel response was to babbler alarm calls and not to the playback. None of the focal squirrels responded with alarm calls. Babblers responded with alarm calls to predators in all of the trials even when foraging alone (n=18), while squirrels foraging alone responded with only behavioural changes (n=19). Neither species reacted with alarm calls to the control (spotted dove) trials. Both babblers and squirrels responded to the alarm calls of the other species with behavioural changes in all trials (n=4 each) and sometimes with alarm calls of their own. The results so far indicate that babblers communicate predator threats to both heterospecifics and conspecifics, while both squirrels and babblers obtain information from alarm calls of the other species.

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Jonsson, Thorin
Montealegre-Z., F.
University of Lincoln, U.K.
Clarke, D.
Robson-Brown, K.-A.
Robert, D.
University of Bristol, U.K.

Biophysics of a pronotal Helmholtz resonator enhancing sound radiation in a neotropical bushcricket

ABSTRACT In the animal kingdom, male calling songs are produced for the purpose of attracting females over long distances. In many cases, calls are loud and repeated at a high rate over a long time span. These advertisement calls involve comparatively high sound pressure, as these propagate over greater distances and therefore have greater attraction. But producing loud calls is metabolically costly, and, due to small body size, animals like insects can be poor sound radiators. Therefore, in some acoustically active animals, there is significant benefit from producing sound amplification using specialised body structures, or exploiting signal-enhancing structures from the environment, like baffles or burrows. In this work we report on the biophysics of an unconventional body cavity, the pronotal chamber, developed in males of a small, neotropical bush-cricket species (Acanthacara acuta; Tettigoniidae: Agraeciini) to enhance signal transmission. Apart from the holotype, only a few specimens have been collected from A. acuta. Generally, male bush-crickets produce mating calls by tegminal stridulation, where one wing pos-

sesses a scraper that is rubbed against a file on the contralateral wing. Males of A. acuta are one of the loudest animals heard at night in the Ecuadorean cloud forest, with the main spectral energy of their calling songs peaking at ca. 10 kHz. They are flightless and the wings have been reduced to stridulatory structures that are completely hidden under a large inflation of the pronotum, the pronotal chamber. Using micro-scanning laser Doppler vibrometry, and broadband stimulation, both passive non-invasive methods, we show that this chamber resonates at the frequency of the calling song and at the resonant frequency of the wings. 3D computer models of a male A. acuta obtained from micro-CT scans, and finite element modelling suggest that the physical properties of the pronotal chamber approach those of a Helmholtz resonator.

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Kerchev, Ivan
Institute of Monitoring of Climatic and Ecological, Systems of the Siberian Branch of the Russian Academy of Sciences, Tomsk, RUS

Investigation of acoustical communication and behavior of invasive fir bark beetle *Polygraphus proximus Blandford*

ABSTRACT Four eyed fir bark beetle is the natural destructor of weakened fir trees in its origin area in the South of Russian Far East, China, Japan and Korea. Presumably P. proximus was transported in Southern Siberia by the Trans-Siberian Railway on unpeeled wood packaging material. In the region of invasion it became the most destructive pest of Siberian fir Abies sibirica Ledeb. due to absence on its new host tree effective defense against invasive pest and its ofiostomatoid associates. The aim of this study was to eliminate a whitespace in knowledge of P. proximus behavior with emphasis on its acoustic component. The presence of elytro-tergal stridulatory organ has been described for this species by Sasakawa and Yoshiyasu (1983). According to critical comments on paper mentioned above from C.H.C Lyal &T. King (1996), the morphology of P. proximus males stridulatory ogan in our study was revised. The normal plectrum instead plots of spines as it described previously is found. Behavioral studies have shown the producing of rivalry chirps by males with evidence of antiphon (frequency range: 1400–22000 Hz), that are produced during contact of two or more individuals. In addition, for males was registered production of more complex chirps before each act of copulation. In courtship chirps production also used ridges on costal margin of elytra and hind legs. The same structures on costal margin of elytra previously discussed as a possible stridulatory apparatus on other species of Curculionidae, but their involvement in sound production hasn´t been observed before. This study was supported by the Russian Federation Presidential Grant: MK-4422.2015.4

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King, S.E.
Fehrenbach, A.K.
Johnson, J.R.
Smith, M.E.
Western Kentucky University, Bowling Green, U.S.A.

Sound-induced hearing loss and recovery in the axolotl *(Ambystoma mexicanum)*

ABSTRACT The axolotl (Ambystoma mexicanum) is used as a model organism for studying development, genetics, and regeneration. Although the sensory hair cells of the axolotl lateral line are able to regenerate, it is unknown whether this also occurs in the inner ear.We recorded auditory evoked potentials (AEPs) of six axolotls at eleven frequencies in order to produce baseline audiograms of underwater pressure sensitivity. Individuals were then subjected to a 48-hour, 150 Hz sound exposure at approximately 170 dB (re 1 μPa). AEPs were then performed to measure hearing thresholds at 0, 2, 4, and 8 days post-sound exposure (DPSE). In the baseline audiogram, axolotls were most sensitive at 600 Hz, with an additional peak of sensitivity at 3 kHz. Following sound exposure, axolotls experienced a 6 to 12 dB temporary threshold shift (TTS). Hearing sensitivity returned to control levels within 8 DPSE, indicating that axolotl hearing sensitivity recovers following acoustical trauma.This study is the first to document hearing loss and recovery in the axolotl. Future studies are needed to correlate these shifts in hearing sensitivity to sensory hair cell loss and regeneration in the axolotl inner ear.

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Kipper, Silke
Technische Universität München, Germany
Bartsch, C.
Freie Universität Berlin, Germany
Weiß, M.
Federal Institute for Risk Assessment, Berlin, Germany

Song features are predictive for male paternal effort in Common nightingales *(Luscinia megarhynchos)*

ABSTRACT The 'good-parent' model predicts that male sexual 'ornamentation' honestly advertises the degree of paternal investment. In passerines, male song is indicative of male attributes and for few species it has been shown that song features also signal paternal investment to females. Males of nightingales Luscinia megarhynchos are famous for their elaborate singing but so far there is only little knowledge on the role of male song characteristics in intersexual communication, and it is unknown whether male song predicts male parenting abilities. We studied the potential relation between courtship song and later parental investment on 20 males of a color-ringed and RFID-tagged population of nightingales in Golm (Potsdam, Germany). Using RFID technology to record male feeding visits to the nest we found that nightingale males substantially contribute to chick feeding. In addition, we analyzed male nocturnal song (prior to breeding) with focus on song features that have been shown to signal male quality before. We found that several song features, namely measures of song complexity and song sequencing, were correlated with male feeding rates. Moreover, the combination of these song features had strong predictive power for male contribution to nestling feeding. These results suggest that females may assess future paternal care on the basis of song features identified in our study. Additionally we underline the importance of multiple acoustic cues for female mating decisions especially in species with complex song such as the nightingale.

Hunger advertising by begging calls in three auk species *(Alcidae, Charadriiformes)*

ABSTRACT Begging behaviour is important element in the parent-offspring conflict. However the majority of the researches in this area have fully been based on call counts, and they agreed that vocal activity was a good indicator of chick's nutritional need and/or condition. Fewer researches were devoted to the temporal-frequency variables of the begging calls themselves and different studies showed opposite results. I studied begging behaviour in three burrow-nested, uniparous species of auks: crested auklet (Aethia cristatella), parakeet auklet (Cyclorrhynchus psittacula), and horned puffin (Fratercula corniculata). These objects provides the opportunity to analyze the signaling value of begging calls in the absence of confounding factors such as nestling competition and predation pressure. The study was conducted in 2013 on the seabird colony of Talan Island (Sea of Okhotsk). I recorded calls of individual chicks (7-9 chicks per species) in two conditions: during natural feeding and after experimental four-hour food deprivation. I found that almost all measured acoustic variables contain information about the chick's state in all species. The hungry chicks produced calls higher in fundamental frequency and power variables and at higher calling rate compared to naturally feeding chicks (e.g. in hungry crested auklet chicks the mean peak fundamental frequency was 2,65±1,16 kHz; in naturally feeding chicks – 1,76±0,66 kHz; ANOVA: F=98,7 p<0,001). The effect of food deprivation on acoustic variables exceeded both the effects of individuality and species. In all species, the frequency variables were stronger affected by hunger than the calling rate and call duration. I suppose that so strong changing of acoustic variables after food deprivation may be explained by the absence of vocal individual identification in these birds. As parents do not need to check their chick's individuality in the burrow, which they find visually, the chicks could use all of the acoustic variables to communicate about their nutritional needs Supported by Russian Scientific Foundation (grant 14-14-00237).

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Klenova, Anna
Lomonosov Moscow State University, RUS

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Klenschi, Elizabeth
Guarato, F.

Jackson, J.C.
Windmill, J.F.C.
University of Strathclyde, Glasgow, U.K.

Technological advances in 3D micro-scanning laser Doppler vibrometry: investigation of the locust ear

ABSTRACT In order to better understand insect hearing, different approaches must be combined to investigate how insect ears detect the different properties of a sound wave, how this signal is transmitted to the central nervous system, and how this information translates into an appropriate behavioural response. The tympanal hearing of the desert locust Schistocerca gregaria has already been the subject of numerous studies investigating membrane mechanics, neurophysiology, and ethology over the past few years. In this context, we are studying the impact of tympanal structure on frequency analysis in the locust. Membrane mechanics have already been investigated in locusts using laser Doppler vibrometry to record tympanal displacement in previous studies. Owing to this approach it is known that, in locusts, sounds of given frequencies will generate travelling waves across the tympanum that propagate to different locations depending on the frequency of the initial stimulus. These travelling waves thus allow for the incoming stimulus to be concentrated in the region of the tympanum best tuned to its frequency, a phenomenon which can be regarded as a first, mechanical step in the process of frequency analysis. The research addressed in this work applies recent technological advances in 3D micro-scanning laser Doppler vibrometry to measure membrane displacement. Thus, in addition to the travelling waves identified through vibration measurements in only one dimension by previous studies, this work has for the first time detected and identified membrane oscillations in three dimensions simultaneously. The results allow us to improve our understanding of the impact of membrane mechanics on frequency analysis in the locust ear.

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Kriesell, Hannah J.
Le Maho, Y.
Le Bohec, C.
Centre Scientifique de Monaco (CSM), France; Université de Strasbourg, France; Centre National de la Recherche Scientifique, Strasbourg, France
Aubin, T.
Université Paris XI, France
Bonadonna, F.
Université de Montpellier, France

Communication in colonial long-lived seabirds: relative contribution of acoustic and visual signalling in sexual selection in penguins

ABSTRACT In order to understand fundamental evolutionary processes, we need to study behavioural and physiological mechanisms involved in sexual selection. Sexual selection is based on intraspecific signalling modalities including visual and acoustic signals. In this study, we aim to investigate the role of calls and ornaments in sexual selection in a non-nesting versus a nesting penguin species: the king penguin (Aptenodytes patagonicus) and Adélie penguin (Pygoscelis adeliae).Data will be collected at three different field sites: Crozet and Kerguelen sub-Antarctic Archipelagos and Terre Adélie in Antarctica. We will record a) display calls of courtshipping individuals, b) physiological (blood samples, body mass) and morphological parameters (beak and flipper length), c) reflectance measurements and size of king penguin's ornaments, and d) nest or territory features. The majority of those birds are being long-term monitored using automatic identification systems, and we have precise life-history information about them: 10.000 king penguins and 2000 Adélie penguins have been fitted with passive integrated transponder tags since 1998 and 2009, respectively.Although both penguin species emit calls that are similarly structured, consisting of a series of syllables separated by strong amplitude declines, calls differ in their complexity and characteristics. Also, unlike the mutually ornamented king penguin, Adélie penguins do not have ornaments (unless cryptic).We predict that the information signalled by display calls of Adélie and king penguins are complementary to the information conveyed by the nest and the ornaments, respectively. We also aim to identify what kind of information is encoded in acoustic (individual display calls) and visual cues (nest-associated features and ornaments) in the mate selection process.

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Kruger, David J.D
Heyns du Preez, L.
North-West University, Potchefstroom, South Africa

The extraordinary vocal characteristics of the South African Common River Frog *(Amietia quecketti)*

ABSTRACT Call repertoire variation for the majority of anuran species usually comprise only of slight modifications of the signature advertisement call, e.g. consisting of a single tonal or pulsatile note, a series of identical repeated notes, or a long trill. The extensive variation in the call repertoire of the South African Common River Frog (Amietia quecketti) has previously been overlooked. This study demonstrates the uniqueness of the call properties of A. quecketti by evaluating the extensive variation in call note types and the occurrence of four nonlinear phenomena. Three call-types for A. quecketti are described, namely biphasic advertisement call, pulsatile aggression/territorial call, and release call. The aggression note emitted by this species is the first reported instance for the Amietia genus. Advertisement calls consisted of an extraordinary variation with four types that are described, namely tonal-notes, creak-notes, iambic-notes, and whine-notes). The calls range widely in spectral characteristics from a narrow-band tonal to broadband chaotic phases, to even broader band, pulsatile advertisement click-notes and pulsatile iambic aggression notes consisting of up to 13 pulses. Temporal variation within pulsatile note-types could be produced at different rates, from 16 pulses/second in advertisement click-notes, to 90 pulses/second in rip-notes, to extremes of 170 pulses/second in creak-notes. Nonlinear events include biphonation, subharmonics, deterministic chaos and frequency jumps.

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Kugler, Kathrin
Greiner, W.
Luksch, H.
Firzlaff, U.
Wiegrebe, L.
Ludwig Maximilians University, Munich, Germany

Echo-acoustic flow guides flight in bats

ABSTRACT Common to all airborne animals is the need to react fast and correct to rapid changes in their environment during flight. Visually guided animals tackle this challenge by evaluating visual flow, generated by their movement through structured environments. Echolocating bats flying in complete darkness cannot make use of visual flow; they can navigate solely by echolocation, i.e, the auditory analysis of self-generated sounds. In contrast to vision, echolocation provides explicit distance information through the analysis of echo delay. Here we show that bats exploit echo-acoustic flow to navigate rapidly through narrow passages. Specifically, we find that bats' navigation between lateral structures is significantly affected by the echo-acoustic salience of those structures, independent of their physical distance. This is true despite the stroboscopic nature of echolocation which interferes with a motion percept and although echolocation, unlike vision, provides explicit distance cues.The results demonstrate that sensory flow elicited by self motion is a ubiquitous principle for guidance of flight in the animal kingdom, independent of the fundamentally different peripheral representation of flow information across the senses of vision and echolocation.

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Lampe, Helene M.
Labra, A.
University of Oslo, Norway

Exploring the relationship between song characteristics of fathers and sons in pied flycatchers

ABSTRACT Song may play a key role in sexual selection in birds. Males use song to attract females and defend territories. In pied flycatchers (Ficedula hypoleuca), the complexity (e.g. repertoire size, versatility) of male song is a good proxy of their quality (e.g. condition, experience), and females use this honest information to select their mate. Males sing until they have attracted a female, but do not use song to defend the territory and more

or less stop singing after pairing, unless singing in their secondary territory to attract a second female. If songs are relevant for male fitness, it may be expected that sons inherit song characteristics. In addition, fathers may be important song tutors for their sons, as has been found in other species. Therefore, fathers and sons could share song syllables since males sing occasionally when feeding nestlings. We tested the two hypotheses using song recordings from a long-term study of pied flycatchers collected during 31 years. We had recordings of both fathers and sons in 28 cases. For each male, we analyzed 25 songs, measuring seven variables: 1) repertoire size (different syllable types in 25 songs), 2) total syllables sung, 3) N° different syllables per song, 4) N° syllables per song, 5) song sample versatility (var1/var2), 6) song versatility (var3/var4), and 7) duration. We found that there is no relationship between any of these variables between fathers and sons even when considering the age of the individuals. The percentage of syllables shared by fathers and sons ranged from 0 to 60%, and did not correlate with any of the sons' song characteristics. In summary, results indicate that in pied flycatchers the capability to sing more attractive songs for females (e.g. complex) is not inherited, and fathers play a variable role as song tutor.

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Lankau, Hedwig E.
Bayne, E.
University of Alberta, Canada

Developing standards and methods for bioacoustic data collection and processing in Alberta, Canada

ABSTRACT Acoustic monitoring using autonomous recording units (ARUs) is fast becoming the most common way of surveying avian communities. By placing an ARU at a station, it is possible to record multiple times per day across multiple days. This is particularly beneficial for surveying species that are rare, nocturnal and/or vocalize infrequently because the longer an ARU records at a station, the more likely the species is to be detected. Because there is no human observer present, there is little risk that individuals will behave differently during the surveys. While getting more data is always good, it brings challenges in extracting the information from vast numbers of acoustic files. Within the Bioacoustics Unit, formally established in 2014 as a collaboration between the University of Alberta and the Alberta Biodiversity Monitoring Institute, our research team is working on solutions to the challenges presented by ARU data. Our efforts fall into three main categories: 1) Developing standard protocols for ARU deployment in the field that can easily be used by other researchers, industry, and communities for their own acoustic monitoring programs so that they can collect the data needed for their specific projects and collaborate to generate large data sets over large spatial scales. 2) Research into efficient and effective ways of extracting species data from the recordings using both human observers and auto-recognition software. 3) Developing a training program for acoustic technicians where new technicians receive mentorship and training from experienced staff in both detailed species identification of complex recordings and in the effective use of auto-recognition software. We are successfully collaborating with other research groups and with industry. We have gather more data on rare species that any other single project to date partly because we have developed recognizers than can process thousands of files in a short time period

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Larsen, Ole N.
Wahlberg, M.
Christensen-Dalsgaard, J.
University of Southern Denmark, Denmark

In-air and underwater hearing of the cormorant studied with ABR

ABSTRACT Numerous studies have mapped the hearing abilities of birds in air but currently there is little or no data on how diving birds hear or react to sound under water. Therefore, it is unknown whether the ears and auditory system of diving birds are adapted to underwater hearing. In the present study, we measured audiograms from wild-caught cormorant fledglings (Phalacrocorax carbo sinensis) using auditory brainstem response (ABR). Each bird was anesthetized and the ABR was measured, first, in a sound attenuated and

anechoic box in air and, secondly, with its head and neck submerged approximately 10 cm under water in a large water filled-tank while being artificially ventilated. ABR-responses to calibrated tone bursts produced by a woofer and an underwater speaker, respectively, were measured at different intensities and frequencies to obtain hearing threshold values in air and under water. The shape of the audiogram was similar to that reported for birds of the same size in air. The bandwidth and slopes of the audiogram were similar in air and water. In air the highest sensitivity was found at 1-2 kHz, while the most sensitive response was displaced towards lower frequencies (lower than 1 kHz) under water. Generally, the cormorant ear was not very sensitive to sound, neither in air nor under water. The hearing abilities in water, however, were better than what would have been expected for a purely in-air adapted ear. (Supported by the Carlsberg Foundation 2009_01_0292 and the Danish Council for Independent Research 4002-00536)

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Lattenkamp, Ella Z.
Kauɪɪ, R.
Koselje, K.
Goerlitz, H.R.
Max Planck Institute for Ornithology, Seewiesen, Germany

Do horseshoe bats complement their echolocation with listening for prey-generated sounds?

ABSTRACT Echolocation is a highly sophisticated sensory system for actively probing light-deficient environments. However, due to the stroboscopic and directional emission of the calls and the strong attenuation of ultrasonic frequencies, the space that can be probed by biosonar is limited both temporally and spatially. We hypothesised that this limitation will favour the opportunistic use of additional information for prey detection, such as prey-generated rustling sounds, and that bats thus exploit a much wider range of environmental information than previously believed. We tested this hypothesis in greater horseshoe bats (Rhinolophus ferrumequinum), whose echolocation is specialised for the detection of fluttering insects, but spatially strongly limited due to high call frequencies. We predicted that bats will react to prey-generated rustling sounds by steering their sonar beam towards the position of the sound for further biosonar-based evaluation. To present prey rustling sounds and monitor bat echolocation, we developed a spherical three loudspeaker - eight microphone array. Each loudspeaker was placed next to one microphone and was symmetrically surrounded by three other microphones. Bats were trained to perch in the centre of the spherical array. Per trial, we played back a rustling sound of a moth fluttering in vegetation from one of the loudspeakers, or alternatively phase-randomized or amplitude-inverted versions of the recordings to control for temporal and spectral cues. We recorded the bat's echolocation behaviour simultaneously with all eight microphones for offline analysis of relative call intensity and thus call direction.

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Laverde-R., Oscar
Caycedo-Rosales, P.
Pulgarín-R., P.C.
Cadena, C.D.
Universidad de los Andes, Colombia

Bird songs in the shelf: temporal patterns of songs and vocal output are lost in sound archives

ABSTRACT Understanding the frequency with which animals sing (vocal output) is of critical importance to address a variety of research questions in behavioral ecology and sexual selection. However, information on vocal output, a central component of the investment in signaling, is lacking for most species and is difficult to collect. We asked whether the number of recordings of avian vocalizations in three different sound archives and the times when such recordings were obtained reflect estimates of vocal output and temporal patterns of vocal activity obtained through systematic monitoring of wild bird populations in three tropical forest sites. Based on a sample of 43 montane species, we found significant relationships between the number of recordings of species detected through continuous monitoring over several months and the number of recordings archived in sound collections, especially when accounting for the area of distribution of each

species. In addition, daily activity patterns based on data collected through continuous monitoring over several days did not differ from those based on recordings archived in sound collections in 12 of 15 species of lowland birds. Annual patterns in vocal activity of two species estimated based on recordings in collections closely resembled previously published patterns. We conclude that recordings in sound collections contain valuable information about the vocal output and temporal patterns in vocal activity of birds. This opens the possibility of using sound collections to assess vocal output and to consider it as a variable of interest in studies on the ecology and evolution of birds and other animals that use acoustic signals for communication. We discuss potential caveats of this approach and make recommendations for field workers contributing to sound archives to maximize the potential usefulness of their material.

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Le Maguer, Lucille
Geberzahn, N.
Université Paris Ouest Nanterre La Defense, France, Université Paris Lumières, France
Derégnaucourt, S.
Université Paris Ouest Nanterre La Defense, France, Université Paris Lumières, France and Institut Universitaire de France

Song learning and cognitive abilities in zebra finches *(Taeniopygia guttata)*

ABSTRACT Despite a recent interest in studying cognitive abilities in oscine songbirds, few research focuses on connecting these capacities to singing behaviour in general and to song learning in particular. Song learning itself is a challenging cognitive task and there is evidence in many oscine songbirds that sexual selection favours precisely-learned song. Recently, it has been proposed that the accuracy with which songs are learned may serve as an indicator of other cognitive abilities for females in mate choice decisions. Here we measured the performance of adult male zebra finches (Taeniopygia guttata) in a cognitive task. We used male offspring of a colony where founder males were originally selected to produce the same song. Using a semi-automated procedure, we measured: 1) song similarity between the song of the offspring and the founders; 2) song complexity. We observed an inter-individual variability in the song: some individuals have learned to produce a very close copy of the founders' song while others produced a poor copy. We observed a positive correlation between the similarity score and the song complexity index, suggesting that the most similar songs to the model are also the most difficult to produce. We investigated whether these proxies of song learning (similarity to the song model, complexity index) were linked to the cognitive abilities of the males by evaluating their performance during a reversal learning (colour association) task. We did not observe a significant correlation between proxies of song learning and male performance to solve the cognitive task. These results do not support the idea that the acoustic structure of song could signal cognitive skills in the Zebra Finch. However, additional behavioural tests and song analysis are required in order to confirm that song learning is not linked to other cognitive abilities in this species.

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Leitner, Stefan
Teichel, J.
ter Maat, A.
Voigt, C.
Max Planck Institute for Ornithology, Seewiesen, Gemany

Hatching late in the season requires flexibility in the timing of song learning

ABSTRACT Most songbirds learn their songs from adult tutors, who can be their father or other male conspecifics. However, the variables that control song learning in a natural social context are largely unknown. We investigated whether the time of hatching of male domesticated canaries has an impact on their song development. Average age difference between early and late hatched males was 50 days with a maximum of 90 days. Song activity of adult tutor males decreased significantly during the breeding season. While early hatched males were exposed to tutor songs for on average the first 99 days, late hatched peers heard adult song only during the first 48 days of life. Remarkably, although hatching late in the season negatively affected body

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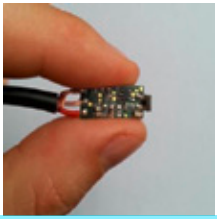

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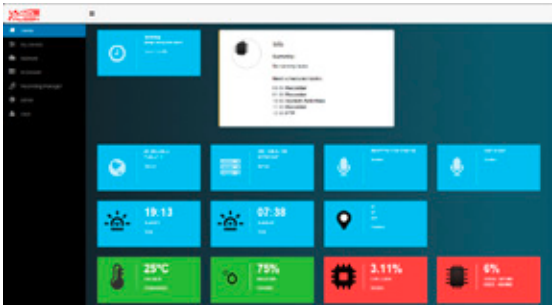

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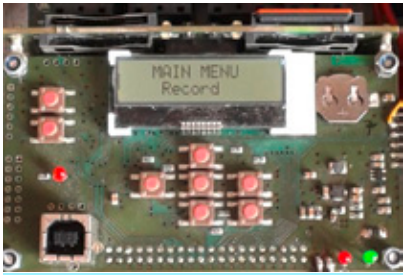

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condition, no differences between both groups of males were found in song characteristics either in autumn or in the following spring. These data suggest that late hatched males must have undergone accelerated song development. Furthermore, the limited adult tutor song exposure did not affect song quality.

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Lewanzik, Daniel
Goerlitz, H.R.
Max Planck Institute for Ornithology, Seewiesen, Gemany

Low-intensity echolocation plus intensity compensation – a means for barbastelle bats to remain undetected by eared moth

ABSTRACT The arms race between insectivorous bats and their insect prey lead to the convergent evolution of ultrasonic sensitive ears in several insect taxa. Eared moths perform evasive flight manoeuvres when they hear bat echolocation calls, thereby significantly decreasing their risk of predation. Yet, the barbastelle bat, Barbastella barbastellus, is able to almost exclusively prey on eared moths. Recently, it has been shown that barbastelle bats emit low-intensity search calls that are not audible to moths at distances at which the bats are already able to detect a moth. However, while bats move towards their prey, the intensity of their calls at the moth's ears increases, eventually becoming audible and potentially eliciting evasive flight. We hypothesized that barbastelle bats lower call intensity while closing in on their prey, such that the intensity at the moth's ear remain below the moth's hearing threshold and the moth fails to elicit the life-saving evasive flight manoeuvre. We tested this hypothesis in the wild by offering tethered moths to free-flying barbastelle bats. We computed the bats' three-dimensional flight paths based on time-of-arrival differences of the echolocation calls at a four-microphone array. We then calculated call source levels and received levels at the moth's position based on an additional miniature microphone at the tethered moth. We show that barbastelle bats continuously reduced call intensity upon detecting a moth and that this intensity reduction is suited to remain undetected by their prey. Barbastelle bats have combined a mechanism for intensity control with low-intensity echolocation to counter moth hearing until the final capture of the moth. This novel strategy might have given them exclusive access to a formerly unavailable food source, thereby probably altering competition between sympatric bat species tremendously. In turn, selection pressure for eared moths might have increased, potentially fostering new anti-bat traits to evolve.

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Linke, Simon
Gifford, L.
Barclay, L.
Karaconstatis, C.
Griffith University, South Brisbane, Australia
Tonolla D.
Zuerich HAW, Switzerland

Real-time acoustic monitoring of freshwater ecosystems

ABSTRACT Traditional methods of freshwater ecosystem monitoring have three key disadvantages due to their invasive nature. The survey techniques bear a) risks to fish health and habitat integrity, b) introduce bias, because it might cause fright responses in key aquatic species and c) standard surveying only produces a snapshot from the time of surveying – which in many cases does not happen more than once a year. Non-invasive passive bioacoustic monitoring can improve all three problems, however it can also offer a holistic real-time glimpse into aquatic ecosystems. We argue that a holistic ecosystem monitoring program is feasible in freshwater ecosystems as a comprehensive literature review has identified considerable knowledge about sonically identifying three key elements in a river ecosystem. 1. Freshwater fish: at least 20% of taxa are estimated to be soniferous. 2. Invertebrates: key indicator families among benthic invertebrates are – at least in part – soniferous. This includes indicators of good water quality (Trichopetera, Odonata) as well as indicators of degraded systems (Coleoptera, Hemiptera) 3. Geophysical habitat: in the last decade, half a dozen studies have measured habitat quality and diversity by sonic properties. With these three main classes of a freshwater ecosystem covered, a real-time holistic ecosystem

assessment seems feasible in the not too far future. We will demonstrate the feasibility of this approach with identified sounds of fish, invertebrate and riverine habitats from Queensland, Australia.

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Lossent, Julie
France Energies Marines, Brest, France
Gervaise, C.
Di Iorio
L.,CHORUS, Fundation of Grenoble Institute of Technology, France

Mapping marine biophony

ABSTRACT 1922 snapshots (10s-long) of sounds have been measured in a small 4km2 coastal area (depth from 0 to 40m) near the pointe of Revelatta (Calvi, Corse). Our aim is to build the soundscape of this complex area hosting four interleaved habitats (rock, seagrass, sand, coralligenous). Wide Band [2kHz, 40kHz] SPL is maximum at the rocks and decreases offshore with the regression law: SPL (dBre.1µPa) = 147 – 14log10(r) with r the distance to the coastline. The range of detection of the biophony of the rocks extends from 1800 to 8300m. This regression law based on "energetic criteria only" allows to think that the rocks' biophony is loud and propagates to the other habitats. We assess the diversity of the spectral shape of the biophony by computing the PCA of 2 million of measured spectra. The two first eigenvalues explain 50% of the spectral variability. The spectra and their scores 1 and 2 create a continuous cloud in {score 1, score 2} plan. Then, we propose to segment the data in 4 quadrants depending of the sign of scores 1 and 2 of the PCA. Each quadrant produces a family of spectral signatures (spectra with high peak at 3 and 4KHz, spectra with wide bump between 5 and 12kHz, spectra with maximum at high frequency more than 20kHz). The 4 proportions of impulses from a given habitat in each of the 4 quadrants are proposed to describe the diversity of spectrum shape of this habitat. For our data base, each habitat hosts the four families of spectral signature but in different proportions. The coralligenous hosts its own sound production with high frequency impulses. The rocks hosts its own soundbproduction with low frequency impulses. Seagrass habitats "listen" to the rocks and sand habitats "listen" to the rocks and the coralligenous.

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Luís, Ana R.
Couchinho, M.
dos Santos, M.E.
MARE - Marine and Environmental Sciences Centre, ISPA - Instituto Universitário, Lisboa, Portugal

Analyzing a graded acoustic repertoire: the use of discriminant analysis to classify burst-pulsed signals of bottlenose dolphins

ABSTRACT Common bottlenose dolphins (Tursiops truncatus) present a complex acoustic repertoire that comprises three major types of signals: frequency-modulated tonal whistles, echolocation click trains and other pulsed-sounds with high repetition rate. While most acoustic studies of dolphins focus on whistles and/or echolocation clicks, research on burst-pulsed sounds (BP sounds) is still scarce. A set of distinct packets of pulses, usually classified according to their aural appearance fall under the designation of BP sounds. However, BP sounds are mainly ultrasonic signals, with inter-click-intervals (ICI) that cannot be perceived by the human hearing; thus, the use of subjective classifications is doubtful. Multivariate classification techniques based on time-frequency parameters may help to overcome the methodological difficulties faced in BP sounds' categorization. Field recordings of bottlenose dolphins' emissions were collected in the Sado estuary, Portugal, from 2011 to 2015. We analyzed the acoustic characteristics (minimum frequency, maximum frequency, peak frequency, duration, repetition rate and inter-click-interval) of 526 BP sounds classified in three categories ("Buzzes","Creaks" and "Squawks"), using aural features and graphical representation aspects. Preliminary results have shown significant differences in peak frequency (FWelch (2, 165.99) = 5.99, P=0.003), duration (FWelch (2, 357.07) = 239.34, P<0.001), repetition rate (FWelch (2, 154.22) = 721.27, P<0.001) and inter-click-interval (FWelch (2, 214.50) = 447.47, P<0.001). Additionally, we applied a discriminant function analysis (DFA) to previously classified BP sounds. Using a stepwise

DFA, three variables were identified as statistically significant for the discrimination among different burst-pulsed signals: ICI ($F(2,412)=735.97$, $p<0.001$), duration ($F(4,822)=369.35$, $p<0.001$) and repetition rate ($F(6,820)=285.75$, $p<0.001$). Discriminant and classification functions were also obtained, and our model correctly classified 87.9% of the analyzed BP sounds in their a priori categories. Considering human auditory limitations, the use of more objective procedures may help to improve the categorization of animal signals, especially in graded repertoires.

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Ma, Shouwen
ter Maat, A.
Gahr, M.
Max Planck Institute for Ornithology, Seewiesen, Germany

Sensorimotor feedback maintains auditory objects formation

ABSTRACT In an international cocktail party, people are able to identify those who speak the same languages from background noises easier than those who speak other languages. It suggests that there must be neural mechanisms for listener to maintain the language sensitivity of his own languages. Reports in human studies that patients with damages to the Broca's area suffered from aphasia, and also had difficulty in speech comprehension, imply that sensorimotor feedback may influence speech perception. In zebra finch, the sensorimotor nucleus HVC (higher vocal center) corresponds functionally to Broca's area. Both HVC and Broca's area were mostly studied in motor domain, whereas the feedback from motor to auditory domain in speech perception is less known. The aim of this study is to investigate the influence of HVC on auditory object formation with regard to the international cocktail party problem. We employed electrophysiological methods to examine responses to auditory objects in both male and female auditory cortices. We found that the habituation rate to auditory objects was higher in male than in female. Inactivation of HVC in male resulted in decrease of habituation rate. Our results provide evidence that sensorimotor integration affect auditory object formation.

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Maciel, Israel
Marino Simão, S.
Federal Rural University of Rio de Janeiro (UFRRJ), Brazil
Figueiredo, L.D.
Instituto Federal do Rio de Janeiro (IFRJ), Brazil

High incidence of non-linear phenomena in Antarctic *Phocidae*

ABSTRACT Nonlinear phenomena (NLP) in vocalizations are still poorly studied, possibly because of the difficulty in identifying that phenomenon, their causes and biological meaning. The non-linearity in vocalizations can be generated by anatomical differences in the vocal tract, whether pathological or because it is young individuals with vocal tract still under formation or else be intentionally produced by animal. This study aims to identify these phenomena in Antarctic Phocidae, as well as a discussion of their biological meaning. Data were obtained by hydrophone of Brazil's Navy, fixed to three meters deep, located on Half Moon Island (South Shetland Archipelago, Antarctica). The data was collected by a hydrophone ITC, model 8073, pre-amplified (20dB) as sampling rate of 22 kHz. Since the sample was passive and Phocidae vocalizations have many similarities, we identify until the lowest taxonomic level as possible. The sampling was recorded from 12 to 30 of November /2012, totalling 372 hours and 24 minutes. The recording was divided into 7,448 files with 3 minutes long. They were detected the occurrence of Phocidae from 12 to 16 November /2012, totalling 834 files (41 hours and 42 minutes). Data were analysed using Raven Pro 1.4 software. Were found 1,786 vocalizations, composed of 930 (52.22%) containing NLP's (e.g. sideband, harmonic, sub-harmonic and bifonation) and 851 (47.78%) without NLP's. Most of the vocals without NLP's consist of pulsed sounds. Bifonic calls regularly showed the same pattern and are unlikely to the incidence of duets. Witch one of the different vocalizations types showed consistently the same type of nonlinearity. In addition, NLP's occurred every day in which there was presence of Phocidae, indicating with production intend a biological meaning in communication. Despite the contribution of this study to understanding NLP's in Phocidae, are necessary more studies seeking understood the meaning of these NLP's in communication.

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Maeder, Marcus
Zurich University of the Arts ZHdK, Switzerland
Zweifel, R.
Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Birmensdorf, Switzerland

„Phyto-acoustics“: acoustic emissions of plants

ABSTRACT Plant physiologists have known that plants emit sounds for several decades now. Many of these sounds are of transpiratory/hydraulic origin and are therefore related to the circulation of water and air within the plant as part of the transpiration process. Some of the acoustic emissions are indications of embolism in the water transport system, which occurs when a plant is subjected to drought stress and desiccation. The excessive water tension in the water-conducting system leads to the rupture of the water columns in the plant vessels. Each plant species—in fact each plant individual—has its own acoustic signature, related to its structure and to the local climatic conditions. Investigating the acoustic emissions of a tree in response to dynamically changing climatic conditions might reveal biological or physical properties that place them in a broader ecophysiological context and enable us to explain processes that are not yet fully understood. In our research, we found an impressive number of acoustic emissions that show different characteristics and occurance than the „classical“ Cavitation pulses caused by embolisms in the plant water transport system. Some of these sounds lie in the audible domain and occur also at night. Such acoustic emissions – which are, as far as we know, for the first time examined in more detail – seem to arise from different processes than light-driven transpiration and relate to other or new models of water transport, distribution of nutrients and plant growth.

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Maigrot, Anne-Laure
Anne, C.
Hillmann E.
Briefer, E.F.
ETH Zürich, Switzerland

Vocal expression of emotions in Przewalski horses

ABSTRACT Expression of emotions plays an important role in social species, including humans, because they regulate social interactions. However, studies testing a direct link between emotions and vocal structure in non-human animals, and especially wild animals, are rare. In particular, little is known about how animals encode in their vocalizations, information about the valence (positive/negative) of the emotion they are experiencing. In this study, we combined new methods developed to study animal emotions and vocalizations, in order to investigate how Przewalski's horses encode information about emotional arousal and valence in their vocalizations. To this aim, we recorded vocalizations produced by the animals in naturally occurring situations characterized by different emotional arousal and valence. Negative situations consisted in agonistic interactions and positive situations in affiliative interactions and food anticipation. Behavioural measures taken when the animals are vocalizing confirmed their emotional states. The results of these experiments provide better knowledge of the way in which emotions are encoded in wild mammal vocalizations. The vocal indicators of emotions that we found would be particularly useful for welfare assessment of wild species, which cannot be easily approached and manipulated, such as the Przewalski's horse that is endangered. Finally, comparisons of our results with those of similar studies in domestic species may reveal interesting findings about the effect of domestication on the structure of animal vocalizations.

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Manfrini, V.
Zoomarine Italia, Rome, Italy
Pelicella, I.
Dodotronic, Rome, Italy
Basile, E.
Zoomarine Italia, Rome, Italy
Pavan, G.
Università di Pavia (CIPRA), Italy

Acoustic monitoring of a pregnant bottlenose dolphin *(Tursiops truncatus)* under human care

ABSTRACT The observations under human care allow to study the behavioral patterns of the pregnancy and mother-calf relationship thanks to non-invasive methods. The same observations in the wild are not easy. Veterinary examinations (e.g. ultrasound) together with the collection of physiological data (e.g. feces) and behavioral (e.g. flexions) allow to monitor the pregnancy over time and to determine the date of birth. This protocol was used to determine the date of calf birth of a Tursiops truncatus female hosted at Zoomarine Italia (Rome). In addition to the observation, we also collected acoustic data of the pregnant female (20 hours) and the couple mother-calf (20 h.) over several days and at different times. In the pool there was the female and then the mother-calf pair. The other bottlenose dolphins were in other connected pools, but the gates were closed by watertight doors. The recordings were made by an Aquarian Audio hydrophone model AS-1 with piezoelectric sensor (not pre-amplified) connected to a preamplifier and A / D converter with USB interface Dodotronic Hydromic200K and this to a laptop with Windows XP. The analyses were performed using the software SeaPro (developed by CIBRA) and Audacity. The signals in the audio and ultrasonic band were sampled at 200kHz / 16-bit with a bandwidth of 95 kHz. The acoustic recordings were coupled with the observations of the animals in the pool. This study is a contribution to collecting acoustic recordings in captivity and especially during the pregnancy (very sensitive moment of the life). Although the pool was a reflective environment that introduces many reverberations, it has been interesting to study the female vocalizations (signature whistles, stress signals, echolocation), the mother-calf communication, and behaviors associated to some sounds.

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Marchenko, Alexandra
Beme, I.
Lomonosov Moscow State University, Moscow, Russian Federation
Sarychev, E.
Vitasfera Rare Bird Species Breeding Centre, Moscow region, Russian Federation

Ontogenesis of vocalization in diurnal bird of prey *(Falconifornes)*

ABSTRACT Most of knowledge about bird vocalization ontogenesis comes from studies of song development in passerine birds (Passeriformes), but development of vocalization in other taxa is poorly known. Some Anseriformes and Galliformes demonstrate gradual changes of call-frequency variables values during development, while some Gruiformes, Coraciiformes and Columbiformes show jump-like changes of them. We analyzed early vocal development in two diurnal bird of prey species (Falconifornes): Saker Falcon (Falco cherrug) and Northern Goshawk (Accipiter gentilis). All diurnal birds of prey have semi-altricial chicks that hatch sighted and stay in nests until fledging. We recorded calls from 7 Saker Falcon and 4 Northern Goshawk chicks between hatching and fledging age stages in Vitasfera Rare Bird Species Breeding center. We collected 15 signals per chick every 3 days (1160 signals in total). We found two main call types - begging for food and discomfort call - in chick vocal repertoire for both species. Chicks used calls of both types since hatching. Call-frequency and call duration variables were observed only for begging for food call. Fundamental frequency gradually decreased between calls of hatchlings and fledglings in both species, but it was higher than that in calls of adults. Call duration decreased in saker falcon, but merely fluctuated in northern goshawk with age. According to fundamental frequency changes we divided period between hatching and fledging in two: early and late ones. Thus, we confirm gradual vocal development in diurnal birds of prey.

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Marfull, Reinaldo
Komdeur, J.
Rijksuniversiteit Groningen, The Netherlands
Korsten, P.
University of Bielefeld, Germany

The effect of sibling competition on the acoustic component of begging behaviour in blue tits *(Cyanistes caeruleus)*

ABSTRACT Begging behaviour of nestling birds mediates parent-offspring interactions through continuous adjustments of postures and vocalizations for food. In this context, competitive state and past experience may be key factors to assess costs and

benefits of begging by the offspring. It has been shown that begging postures of hand-raised nestlings can be modified as a result of training regimes, and that these different levels of postural begging may persist later on. Here, we looked at whether competition during early-life influences the acoustic component of begging behaviour between- and within-nests. Using brood size manipulations, we created different sibling competition levels for 36h in natural nests (i.e. reduced and enlarged nests), from which the second lightest and the second heaviest nestlings were chosen to be exposed to 30, 90 and 150 min of food deprivation. We show that isolated nestlings that were satiated to equal levels at the start responded with increased call output (e.g. bout duration, frequency and sound level) with an increase in food deprivation. Remarkably, nestlings reared in broods with low levels of sibling competition (i.e. reduced) showed short and narrow calls with lower dominant frequency and sound level. No within-nest differences were found. These results indicate that the acoustic component of begging is dynamically adjusted according to the present hunger level and the intensity of past sibling competition, and hence expand the evidence on the role of the past experience in shaping relevant early-life behaviours. Potentially, individual offspring may be able to match begging behaviour to optimal levels in relation to family interactions.

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Martin, Juliette G.
University of Edinburgh, U.K. and MARE - Marine and Environmental Sciences Centre, ISPA - Instituto Universitário, Lisboa, Portugal
Luís, A.R.
MARE - Marine and Environmental Sciences Centre, ISPA - Instituto Universitário, Lisboa, Portugal and Projecto Delfim - CPEMM dos Santos, M.E., MARE - Marine and Environmental Sciences Centre, ISPA - Instituto Universitário, Lisboa, Portugal and Projecto Delfim - CPEMM

Differences in the vocal emissions of bottlenose dolphins during surface feeding and bottom foraging events

ABSTRACT The Sado Estuary in Portugal harbours one of the few resident communities of bottlenose dolphins (Tursiops truncatus) in Europe. These dolphins' complex social behaviour entails a particularly diverse vocal repertoire. They emit mainly three different types of sounds: 1) tonal, frequency-modulated whistles, 2) echolocation clicks and 3) rapid repetition rate "burst-pulse" packets, which include so-called "buzzes", "creaks", "squawks", and "bray series", composed of "gulps", "squeaks" and "grunts". Underwater vocal behaviour during feeding and foraging events is of particular interest, since these are critical activities carried out by dolphin groups. Behaviourally, predation episodes on fish schools near the surface are considerably different from the dolphins' search for prey hidden near the substrate. Nevertheless, little is known about how echolocation clicks and burst-pulse emissions differ during these events. Recordings of dolphin vocal behaviour during surface feeding events and bottom foraging events were collected in the Sado Estuary between 2011 and 2015 (213 events). A Mann-Whitney U test revealed that the overall emission rates differed significantly between surface feeding and bottom foraging events ($U(1,212) = 3195.5$, $p < 0.001$). Further analysis showed that emission rates of "creaks", "squawks" and echolocation clicks were significantly higher during surface feeding events ($U(1,212) = 2363.5$, $p < 0.001$, $U(1,212) = 3689$, $p = 0.001$ and $U(1,212) =$ and 3281.5, $p < 0.001$, respectively). These results suggest that, while foraging, these dolphins might depend mainly on passive hearing for prey detection, whereas surface feeding may require more active acoustic emissions. While "creaks" may possess echolocation value, "squawks" may represent social communication signals used in close proximity. However, the specific functions of individual burst-pulses requires further investigation. Also, the question of whether the observed acoustic behaviour is associated with cooperative (e.g. sharing of information) or competitive interactions remains to be answered.

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Martinez-Alvarado, Dariel
Jaramillo-Calle, V.
Rivera-Gutierrez, H.R.
Universidad de Antioquia UdeA, Medellin, COL

Does noise affect song activity of oscine and

suboscine species between urban and rural areas?

ABSTRACT Many bird species use song for communicating, and it is well known that birdsong plays an important role for finding mates, defending territories and for social integration. Recent studies on birdsong in urban environments have found that increased noise may limit acoustic communication in birds by masking the song. Bird passerine species are classified in two main groups, birds that learn their song (Passeriformes: Oscines), and birds that do not learn to sing (Passeriformes: Suboscines). While the effect of urban noise on acoustic communication of oscine species has been thoroughly studied, little is known on the responses or strategies of suboscine species. Given that spectral characteristics of song in suboscine species may be consistent through different environments, non-learning species may use different strategies for avoiding the masking effect of anthropogenic noise. We hypothesized that suboscine species may shift the timing and places in which they sing (song activity) for noise avoidance. Here we present a study on the song activity of eight passerine species (four oscine, four suboscine) in eight different localities along an urban-rural gradient, and that differ in noise levels. Five different points were randomly selected at each locality, and song activity of the chosen species was measured by registering the number of strophes sung by species. Song activity and noise levels at each point were measured during five minutes, every hour, during four hours, starting at sunrise. Order of points was randomized. Each locality was visited during four consecutive or semi consecutive days, in case of rain, or bad weather conditions. Our results suggest that song activity differs between oscine and suboscine species, and between urban and rural areas. Our study shows for the first time variation in song activity of oscine and suboscine species in urban and rural localities.

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Martínez-Serena, Abigail
Ibarra-Macías, A.
Torres, L.
Víquez-R., L.
Medellín, R.
Universidad Nacional Autónoma de México,MEX
Gonzáles-Terrazas, T.P.
Ruiz., T.
Jung, K.
University of Ulm, Germany
Tschapka, M.
University of Ulm, Germany and Smithsonian Tropical Research Institute, Balboa, Panama

Mexican bat acoustic monitoring system (SIMMA)

ABSTRACT Despite the current threats faced by many bat species (e.g., habitat destruction, wind farming, diseases), large-scale, long-term monitoring programs for determining bat population trends are non-existent in tropical countries. Existing monitoring programs are limited in time and space due to high costs and the amount of human resources needed. We designed and implemented in a local scale a standardized acoustic bat monitoring protocol for Mexico (SIMMA given by Sistema Mexicano de Monitoreo Acústico). The first implementation of the monitoring program was conducted in a tropical rainforest at Montes Azules Biosphere Reserve in Southeast Mexico. We selected four permanent acoustic recording stations, each station consisting of a forest and a gap or edge site. We used one bat detector at each site (SM3, Wildlife Acoustics) and programmed to record consistently 4 hours per night (18:00 to 22:00) during 30 consecutive nights. To assess the performance of our approach we analyzed the recordings, focusing on the total of collected call sequences, effects of weather and moonlight, and the influence of open and closed spaces on species diversity. In addition, we compared two different recording schedules: one recording the first 4 hours, as established in our protocol, and one recording 12 hours per night. This comparison will help us to evaluate the effectiveness of our protocol, improve the next implementations and allow us to establish a standardized long-term system at national scale.

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Martins, Joao
Fiat Sonitus, Cologne, Germany

Rhythms from the animal world in the practice of composers

ABSTRACT The pervasiveness of animal sounds in musical activity gives plenty of space for investigation of the relevance of animal sounds in musical practice. If music has any parallel to other representational arts, namely painting and sculpture, then animal sounds must have been a constant presence in early stages of human development. It is not possible to listen to these songs today, but by looking into the archaeology of musical instruments and to the recorded practice of musicians, it is possible to get some insights into the music of the time. As soon as a fully fledged music notation system was developed in 13th century, with melodic and rhythmic components, music was represented with a relatively precise method and from the beginning we can observe human interpretations of animal sound. A direct reference can be heard in the original work of the 13th century „Sumer Is Icumen In", where the cuckoo song is developed as a canon. Examples of this practice can be found in the works of numerous composers to this day, with a special mention to Olivier Messiaen who exhaustively notated the sounds of birdsong. This work explores and analyses the representation and fixed media examples of music that have drawn influence from animal vocalization. Examples of musical works that have explicit connections to animal vocalisations, whether imitative or symbolic, will be shown in connection to their original animal correlates. The rhythmic features in both vocalisations and musical representations are analysed.

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Matrosova, Vera
Engelhardt Institute of Molecular Biology RAS, Russian Federation
Volodin, I. A.
Lomonosov Moscow State University Moscow, Russian Federation
Volodina, E.V.
Scientific Research Department, Moscow, Russian Federation

What affects alarm call structure in speckled ground squirrels: multifactor analysis

ABSTRACT Processes, responsible for vocal variation in mammals are poorly understood so far. This 10-years-long study focuses on factors affecting evolution of alarm communication in speckled ground squirrels Spermophilus suslicus. In individually chip-marked animals from natural colonies, we investigated effects on the alarm call structure of 1) caller identity, 2) sex, 3) age, 4) time-span between recordings, 5) population membership and 6) genetics. In total, we examined 171 individuals, 10 calls per animal, 8 acoustic variables per call. Caller identity had strong effects on all acoustic variables. Age effects were significant on call duration and fundamental frequency bandwidth. Age-class differences in the maximum and dominant fundamental frequencies of alarm calls lacked despite prominent age differences in body weight (222±50g vs. 88±34g). No sex effect on call variables was found. Twenty individuals were recorded 4 times with time-spans of 1 day, 2 weeks, and 1 year. Calls from individual callers were highly similar within recordings, but vocal individuality decreased drastically with increase of time span between recordings. However, calls remained individualistic, allowing distinguishing individual callers higher than was expected by chance. We compared alarm calls and polymorphism of mtDNA control region for 90 individuals from 6 scattered populations, 15 animals per population. Population membership and individual identities affected strongly the acoustic variables, especially the mean fundamental frequency and duration of the calls. Comparison among populations by acoustic, genetic and geographic distances with Mantel test revealed a highly significant positive correlation between the genetic and geographical distances ($r=0.97$, $p<0.001$) as well as significant correlations between acoustic and genetic ($r=0.66$, $p<0.01$) and between acoustic and geographical distances ($r=0.74$, $p<0.01$). Genetic differences among populations gradually increased with the increase of the geographical distance. Acoustic differences followed the same pattern, in support of gene drift hypothesis. Financial Support: RFBR grant 15-34-20589.

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Matsinos, Yannis
Economou, C.
University of the Aegean, Mytilene, Greece

Defining quietness in urban green areas

ABSTRACT The existence of green areas in a city has proven to be beneficial due to their ability to increase biodiversity and provide city dwellers with several direct and indirect ecosystem services. The provision of quietness, as a direct ecosystem service, is a major indicator of environmental quality. Nevertheless, the way that city inhabitants perceive their acoustic surroundings could determine the character of the landscape along with the quality of the soundscape and define the meaning of quietness that still remains vague. Furthermore, the assessment of acoustic perception in an urban green area could enhance knowledge regarding quiet areas in agglomerations. The way that soundscapes are being perceived by urban park users, is an issue that could be investigated using both, quantitative and qualitative data. A number of noise measurements and sound recordings were conducted, in order to portray the acoustic identity of two parks located in the center of the coastal city of Mytilene, which is a small urban setting in Lesvos Island (North Aegean, Greece). The noise maps that were created, accompanied with the analysis of several acoustic indices (Acoustic Complexity Index, Normalized Difference Soundscape Index), provided the necessary quantitative data. Additionally, a soundwalk including the two urban green areas under consideration was conducted in order to assess the perceived noise level (PNdB) of individuals with the results with the accompanied actual measurements. From the statistical analysis that followed resulted that the quality of each soundscape is directly associated by both audible and visual attributes. Furthermore, the soundwalkers highlighted the "soundmarks" of their preference in order to compose a more desirable soundscape. Quietness in an urban environment, as difficult as it is to be achieved, requires soundscape planning and environmental awareness by its users.

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Matsinos, Yiannis
Economou, C.
University of the Aegean, Mytilene, Greece

Soundwalk as a landscape remodeling driving tool

ABSTRACT A soundwalk is any excursion in the urban and rural landscape, in order to listen to the environment. The purpose of this procedure is soundscape evaluation, primarily using the sense of hearing and secondary the other senses-feelings (mainly optical stimuli). Soundwalks are considered tools in soundscape research that could be used in order to collect the necessary qualitative and quantitative data, concerning a specific location or a larger area. The main driving force of soundwalking, is the acoustic perception of individuals while its flexible methodology, allows application in various interdisciplinary areas such as ecology and urban design. This research focuses on the way that urban park users perceive their acoustic surroundings, incorporating the ecology of bird habitat and vegetation. The participant's acoustic perception was assessed during a soundwalk specifically designed for two urban parks, located in the center of the coastal city of Mytilene, which is a small urban setting in Lesvos Island (North Aegean, Greece). Using a novel soundwalk methodology that differs from the common practices, both quantitative and qualitative data were collected. The scope of this research was to utilize the findings of this soundwalk and visually present them, in order set the ground for a future landscape remodeling. As a result, amongst others, the areas vulnerable to intrusive noise derived. Furthermore, the soundwalkers highlighted the "soundmarks" of their preference and proposed new ones in order to compose a more desirable soundscape and therefore, reshape the landscape.

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Matsinos, Yiannis
Economou, C.
University of the Aegean, Mytilene, Greece

Vocalization attributes of specific song notes and distress calls (churring) between urban and rural great tits *(Parus Major)*

ABSTRACT 40 years after its proposal, the acoustic adaptation hypothesis remains a provisional idea whose merit still requires evaluation. The idea of animals adaptively responding to the alteration of the acoustic background, by respectively altering their vocalizations, as appealing as it sounds to classic biologists, undergoes investigation from

the scientific community. Skepticism is solely based upon the mechanism utilized towards such an alteration –whether a shift in pitch (AAH) or a shift in amplitude (Lombard Hypothesis) takes place. Up to now, studies investigating possible differences between bird vocalizations have been mainly focused on song features. Latter studies attempted to distinguish between these hypotheses by investigating how calls other than songs (e.g. alarm calls) are affected. Our study tried to combine the two approaches and compare specific vocalization attributes of both songs and calls. We compared urban and rural great tits, Parus Major, specific song notes and distress calls (churring), recorded in situ across Lesvos Island in Greece, and selected recordings containing both types of vocalizations from the same individual, thus to eliminate the amplitude difference parameter. We found -as expected- that rural song notes had lower mean frequencies than urban, but no significant difference was found for the distress calls. This latter runs contrary to expectations as suggested by both the hypotheses. Furthermore, the frequency differences observed in low pitched notes of the songs were smaller than the high pitched ones, both findings being totally opposite from the expectation of the response to the low frequency positioned masking Having in mind the words of Hainman (1989) "It may therefore seem ironic that I remain uncertain about vocal organization in this species-but for a simple reason: it mimics other species, including other tits", we conclude that there exists a growing necessity of incorporating ecological aspects in our studies.

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McLeod, Logan
Bayne, E.
University of Alberta, Canada

Using emerging bioacoustic technologies to model for Yellow Rail occupancy

ABSTRACT New technology for acoustic recordings and signal processing have opened up new avenues for monitoring animal populations. Passive, automated recording units (ARUs), are being used widely in Alberta, Canada, for biodiversity monitoring efforts. We have used a classifier, built in the software Song Scope, to automatically detect and classify vocalizations of the Yellow Rail. This species is a monitoring priority in the province given our lack of knowledge regarding its population in the region, as well as, its proximity to energy development. It is rare and poorly detected by traditional surveys because it is nocturnal and its wetland habitats are remote and difficult to access. Occupancy modelling provides us with a useful framework for understanding differential habitat use and changes in sites occupied by the rail. Here, we make use of detection histories derived from our Yellow Rail classifier to produce occurrence estimates. By comparing these estimates with those generated from human processing in a manner akin to traditional surveys we gain important insight into the robustness of occupancy models to a when the input is 'scaled-up'. We aim to determine how the results of the approaches compare.

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Melotte, G.
Michel, C.
Parmentier, E.
University of Liège, Belgium

Sound production in piranhas and relatives: comparisons between species Mélotte, G.

ABSTRACT Acoustic communication plays an important role in the life of many teleost species where it is mainly involved in agonistic and/or courtship behavior. Despite the large number of Serrasalmidae species (92), sound production has been described only in the genera Serrasalmus and Pygocentrus. The aim of this study was first to investigate the sound producing abilities of different Serrasalmidae species and then to describe and understand the corresponding mechanisms. One herbivorous species, Piaractus brachypomus, produces sounds composed of a single pulse. The mechanism would involve the vibration of the bladder due to the hypaxial musculature contraction. In contrast, the calls emitted by Serrasalmus rhombeus, Serrasalmus compressus, Serrasalmus marginatus, Serrasalmus elongatus, Pygocentrus nattereri and Pristobrycon eigenmanni are all harmonic sounds composed of several pulses without inter-pulse interval. They all show the same

kind of mechanism: the sound results from the forced vibration of the swimbladder following the contraction of sonic muscles that are attached to a perpendicular tendon surrounding ventrally the bladder. A last species, Pygopristis denticulata, is able to produce another type of sounds. It consists of several pulses with irregular pulse period and is likely produced by a sonic muscle inserting on the skull and on the rostral part of the swimbladder. The relatively high diversity of sound types and mechanisms in Serrasalmidae will be used in the future to understand the evolutionary development of this particular behavior. Do the mechanisms evolve separately or is there a continuity between them?

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Meyer, Julien
Laboratoire sur le Langage le Cerveau et la Cognition (L2C2), CNRS, Lyon, France

Speaking and singing with whistles around the world: speech and music in a simple narrow frequency band

ABSTRACT The main focus of this paper deals with the results of a worldwide inquiry on whistled speech and whistled singing. Around the world, it is rather common to hear people whistling the tune of a song by following the prosody of its sung lyrics. This kind of performance can be defined as the 'whistling mode of singing' or the 'singing mode of whistling'. It is characterized by a musical valence that puts rather little pressure on the whistler for the transmission of the meaning of the lyrics. By contrast, several remote rural populations around the world also use a special speech register based on whistling that fulfils purely communicative purposes: commonly called 'whistled speech' or the 'speaking mode of whistling'. In these local communities, the speakers learn since childhood to copy any sentence of their language into a simpler whistled signal with the clear objective to transmit spoken messages to the listener(s). Whistled speech is always based on a spoken language. Whistled Greek is still Greek but adapted to another speech register. Basically, people articulate words while whistling and thereby transform spoken utterances by simplifying them, syllable by syllable, into whistled melodies. After 12 years of inquiry we found that the speaking mode of whistling is distributed worldwide. It is not limited to a given continent, language family or language structure. One of the most striking aspects of this whistled transformation of words is that the whistled sentences remain highly intelligible to trained speakers in several languages, despite a reduced acoustic channel to convey meaning. By comparing whistled speech and whistled singing in several languages of the world we also managed to explain their typology and to explore the intricate relationship between music, speech and language in whistling.

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Mishima, Yuka
Morisaka,T.
Mori, Y.
Miyamoto, Y.
Tokyo University of Marine Science and Technology, Japan

PS1 call is determined as an affiliative contact call in captive belugas *(Delphinapterus leucas)*

ABSTRACT Previous studies on one captive beluga population in Japan indicated that they frequently exchanged one of the pulsed sounds ("PS1 call"). PS1 was the most common call type in isolation context. Some acoustic parameters of PS1 were individually different, especially inter-pulse interval patterns (IPI contours), which were stereotyped intra-individually. PS1 was thus thought to function as an individualized contact call, but larger samples are required. To verify the PS1 characters and functions which previous studies suggested, we collected PS1 calls from other captive belugas kept at Shimane Aquarium in Japan. There were two beluga pools, the pool A containing three belugas and the pool B containing four belugas. Recordings were made in both pools during free swimming. The pool A belugas produced PS1 calls most frequently with 40% (971 calls) of total calls during twelve 30-min sessions. Analysis of Inter-PS1 intervals represented that PS1 calls were produced in bouts with a criterion interval of 5.1 s. Only 2 out of 69 aggressive behavior occurred in PS1 bouts and the number of aggressive behavior per unit time was significantly smaller in PS1 bouts than other

times (Wilcoxon Signed-ranks Test, P=0.0224). PS1 sequences by different belugas occurred most commonly within an interval of 0.5 s (28.0%), and 75.1% of the sequences occurred within 2.0 s. Individual comparison on temporal parameters of PS1 calls revealed that duration and the number of pulses were significantly different (one-way ANOVA, F(2,151)=52.72, P<0.0001 and Kruskal-Wallis test, $\chi 2$=64.98, P<0.0001, respectively). Furthermore, the belugas had individually specific, stereotyped IPI contours in PS1 calls with some variables at extremely lower rate. These results suggested that PS1 was commonly produced, affiliative call type and used for vocal exchange not only in one captive population but as a species character of belugas. The results of pool B belugas will also be presented.

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Montealegre-Z., Fernando
Sarria, F.
Chivers, B. D.
Jonsson, T.
University of Lincoln, U.K.
Robert, D.
University of Bristol, U.K.

Song quality and sound-generator asymmetry in bushcrickets

ABSTRACT Male bushcrickets (or katydids) generate mating songs to call distant females by wing stridulation. The calls are usually ultrasonic although many species communicate in the human audio range, and the call varies from sharp pure tones (tonal calls of high purity) to broadband (non-resonant calls with noisy spectra). The right wing possesses a plectrum (the plectrum bearing wing PBW), while the left wing bears a file (referred to here as the file-bearing wing FBW) and sits on top of the PBW. Different to crickets, in which both PBW and FBW are more or less mirror images of each other to the human eye, katydids exhibit remarkable bilaterally asymmetrical wings, with the FBW usually showing atrophied sound radiating areas. The PBW on the other hand has well developed membranous areas for sound radiation. But different from crickets, which have at least three major cells for sound radiation, katydids show a strong tendency to have all these areas reduced to a single major cell (the mirror) in the PBW for sound radiation (some species however, show PBWs with a complex arrangements of cells.) In this research we test the hypothesis that the observed morphological wing asymmetry in katydids has an effect on the resonances of both wings. Using micro-scanning laser Doppler vibrometer and broadband sound stimulation we measured the resonance and wing deflection of both the PBW and FBW across different species of katydids. Results show that across species the stridulatory area of the PBW dominates in the amplitude of deflection, while the FBW tends to be damped. These measurements also allow us to quantify the levels of mechanical asymmetry between both wings. Interestingly, the degree of asymmetry is highly associated with the purity of the call at ultrasonic frequencies.

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Montes-Medina, Adolfo C.
Renton, K.
Universidad Nacional Autónoma de México
Salinas-Melgoza, A.
Centro Tlaxcala de Biologia de La Conducta, México

Functional diversity in the vocal repertoire of the lilac-crowned parrot

ABSTRACT Understanding the role of avian vocal communication in reproduction and social organization requires greater knowledge of the vocal repertoire used to convey information. Parrots have complex social systems, and are vocal learners able to transmit acoustic signals through social interaction. We describe the vocal repertoire of the Lilac-crowned Parrot (Amazona finschi) in nine behavioral contexts (alarm, threat, flight, take-off, landing, foraging, perched, food soliciting, and nesting). We spectrographically classified 101 note-types, though for analysis we considered 38 note-types that were emitted at least 5 times. We evaluated 15 spectral and temporal variables for each note, and identified four Principal Components that explained 75.15% of the variation among notes. Statistical validation of these components using Discriminant Function Analysis determined a final 60.6% correct classification. Vocalizations emitted

in nine behavioral contexts could be separated into two main groups based on frequency and temporal characteristics of short-range, low-intensity calls and long-range, high-intensity calls. The Lilac-crowned Parrot had a diverse vocal repertoire with the highest variety of note-types of any Neotropical parrot, where only Australian psittacines have a richer vocal repertoire. Threat interactions had the greatest variety of notes and proportion of exclusive notes, and alarm calls had the highest frequency of notes/sec. The most common notes used by parrots were notes C (26.4% of notes) and B (23.7%) presented in all behavioral contexts but emitted mainly in long-range, high intensity calls to attract attention of conspecifics. These features indicate that the Lilac-crowned Parrot has a complex system of communication, where differing functions were achieved by modifying the composition of notes, emission rate, and acoustic parameters of notes in each context. Finally, we propose a standardized nomenclature and statistical analysis to permit comparative studies of cross-functional use of vocalizations by parrots to elucidate signal design rules for differing social functions.

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Moskalenko, Viktoria
Goretskaia M.
Belokon, M.
Belokon Y. S.
Lomonosov Moscow State University, Russian Federation
Politov, D.
Vavilov Institute of General Genetics RAS, Russian Federation

Song types are genetically determined in birds with the single song type

ABSTRACT Bird song is a sexually selected male trait where females select males on the basis of song quality. It is well known that in Passerine birds song learning plays an essential role in song development (Hultsch, Todt, 2004; Catchpole, Slater, 2008). Genetics is also important in song development, but little is known about relations between individual genotype and song structure. However females selecting males by preferring certain song characteristics may choose a good genes (Foerster et al. 2003). In our work we test the hypothesis that certain song characteristics may be genetically determined. The Wood Warbler (Phylloscopus sibilatrix) singing a very simple song has been chosen as the model species. Wood Warbler songs consist of two phrases. The frequency modulation of the first phrase is similar in all males, the second phrase varies among males and has three types which differ significantly in frequency band and trill rate ($p<0.001$, 60 males, 10-15 songs per male). Every male performs only one type of the second phrase. We expect that if the second phrase type is genetically determined then the close related males should have the same phrase type. For the preliminary analysis we have studied 95 songs of 19 males, the genetic distances between them were estimated in GenAlEx 6.5 on the basis of 5 micro-satellite loci analysis. Pairwise individual genotype and individual second phrase structure were tested for correlation using Mantel tests. Mantel test showed significant ($p<0.006$) correlation between matrices of male genetic distances and the second phrase structures. This result supports the hypothesis that the Wood Warbler second phrase structure has some genetic determination.

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Motes Rodrigo, Alba
Labra-Lillo, A.
Lampe, H.M.
University of Oslo, Norway

Testing the nutritional stress hypothesis and learning capacity in pied flycatchers

ABSTRACT In songbirds song is used in sexual selection; males sing to compete with other males over territories and/or to attract females. More complex songs are related to high-quality males that have more possibilities of being chosen by a female. It could be possible for a male to exaggerate his quality when singing in order to cheat females. However, if song features are costly to produce, they can be reliable signals of male quality. The nutritional stress hypothesis is an explanation of how songs can be costly. It suggests that if a male nestling is well fed, he has more energy to develop the brain structures needed for singing more complex songs later, while an underfed male needs all

the energy he gets for developing other parts of the body and brain. Thus, males that receive less food should have less complex songs. The pied flycatcher is a good species for testing this hypothesis since the males use songs almost exclusively to attract females, and females are found to prefer large syllable repertoires. We analysed if there was a relationship between the versatility of pied flycatcher songs (number of different syllables per song or song sample) and their tarsus length and body mass measures when nestlings, but found no such relationship. They are open-ended learners, so we also analysed males returning to breed a second time to see if they could improve their songs from their first breeding season to their second. We found that they had on average doubled their syllable repertoires. Thus, female pied flycatchers could use song to separate between males with breeding experienced and inexperienced male.

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Njoroge, Anastasia W.
Affognon, H.
Mutungi, C.
International Center for Insect Physiology and Ecology, Nairobi, Kenya
Richter, U.
Hensel, O.
Mankin, R.
University of Kassel, Germany

Acoustic characteristics of *Prostephanus truncatus (Horn) (Coleoptera: Bostrichidae)* and *Sitophilus zeamais (Motschulsky) (Coleoptera: Curculionidae)*

ABSTRACT Prostephanus truncatus (Horn) (Coleoptera: Bostrichidae), and Sitophilus zeamais (Motschulsky) (Coleoptera: Curculionidae) are highly damaging storage insect pests for maize. Timely detection of infestations using acoustic means can enable effective and timely control measures that help to avoid destructive losses. There is little research on acoustic detection of these two pests. Laboratory experiments were conducted to characterize the acoustic profiles of the last instar larvae and adults of P. truncatus and S. zeamais on stored maize. Spectral and temporal features of recorded sound signals taken in an anechoic chamber were analyzed. Sitophilus zeamais larvae displayed continuous low amplitude impulses whereas P. truncatus larvae displayed continuous higher amplitude impulses. In addition, spectrograms associated with S. zeamais larvae had fewer high energy regions as compared to those of P. truncatus indicating that movement and feeding by the S. zeamais larvae is generally associated with low energy sound. Contrastingly, oscillograms of P. truncatus adults were characterized by lower amplitude impulses compared to those of the S. zeamais adults. Analysis of impulse and burst rates revealed that rates of noise impulses in P. truncatus and S. zeamais sounds varied significantly. For adults, the rates of burst and the impulses per bursts were significantly ($P < 0.05$) different. However, for the larvae, there was no significant ($P > 0.05$) difference in the rate of bursts or rate of impulses although the impulses per burst varied significantly ($P < 0.05$). These findings would be useful in developing maize acoustic sensors for real-time detection of P. truncatus and S. zeamais in bulk storage warehouses.

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Nolan, Huw
Brown, W.
Ballard, G.
Zewe, F.
University of New England, Armidale, New South, Australia

Dingo communication

ABSTRACT Dingoes (Canis familiaris) have a controversial place in the Australian landscape. They are apex predators that many people believe are vital for conservation while to others they are invasive pests to be controlled. Despite this controversy, little is known about their behavior in the wild. As with many canid species, dingoes have complex vocal repertoires that, if better understood, might be used for conservation and management. However, we remain largely ignorant of the role of vocal communication in dingo social systems. Initially, to understand the vocal repertoire of wild dingoes we quantitatively described the recorded vocalizations of 45 trapped animals using acoustic parameters including spectral (such as frequency

and amplitude shifts) and temporal (such as call length) components. Based on this analysis, vocalizations were categorized into seven distinct call types. Dingoes used these call types singly or in combination, with gradation present between some calls. Additional analysis of vocalizations of a random subsample of dingoes from four ecologically distinct habitats (five dingoes per habitat) demonstrated there were habitat-specific differences (p < 05) in their acoustic structure, consistent with predictions of the acoustic adaptation hypothesis. Currently, we are investigating the variation in vocalizations of dingoes recorded in a single habitat. Data collection is on-going but recordings analyzed to date indicate there are acoustic differences in vocalizations associated with factors such as size, status, sex and degree of hybridization. In addition, we are finding differences in the acoustic structure of calls in different contexts, e.g. presence/absence of humans. Understanding the differences in vocalizations of dingoes in varying environments and situational contexts is vital to the success of remote monitoring and can help improve wildlife management and increase our knowledge of the ecology of the dingo.

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Noriega Romero Vargas, Maria F.
Hallerberg, S.
Timme, M.
Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany
Vester, H.
OceanSounds e.V., Germany
Hammerschmidt, K.
German Primate Center, Göttingen, Germany

Bigrams in sequences of pilot whale calls

ABSTRACT Vocal communication is highly evolved in social marine mammals such as killer whales, pilot whales or other dolphins. Their vocal repertoires consist of multiple sounds like clicks, buzzes, grunts, and a variety of pulsed calls including whistles. There is evidence that killer whales have specific call combination and that they communicate by exchanging vocal signals. However, the way these vocal signals are combined and used by the animals is largely unknown. In this study we explore the sequences of pilot whale calls recorded from six different groups of animals. We observe that the distribution of time intervals between consecutive calls is similar for all six groups of whales. Additionally, we analyse pairs of consecutive calls (call bigrams). We are interested in the question whether such combinations occur more, or less often than expected when the calls are assumed to be independent.

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Osiejuk, Tomasz
Jakubowska, A.
Adam Mickiewicz University, Poznan, Poland

Soft song use in the presence of predator and during rival's intrusions in the Ortolan Bunting *(Emberiza hortulana)*

ABSTRACT The soft (low amplitude) song is a poorly understood acoustic communication phenomena despite the fact that it seems to be common and widespread in birds. Several hypotheses were raised in order to explain soft song functionality. We present results from a project design to test all working hypotheses on soft song functionality in the ortolan bunting (Emberiza hortulana). The first experiment (27 males tested twice) was designed to test hypothesis that males use soft song during territorial intrusions to avoid being predated. We used microphone array allowing for amplitude measurements in the field and simulated territorial intrusion into ortolan bunting territories by a stranger male (playback + model presented) in a paired design experiment. In random order, we presented (treatment) or did not (control) a predator model and its calls before simulated intrusion of a non-neighbour male. We found no significant relationship between presence of a predator and response of males to playback with soft song. However, the presence of other conspecific males in vicinity affected response. In the second experiment with similar design we initially lured male to loudspeaker with regular (loud) songs and after approaching to a standardized distance we played back regular or soft song (22 males tested twice). We found that loud songs evoked stronger response than soft songs. However, tested males used soft songs and it seems that this is an acoustic tool for verifying if the potential rival

is close. These results suggest different function of soft song than in any hypotheses presented earlier. (Financial Support: National Science Center, Poland, grant no. 2013/09/B/NZ8/03275).

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Oswald, Julie
Bio-Waves, Inc., Encinitas, U.S.A.
Rankin, S.
NOAA Fisheries, Southwest Fisheries Science Center, La Jolla, U.S.A.
Gannier, A.
Fuchs, S.
Group de Recherche sur le Cetaces, Antibes, France

Geographic variation in delphinid whistles – implications for classifier development

ABSTRACT The Real-time Odontocete Call Classification Algorithm (ROCCA) is a whistle classification module in the acoustic processing software platform, PAMGuard. ROCCA contains classifiers for the tropical Pacific and northwest Atlantic oceans. Can these classifiers be used to analyze data collected in other locations? Characteristics of whistles produced by three delphinid species (Delphinus delphis, Stenella coeruleoalba, S. attenuata) in the tropical Pacific Ocean and Mediterranean Sea were examined to evaluate the differences that exist between and within species. Fourteen variables describing frequency, shape and duration were measured and compared (t-tests and Mann-Whitney U tests, ɪ=0.05). Between-species comparisons showed that the degree of difference varied with location. Few significant differences were found between whistles produced by D. delphis and S. coeruleoalba in the tropical Pacific. In contrast, many significant differences were found between these same species within the Mediterranean. Using Discriminant Function Analysis (DFA), 69% of Mediterranean whistles were classified to the correct species. This correct classification score was significantly greater than chance (ɪ2 test, ɪ = 0.05). In contrast, the correct classification score for the tropical Pacific (55%) was not significantly greater than chance (ɪ2 test, p = 0.37). This implies that, for these species, differences within the tropical Pacific are smaller than differences within the Mediterranean. Within species, 72% of S. coeruleoalba whistles and 73% of D. delphis whistles were classified to the correct ocean basin. Within the tropical Pacific, many significant differences were found between populations of D. delphis recorded in the North and South Pacific and between subspecies of S. attenuata (coastal – S.a. graffmani, and offshore – S.a. attenuata). Using DFA, 95% of D. delphis whistles and 80% of S. attenuata whistles were classified to the correct population or subspecies. These results suggest that classifiers should be trained using data collected in the location where they will be used.

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Padilla de la Torre, Monica
Briefer, E.
Hillmann, E.
ETH Zurich, Switzerland

Vocal expression of emotion in cattle

ABSTRACT Emotions have a crucial function for an animal's life, because they facilitate responses to external or internal events of significance for the organism; positive emotions trigger approach behaviour towards stimuli that enhance fitness ("rewards"), whereas negative emotions trigger avoidance behaviour when encountering stimuli that threaten fitness ("punishers"). Expression and perception of emotional states play an important role in social species, because they inform individuals about the probable intention of behaviours of others and therefore, regulate social interactions. Although some studies have suggested that emotions might be encoded in vocalisations, it has never been tested in cattle. To achieve this goal, we triggered emotions in beef cattle using mother-offspring separation as a negative context, including low arousal (partial isolation – physical but not visual) and high arousal (full isolation), and mother-offspring partial and full re-union as a positive context Behavioural and physiological data were collected for each situation, in order to confirm underlying emotional arousal and valence of the situations. Preliminary results showed that cow and calf heart rates were very high during visual re-union and rapidly decreased after full-reunion. In accordance with recent findings about ear positions

in cattle, mothers and calves spent longer times displaying forward ear positions during negative contexts (partial isolation and full isolation) than during positive contexts (partial re-union and full re-union). Preliminary acoustic analyses of cow calls suggested that source-related parameters, such as fundamental frequencies (F0), were lower during partial isolation than during full isolation. As expected, F0 decreased after full re-union with their calves. Nevertheless, calves produced vocalisations exclusively during full isolation. Two different types of vocalisations (high and low frequency calls) were produced in this context. These non-invasive indicators of emotions could allow us to develop better and more accurate welfare measurements for domestic cattle worldwide.

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Palhares, Cíntia O.M.
Lopes, L.E.
Federal University of Viçosa, Brazil

Description of the vocalization of *Melanopareia torquata bitorquata* (D'orbigny & Lafresnaye, 1837) in Mato Grosso, Brazil

ABSTRACT Biocoustics has proven to be a very useful technique for accessing the taxonomy of Suboscines passerines. Preliminary taxonomic studies conducted by LEL using external morphological data suggested that M. t. bitorquata should be given full species status. This taxon is endemic to the open grasslands of eastern Bolivia and south-west Brazil and its conservation status is unknown. This study aims to describe the far-reaching vocalization of M. t. bitorquata, providing the bases for future taxonomic studies. We analyzed 11 tape recordings obtained on December 2009 and November 2014 in the municipality of Vila Bela da Santíssima Trindade, Mato Grosso. We used the Raven Pro 1.5. software for evaluating the following parameters: duration (ms), energy (dB), maximum frequency (Hz) of the notes; internote and interseries intervals (ms); dominant frequency (Hz) and number of notes per series. The notes have a harmonic spectrum structure with until seven harmonic components visible, on the best quality records. The fundamental frequency presents the highest intensity (2,587 kHz ±0,128; n=304), followed by fifth harmonic. It was found in some notes descending frequency modulation until 516,8 Hz from the beginning to the end of the fundamental frequency. There was a significant variation in values of interseries interval (867,41 ms ±1222,49; n=78; CV=104,9%) and number of notes per series (2,81 notes ±1,76; n=68; CV=62,5%). Our results suggests that duration and frequency of the notes as well as intensity and frequency of the harmonic components, can be used as useful measures for taxonomic comparisons between subspecies of M. torquata.

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Parks, Susan
Root-Gutteridge, H.
Cusano, D.A.
Syracuse University, U.S.A.
Conger, L.
van Parijs, S.M.
NOAA Northeast Fisheries Science Center, U.S.A.

Description of the ontogeny of acoustic communication behavior of North Atlantic right whales

ABSTRACT The vocal ontogeny of species can provide insight into their physical and social development and capacity for social learning. North Atlantic right whales (Eubalaena glacialis) are a highly endangered species of baleen whale with a complex range of vocalizations used in a wide range of social contexts, and show evidence of behavioral plasticity of signal production in the presence of noise. In this study, we systematically characterized developmental changes in the sound production behavior from shortly after birth through adulthood. Calls were recorded from 47 different individuals between 2001 through 2015, and include data from calves as young as 1 month of age to adults > 30 years of age. Data included recordings from hydrophone arrays and non-invasive suction cup digital acoustic recording tags. Only calls that could be confidently attributed to a specific whale of known age were used in the study. Analyses indicate a gradual maturation of sound production with increasing age of individuals, with typical stabilized 'adult' vocalizations identified around 4 years of age. Early sound production by calves in their first months of life are generally unstructu-

red, amplitude modulated, and short in duration, often produced during social interactions with their mother. Specific landmarks for vocal development included first occurrence of particular calls types, along with documented evidence of increasing vocal control with maturation including increasing stability of tonal frequencies, a reduction in the presence of chaotic segments within calls, and increasing frequency bandwidth and modulations rates. The developmental changes observed in right whale sound production track those described for other typical mammalian systems and suggest that vocal repertoire development in right whales may rely upon a combination of physical maturation and social learning.

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Penna, Mario
Quispe, M.
Muñoz, M.
Ramos, N.
University of Chile, Chile

Communication amidst biotic and abiotic interference in frogs of the austral temperate forest

ABSTRACT Interfering sounds from biotic and abiotic origins are likely to shape the responsiveness of sound communicating animals. Anurans adopt different strategies to communicate in noisy environments: some species increase, while others decrease their vocal activity in the presence of interfering sounds. The acoustic environments where frogs from austral temperate latitudes communicate are relatively simple; few anuran species vocalize in synchrony, in contrast with jammed tropical sound landscapes. To gain an understanding of the abilities of anurans from temperate environments to overcome interferences of various origins, we explored the vocal activity of male frogs Batrachyla in the southern temperate forest in Chile during exposures to prolonged natural abiotic noises of wind, creek, rain, and to a band-pass noise centered at about the dominant frequency of their calls (2000 Hz). Males were also exposed to synthetic conspecific and heterospecific calls. In response to prolonged noises, males of Batrachyla taeniata increased their vocal output significantly, while B. antartandica and B. leptopus did not alter their calling rates. When presented with heterospecific calls, B. taeniata and B. antartandica decreased their vocal output as compared to their responses to conspecific signals, while the responses of B. leptopus to conspecific and heterospecific calls did not differ over most playback conditions (GLM ANOVAs and Tukey post-hoc tests, $P < 0.05$). Vocal activation overcomes limitations to active space, while decrease in vocal output restricts energy expenditure amidst interference. The different responses in the presence of prolonged noises and temporally-structured signals by these anurans contribute further considerations on the adaptive significance and evolutionary determinants of such vocal strategies by sound communicating animals.
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Pereira Chaves, Patricia A.
University of Saint Joseph, Macau, SAR China and MARE, ISPA, Lisboa, Portugal
Vasconcelos, R. O.
Valdoria, C.M.C.
University of Saint Joseph, Macau, SAR China

Development of the inner ear morphology and auditory sensitivity for social acoustic communication in the Lusitanian toadfish

ABSTRACT Fish represent the largest group of sound producing vertebrates and exhibit the highest diversity in peripheral auditory mechanisms. The inner ear endorgans, including the otoliths and sensory epithelia, grow in most fish species throughout their lifespan. However, studies addressing the functional consequences of such development of the peripheral auditory system in this taxon are rather sparse compared to other vertebrate groups. The highly vocal Lusitanian toadfish (Halobatrachus didactylus) has become a particularly interesting model to investigate questions concerning the development of auditory-vocal systems as social acoustic communication is initiated early in development. A previous study has shown an improvement in auditory sensitivity during development, namely among juveniles (> 5 cm SL), which was coincident with a significant increase in the vocal repertoire. The goal of this study was to investigate

the morphological development of the inner ear saccule (the main auditory endorgan in teleosts) in H. didactylus throughout ontogeny, comparing it with the development of auditory saccular sensitivity in this species. Sensory epithelia were removed from the inner ear saccules of previously fixed specimens, ranging from fry (<1,7 cm SL) to the adult stage (>25 cm). Hair cells were stained with phalloidin and their number, density and orientation patterns determined across the different size groups. Even though the number of hair cells and epithelium size increased with fish growth, the hair cell density remained similar within the 1,7-25 cm range. However, fry <1,7 cm revealed higher hair cell density than older developmental stages. We propose that other morphological features or steroid levels might be involved in the saccular sensitivity improvement in this species. Furthermore, the increased hair cell density early in ontogeny may result from a rapid increase in the hair cell number relative to the growth of the sensory epithelium, which slows and reverses later during development.

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Petrusková, Tereza
Reif, J.
Vokurková, J.
Jiran, M.
Petrusek, A.
Reifová, R.
Charles University in Prague, Czech Republic
Kipper, S.
Free University of Berlin, Germany

Song convergence and aggressive interactions of two closely related songbird species in their contact zone: the case of Nightingales *(Luscinia spp.)*

ABSTRACT Understanding mechanisms causing reproductive isolation and interspecific competition between incipient bird species can provide important insights into the speciation process. We study these mechanisms in closely related species pair of songbirds, Common Nightingale (Luscinia megarhynchos) and Thrush Nightingale (L. luscinia), combining multiple approaches ranging from ecology and genetics to bioacoustics and behavioural experiments. Populations of these two species came recently into secondary contact in Northern and Eastern Europe, where they occasionally hybridize. They are morphologically and ecologically very similar; however, Thrush Nightingales are slightly larger and several lines of evidence indicate competitive dominance of this species. Nightingales in the contact zone show asymmetric convergence in song: most Thrush Nightingale males include in their repertoires song types copied from Common Nightingales but not vice versa. This convergence apparently does not increase hybridization, as hybrids are relatively rare and most of them result from mating of Thrush Nightingale females with Common Nightingale males. As vocalization is an important component of territorial defence, we evaluated in playback experiments the strength of aggressive responses of both species to conspecific and heterospecific song stimuli. The species did not differ in reactions to heterospecific playbacks, suggesting that competitive dominance is not associated with higher interspecific aggressiveness in nightingales. Interestingly, while the Common Nightingale reacted more aggressively to the conspecific stimulus, the Thrush Nightingale showed similarly strong responses to both stimuli. We suggest that this pattern results from mixed singing of the latter species in sympatry, as males may not distinguish conspecifics from heterospecifics by song alone. These results are consistent with the concept of convergent agonistic character displacement, which suggests that vocal convergence might be adaptive in species that overlap broadly in resource use. However, the potential role of female preferences in interactions between the two species, and specifically in song convergence, should also be evaluated.

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Popova, Daria
Beme, I.
Lomonosov Moscow State University, RUS
Sarychev, E.
Vitasfera Rare Bird Species Breeding Centre

Ontogenesis of vocalization in several owl species *(Strigiformes)*

ABSTRACT In comparison with Passeriformes, ontogenesis of birds of prey vocalization is poorly

studied at the present time. The main goal of our research was to study owl vocalization ontogenesis. We were first to trace acoustic signals structure and their time-frequency parameter values change with age (from hatching to fledging and further) in chicks of two owl species: tawny owl (Strix aluco) and great gray owl (Strix nebulosa). In particular, we have studied mechanisms of transformation of juvenile calls into calls of adult birds. Also, we made an attempt to uncover possible reasons of owl calls transformation with age. We choose chick calls that we defined as ones of begging for food as the object of our study; in adult birds we used all recorded acoustic signals as study objects. In addition, comparison between signals of chicks and adults of the same species was made. In our study we checked hypothesis about abrupt changes in signal structure and time-frequency parameters values in chick calls after their eyes opening. We carried out a comparison of acoustic signal parameters values and ways of their transformation with age between owl species: we checked hypothesis about connection between signal structure and time-frequency parameters with habitat features and life habits of the birds. The study was conducted at Vitasfera Rare Bird Species Breeding Centre and supported by RFBR grants I 11-04-00062I and I 14-04-00108/14.

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Porteš, Michal
Petrusková, T.
Pišvejcová , I.
Petrusek, A.
Charles University in Prague, Czech Republic

Who is who? Acoustic monitoring of migratory passerines with complex and simple song as a tool for individual recognition

ABSTRACT In field studies, it is often necessary to identify specific individuals. Colour rings frequently used to mark birds are often difficult to observe, especially in small passerines and dense habitats. Acoustic-based monitoring detecting individuals by their characteristic vocalization is a potentially suitable alternative, but this approach is challenging in species with complex songs. Here we present its application on two species of pipits (Anthus spp.). From a three year study on Tree Pipits (A. trivialis), which often sing in flight or from perches, we conclude that acoustic monitoring based on the syllable repertoire can be substantially more efficient for individual recognition than colour ringing. Repertoire of each banded male was distinct and stable within as well as between seasons; and males with similar syllable repertoires differed in syntax. Thus, we were able to unambiguously identify singing males in the studied population from analysing a recording containing 20–30 songs, and use the data to track territory changes and detect returning individuals. We will contrast these results with those from terrestrial Tawny Pipit (A. campestris) with much simpler song. For this species, we will present first data about song stability of individually banded males recorded repeatedly during one breeding season.

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Prior, Nora
Vignal, C.
Université Jean Monnet, St. Etienne, France
Fernandez, M.
Université Jean Monnet, St. Etienne and INSA Lyon, France
Soula, H.
INSA Lyon, France

Acoustic behavior in paired, breeding and non-breeding condition zebra finches

ABSTRACT Zebra finches are native to the deserts of Australia, where environmental conditions are unpredictable. To facilitate survival in this harsh climate, zebra finches have evolved to be opportunistic breeders and form life-long monogamous pair bonds. Zebra finches integrate several environmental cues in order to make breeding decisions, and in the laboratory, manipulating water availability is sufficient to affect reproductive condition. Importantly, both the initiation and cessation of breeding must also be coordinated at the level of the pair. However, it is unclear how pairs coordinate these decisions. It is possible that acoustic communication between partners facilitates this decision-making. There are at least two ways that a zebra finch could use vocalisations to inform their partner about their state of breeding readiness: (1)

the use of vocalization subtypes (i.e., tet call, distance call, male song) may change throughout the breeding cycle; and/or (2) the acoustic structure of vocalizations may change, functioning as an 'honest signal' for the hormonal or reproductive state of an individual. Here, we recorded acoustic behavior within zebra finch pairs that were visually isolated. When acoustic contact is the only available communication channel, pairs have more synchronized and structured calling exchanges. Pairs were recorded in non-breeding condition (water restriction), breeding condition (water ad lib), and while actively incubating eggs. Firstly, we quantified overall vocal activity and temporal aspects of the calling exchange: call rate, time spent, the cross-correlation of female-male calling, and the frequency and duration of male song in visually-separated pairs. Secondly, we quantified structural parameters of short calls and male song. Determining whether the structure and/or use of vocalizations shifts across breeding cycles will help elucidate the mechanisms zebra finches use to coordinate reproductive attempts, and more broadly contribute to our understanding of partner dynamics in pair-bonded individuals.

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Ptacek, Ladislav
Vanek, J.
Linhart, P.
Muller, L.
University of South Bohemia, Ceske Budejovice, Czech Republic

Improving the automatic bird individual identification method by parametrization data merging

ABSTRACT This research deals with a method for improving an automatic identification of individual birds for cases when only a limited amount of recorded data is available. The method applies pre-merging of the parametrization data before processing the model of an individual. Although the model is based on the same amount of data, it can be made more robust and discriminative because of the data bundling. The testing was based on the Gaussian Mixture Model and Universal Background Model (GMM-UBM) identification method. Ten sets of chiff-chaff recordings were randomly compiled. Each set consists of approximately 2,000 songs; about 1.3 million trials were processed in total. The number of merged data was incrementally increased from two to ten for each experiment. We provided 90 experiments ie. combination of all sets x nine merging levels. An improvement in accuracy of recognition was achieved for 71.4% of these experiments. The achieved improvement was 1.7 % on average, and the highest improvement was 13.4%. The best results consist of the merging of 4 songs, where an average of 2.1% improvement was achieved. There was no direct correlation between any particular merging level and improvement. The results lead to the assumption that the method cannot be apprehended as a universal means for improvement. However it should be useful when it is generally tuned for acquisition of particular data and specific requirements of the experiment. The results demonstrate how the method can partially eliminate disadvantages for cases when only a limited number of records is available. The method should be beneficial in the cases for which there are a small number of songs, short vocal duration, or insufficient recording quality.

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Quispe, Rene
Gahr, M.
Max Planck Institute for Ornithology, Seewiesen, Germany
Sebe, F.
Université Jean Monnet, St. Etienne, France

Seasonal and Daily Timing of Dawn Chorus in an Equatorial Songbird

ABSTRACT In songbirds, the most prominent period of singing occurs prior to sunrise during the reproductive stage, creating the so-called "dawn chorus". Several factors are involved in the regulation of singing at dawn. One important aspect is the close relationship between dawn chorus and territorial establishment, which defines its behavioral context within the annual cycle. Dawn chorus can be stimulated by increased levels of song-controlling hormones, such as testosterone. Besides, environmental factors including food availability, photoperiod, sunrise time, and climatic variables can influence dawn chorus performance.

Thus, dawn singing is intimately linked to the phenological characteristics of the species and their niches. However, much less is known about this behavior in tropical songbirds and there is even fewer information available regarding equatorial populations. We studied the dawn chorus timing in silver-beaked tanagers (Ramphocelus carbo) from an equatorial population at the lowland Amazon of Brazil. During the course of a year, we recorded the seasonal and daily onset of dawn chorus. We correlated this with circulating cortisol and testosterone levels, molting rate and the diet composition estimated by stable isotopes measurements. In addition, we analyzed these data in the context of local abiotic changes, including sunrise and twilight timing, photoperiod and precipitation rate. The dawn chorus was displayed by silver-beaked tanagers for a long period during the year. We found well-defined seasonal/daily timing of dawn singing that differentially correlates with the expression of distinct life history traits. This study contributes to the scarce knowledge of song behavior in equatorial songbirds, in the frame of the annual cycle and the environmental characteristics that define the lowland Amazon regions.

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Riebel, Katharina
Varkevisser, J.
Kriengwatana, B.
Verhulst, S., Leiden University, The Netherlands

How ‚crystallised' is crystallised birdsong? Changes in singing over time in adult male zebra finches

ABSTRACT Morphological sexual ornaments and mate-advertising displays often show age-dependent variation. Many songbird species are closed-ended learners that learn their songs early in life during a limited sensory-motor learning phase and do not change their song repertoire thereafter. However, even if no new songs are learned, singing performance might change over time: song features such as vocal consistency or tempo have been suggested to change with age after song crystallization. We therefore investigated whether long-term changes occur in the crystallized song of the zebra finch, Taeniopygia guttata, an important model for the study of vocal learning and sexual selection. Males' undirected singing was recorded twice, approximately two and a half years apart. Longitudinal comparisons showed changes in performance parameters and song length. We discuss potential implications for intraspecific communication and its relation to senescence.

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Rivera-Gutierrez, H.-R.
Jaramillo-Calle, V.
Martinez-Alvarado, D.
Universidad de Antioquia, Medellin, Colombia

Does song-learning play a role in acoustic adaptation to urban environments?

ABSTRACT Bird species living in the cities may face limitations for communicating in noisy urban environments. Urban birds can avoid the masking effect of urban noise by rapidly adjusting temporal or spectral parameters of the song during noise exposure. For instance, they may increase the song amplitude, sing at higher pitch, or change the timing of singing. Whereas the strategies for noise avoidance are well known for bird species that learn their song (Passeriformes: oscine), little is known on the adaptations of Passerine species that do not learn to sing (Passeriformes: suboscines). Given that many suboscine species inhabit and are common and successful in the cities, we tested whether song learning plays a role in the acoustic adaptation of passerine species in urban environments. We hypothesized that suboscine species may face limitations for rapid changes in acoustic or temporal patterns of their song (song plasticity), and therefore, they may have developed different strategies, compared to oscine species. Using a correlational study in a paired design (urban-rural) we tested whether song activity differs between suboscines and oscines. In addition, using a comparative phylogenetic analysis, we tested if song structure in suboscines that inhabit urban environments is a preadaptation for effectively communicating in noisy places. Our results suggest that suboscine species lack plasticity and show larger song activity, even when noise may mask acoustic communication. On the other hand, song characteristics of suboscines seem to confer an

advantage for communicating in noisy places. Our study tests for first time the adaptations in both oscine and suboscine species for communicating in urban environments.

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Romero-Vivas, Eduardo
Centro de Investigaciones Biologicas del Noroeste, CIBNOR. La Paz, B.C.S, Mexico
Leon-Lopez, B.
University of St Andrews, U.K.

Spectrogram differences approach for extracting fundamental frequency variation of dolphin whistles

ABSTRACT Studying acoustic communication in the wild usually presents the challenge of detecting signals of interest in noisy environments, which is a common situation for underwater species. In addition, the use of stationary underwater devices has increased the capacity of obtaining large amount of acoustic data, leading to an increasing need for accurate automatic detection methods of animal signals. Dolphin species are well known for having a complex acoustic repertoire which includes pulsed (echolocation clicks) and tonal sounds (whistles). We present a method, based on the differences of contiguous windows of the spectrogram, to detect and identify modulation of the fundamental frequency of tonal sounds. We tested the effectiveness of the method using recordings from two dolphin species, long-beaked common dolphins (Delphinus capensis) and bottlenose dolphins (Tursiops truncatus) in the Gulf of California, Mexico. Results show that the structure of whistles can be clearly identified even in noisy environments. This approach is simpler than other current methods, but with a high effectiveness in signal detection and it could be used to complement acoustic classification methods.

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Rosa, Fernando
Sanluis, J.C.
Lüke, J.P.
Universidad de La Laguna, San Cristobal de La Laguna, Spain
Almunia, J.
Loro Parque Foundation, Tenerife, Spain

Looking for number of degrees of freedom at *Orcinus orca* calls for the design of a classifier

ABSTRACT Orcinus orca acoustic behavior has revealed as a source of non-linear calls that includes harmonic limit cycles, biphonations and even chaotic events. The sound production is based on a complex nasal system, and its precise source is under discussion since various decades. Here we try to establish a methodology from differential equation modeling that allows to calculate the number of degrees of freedom of the sound production device in these odontocetes. These number is related with the ability of the animal to choose a call and to control its production, something that must be in a slower temporal scale than the fundamental frequency. We have developed a smart net of hydrophones that have been tested at Loro Parque facilities in Tenerife Island. We start with the acquisition of data and the detection of call events, but our main objective is to produce a good algorithm to classify these calls and even the caller. The determination of the number of degrees of freedom, is directly related with the space parameter to classify.

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Ruiz, A.Tonatiuh
Jung, K.
Schwenker, F.
University of Ulm, Germany
Tschapka, M.
University of Ulm, Germany and Smithsonian Tropical Research Institute, Balboa, Panama

Software-aided identification of Neotropical bat calls: an active learning approach.

ABSTRACT Recent years saw the development of computational methods for the acoustic identification of bat species, using supervised-learning techniques. In order to train an accurate model it is necessary to dispose of a large call library previously verified by human experts. However, usually the manually verified data is scarce since the manual

species identification of calls is time-consuming and requires high skills. To address this problem we propose a novel method for software-aided identification of bat species implementing active learning algorithms. This method aims to minimize the human supervision for training accurate classification models. As database we used a library of echolocation calls of Neotropical bats from Mexico, Panama and Costa Rica with more than 30 species. We designed a user interface (BatAL) to detect and classify sequences of bat calls in field recordings. In addition to an automated classification process we implemented an active learning algorithm (query strategy) that allows to retrain the classification model with new call data. The active learning algorithm processes the new training data and selects the most informative samples. Then this selection is presented to the user (human expert) to reconfirm the calls´ species suggested by the current classification model. After each query the classifier model is retrained, including the newly verified calls. Additionally, to asses which is the optimal configuration of classification models and query strategies we conducted a performance test. We evaluated the accuracy of query strategies such as Uncertainty Sampling and Query-By-Committee combined with classifiers such as K Nearest Neighbors and Random Forest configured singly or as an ensemble. Our results show that our active learning approach is more efficient than supervised learning techniques, as we achieve higher identification accuracy with less training call samples.

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Sarria-S., Fabio A.
Montealegre-Z., F.
University of Lincoln, U.K.
Morris, G.K.
University of Toronto at Mississauga, Canada
Windmill, J.F.C.
Jackson, J.
University of Strathclyde, Glasgow, U.K.

Loud extreme ultrasonic frequencies produced by a small generator

ABSTRACT Male bushcrickets sing by rubbing their wings together to attract distant females. The left wing bears a vein modified as a file and sits on top of the right wing, which bears a scraper. Sound is produced when the scraper is passed across the file. Bushcrickets song frequencies usually range from audible signals (5 kHz) to low ultrasonic (30 kHz). We report on the discovery of Supersonus, a new genus with three new species of predaceous katydid (Insecta: Orthoptera) from Colombia and Ecuador in which males produce the highest frequency ultrasonic calling songs ever recorded from an arthropod. Males of Supersonus spp. call females at 115 kHz, 125 kHz, and 150 kHz. Exceeding the human hearing range (20 Hz - 20 kHz) by one order of magnitude, these insects emit their ultrasound at unusually elevated sound pressure levels (SPL). In all three species these calls exceed 110 dB SPL rms re 20 μPa (at 15 cm). Males of Supersonus spp. have unusually reduced forewings (<0.5 mm2). Using high-speed video synchronized with ultrasound-sensitive equipment, and Laser Doppler Vibrometry, we demonstrate that the right wing radiates appreciable sound, and that the file-bearing wings (left wing) does not show a particular resonance. In contrast to most katydids, males of Supersonus spp. position and move their wings during sound production so that the concave aspect of the right wing, underlain by the insect dorsum, forms a contained cavity with sharp resonance. The observed high SPL at extreme carrier frequencies is better explained by wing anatomy, a resonant cavity with membrane, and cuticle deformation.

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Schneiderová, Irena
Šmíd, J.
Smetanová, M.
Lhota, S.
Brandl, P.
Bolfíková, B.C.
Czech University of Life Sciences, Prague, Czech Republique

Species determination of captive lesser galagos *(Galago spp.)* integrating molecular-genetic and bioacoustic data

ABSTRACT Lesser galagos (Galago spp.) typically show a lack of overt morphological diversity, which complicate their correct determination, thus breeding management at zoos. On the other hand,

they produce highly species-specific vocalizations that can be recommended for species determination. We used molecular-genetic and bioacoustic approach to determine the lesser galagos with unclear taxonomic status kept at European zoos. For this purpose, all major lines were sampled for DNA and their species-specific advertisement calls were recorded. Both approaches were applied successfully, and showed high potential for species determination of the lesser bush babies. Together with data extracted from studbooks, our results confirmed that G. moholi is kept at five zoos, and G. senegalensis at 18 zoos. Surprisingly, molecular-genetic data showed that there are two clearly separated genetic lineages of G. senegalensis at European zoos. The first lineage is represented by animals originating from Ghana and Togo and the second lineage by animals originating from Guinea. Bioacoustic data indicate that the observed variability is at an intra-species level. Study was supported by Internal Grant Agency of the Czech University of Life Sciences in Prague (CIGA CULS Prague) project no.: 20134311.

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Schneiderová, Irena
Schnitzerová, P.
Uhlíková, J.
Brandl, P.
Mateju, J.
Czech University of Life Sciences, Prague, Czech Republique

Differences in alarm calls of juvenile and adult European ground squirrels: findings from a semi-natural enclosure

ABSTRACT The European ground squirrel (Spermophilus citellus) emits alarm calls that warn conspecifics of potential danger. Although it has been observed that inexperienced juveniles of this species emit alarm calls that sound similar to those of adults, studies focusing on juvenile alarm calls are lacking. We analyzed the acoustic structure of alarm calls emitted by six permanently marked European ground squirrels living in a semi-natural enclosure when they were juveniles and after one year as adults. We found that the acoustic structure of the juvenile alarm calls was significantly different from those of adults and that the alarm calls underwent nearly the same changes in all studied individuals. All juveniles emitted alarm calls consisting of one element with almost constant frequency, but their alarm calls included a second frequency-modulated element after their first hibernation as adults. Our data show that the duration of the first element is significantly shorter in adults than in juveniles. Additionally, the frequency of the first element is significantly higher in adults than in juveniles. Similar to previous findings in other Palearctic ground squirrel species, our data are inconsistent with the assumption that juvenile mammals emit vocalizations with higher fundamental frequencies than adults. However, our results do not support the previously suggested hypothesis that juvenile ground squirrels conceal information regarding their age in their alarm calls because we found significant differences in alarm calls of juveniles and adults.

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Schoeppler, Diana
Schnitzler, H.-U.
Denzinger, A.
University of Tuebingen, Germany

Non-paradoxical Doppler shift compensation in *Rhinolophus paradoxolophus*

ABSTRACT Horseshoe bats emit long CF-FM signals to detect prey in narrow space. By compensating Doppler shifts created by their own flight speed the echo frequency is kept in the auditory fovea which allows the evaluation of the prey generated flutter information in the echoes. In horseshoe bats, the species specific CF-frequencies of the echolocation calls correlate negatively with body size. However, members of the poorly investigated R. philippinensis-group are outliers as they emit unexpected low call frequencies despite of their small body size. Rhinolophus paradoxolophus, a member of this group, was named according to the deviating and paradoxical morphology of the nose leaf and the ears. In this study we investigated whether this species also use Doppler shift compensation, and if yes, whether the precision of the Doppler shift compensation system is similar to that of other horseshoe bats. We trained three R. paradoxolophus to

fly from a starting point to a landing grid and analyzed the echolocation and flight behavior. During approach bats shortened call duration and pulse interval and increased duty cycle and terminal FM bandwidth. They also compensated Doppler shifts with high precision and kept the calculated echo frequency constant at a reference frequency independently from their flight speed. Even the offset between the reference and resting frequency was lower than in other horseshoe bats. Despite of the paradoxical morphology, the echolocation behavior in approach flight and Doppler shift compensation of R. paradoxolophus are non-paradoxical and very similar to those of other horseshoe bats.

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Schulz-Mirbach, Tanja
Ludwig Maximilians University Munich, Germany
Ladich, F.
University of Vienna, Austria

Diversity in swim bladder morphology affects hearing in cichlid fishes

ABSTRACT For animals, the sense of hearing plays an important role to gain information about biotic (e.g. predators, prey, conspecifics) and abiotic sound sources in their environment. Several bony fish species have evolved anterior extensions of the swim bladder which come close to or directly contact the inner ears which may result in improved hearing. So far only few comparative studies on two groups (drums and squirrelfishes) have shown that these morphological specializations may enhance hearing abilities; however, outcomes of these investigations were in part contradictory. Here we thus asked whether the diversity of swim bladder morphology in the speciose family Cichlidae affects their hearing abilities. We studied swim bladder morphology and inner ears by dissections and by making 3D reconstructions based on high-resolution microCT imaging. Auditory sensitivities were determined in terms of sound pressure levels (SPL) and particle acceleration levels (PAL) using the auditory evoked potential (AEP) recording technique. The swim bladders in the jewel cichlid Hemichromis guttatus and the rheophilic Steatocranus tinanti lacked anterior extensions and the swim bladder was distinctly small in the latter species. In contrast, orange chromide Etroplus maculatus possessed anterior extensions connecting the swim bladder to the inner ears. Hemichromis guttatus and E. maculatus were able to detect frequencies up to 3 kHz (SPL) whereas S. tinanti only responded to frequencies up to 0.7 kHz. In addition, E. maculatus showed significantly higher auditory sensitivities at 0.5 and 1 kHz than the two species lacking anterior swim bladder extensions. Our results indicate that anterior swim bladder extensions seem to improve significantly auditory sensitivities between 0.5 and 1 kHz. Besides anterior extensions, the size of the swim bladder appears to be an important factor for extending the detectable frequency range (up to 3 kHz).

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Seltmann, Susanne
Max Planck Institute for Ornithology, Seewiesen, Germany

The influence of sleep on song-related neuronal activity in RA – what role does Melatonin play?

ABSTRACT Sleep is essential for song learning and song production in birds. The song control nuclei HVC and RA, which both show changes in their neural activity patterns during sleep, play a crucial role in these processes. The presence of Mel-1B receptors in both nuclei suggests that melatonin may be directly involved. However, it is still largely unknown how melatonin affects song structure and its neuronal correlates. To address this question we used wireless transmitters (~1g including batteries) to record the neuronal activity of individual premotor neurons in the RA of free-ranging zebra finches up to several days while simultaneously manipulating melatonin levels. By using melatonin-containing cream we were able to simulate and maintain natural melatonin levels for several hours with a single, non-invasive treatment. Our results suggest a direct influence of melatonin on the activity pattern in RA. Melatonin was found to increase the interspike interval during the steady firing that RA projection neurons show during non-vocal periods, an effect normally observed in the transition to sleep. Furthermore, we found that melatonin is crucial for the occurrence of an auditory response in RA that occurs spontaneously, or can be triggered by play-

back of bird's own song, during sleep. In absence of melatonin these spiking patterns did not occur. We therefore speculate that the effects of melatonin on RA firing properties are important for the sleep related maintenance of song structure and could also be involved in song learning.

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Sibiryakova, Olga
Volodin, I.A.
Lomonosov Moscow State University, Russian Federation
Volodina, E.V.
Moscow Zoo, Russian Federation

Acoustic variation in Siberian wapiti *Cervus elaphus sibiricus:* effects of sex and age

ABSTRACT Red deer Cervus elaphus is the widespread species that forms many subspecies displaying a strong divergence of vocal characteristics. Studying vocal divergence across subspecies and sex and age-classes of Cervus elaphus might help to trace the evolution of vocal communication in this species. Unlike well-studied European subspecies, acoustic variation of Asian subspecies is poorly understood. We analyzed frequency, temporal and power variables of 251 contact and rutting calls, collected from 20 individuals (3 calves, 9 hinds and 8 stags) of the most abundant Asian subspecies, Siberian wapiti Cervus elaphus sibiricus. We registered open-mouth (oral) and the closed-mouth (nasal) contact calls in all sex and age-classes, whereas the open-mouth rutting calls were only produced by stags. The maximum fundamental frequency was similar between contact calls of calves and hinds (in oral contact calls 1.50 vs. 1.39 kHz, and in nasal contact calls 1.06 vs. 0.81 kHz, in calves and in hinds respectively). The maximum fundamental frequency of stag oral contact calls (0.87 kHz) was significantly lower than those of contact calls of hinds or calves, and lower than in stag rutting calls (1.20 kHz). This study is the first reporting emission of contact calls (oral and nasal) by stags of Cervus elaphus; previously, contact calls were found only in hinds and calves. Siberian wapiti contact calls were close in values of fundamental frequency between hinds and calves, what means only a minor ontogenetic decrease of call fundamental frequency. Siberian wapiti vocalizations were more similar to respective call types of American subspecies than those of European red deer, with intermediate values of fundamental frequency between them, substantially higher than in European subspecies, but substantially lower than in American subspecies. The research was funded by grants from the Russian Scientific Foundation, grant No 14-14-00237.

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Simon, Ralph
Rupitsch, S.
Friedrich-Alexander University Erlangen-Nuremberg, Germany
Steckel, J.
Peremans, H.
University of Antwerp, Belgium

Driverless vehicle guidance by using bio-inspired sonar reflectors

ABSTRACT In tropical South and Central America, some 1000 plant species chose a quite rare pollination system: they are pollinated by bats. As bats are active at night, so too the flowers open and produce nectar at night. These plants must surmount a major challenge; in the absence of light they cannot attract their pollinators with conspicuous colors, as other plants do. Instead they have found a sophisticated solution: they have developed floral reflectors, which reflect the ultrasound signals of bats in special ways, making the flowers acoustically conspicuous to the bats. The trick of these concave shaped reflectors is that the echoes are not only broadcast over a wide range angles of sound incidence but are also marked with a spectral signature, which is acquired through an interference mechanism. Experiments show that such passive acoustic signals can reduce bats' search time for flowers by 50%. Moreover, these signals not only help guide bats to small targets (i.e., flowers) in acoustically complex environments, they also provide information about the flowers' orientation, helping coordinate the animals' approach. We think that such floral reflectors, shaped by evolution to specifically „respond" to the bats sonar signals, could inspire the design of artificial sonar reflectors that may facilitate orientation as

well as navigation of robots and perhaps of cars, as they too are typically equipped with sonar systems. Such systems are often guided by artificial landmarks, including visual signals, laser beacons, and omni-directional radar reflectors, which are already in use to streamline the navigation efficiency of robots. However, there is a lack of suitable sonar landmarks for airborne sonar systems. We think that sonar reflectors inspired by the form of floral reflectors can easily be used as landmarks. They could help guide towards targets and they could function as beacons indicating obstacles. Moreover different forms and types of reflectors may transmit certain kinds of information.

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Singh, Yajuvendra
College of Veterinary Science and Animal Husbandry; DUVASU, Mathura, India
Lathwal, S. S.
National Dairy Research Institute, Karnal, Haryana, India

Bioacoustic sensing an authentic descriptor of individual's identity

ABSTRACT The present investigation was performed to investigate the significant differences for various acoustic features of vocal signals articulated from different individuals of a buffalo herd. Analysis of bioacoustics features extracted from 300 voice samples of ten adult lactating Murrah buffaloes revealed that differences for amplitudes (minimum, maximum and mean), total energy, mean power, pitch (median, minimum, range and mean), mean ($p<0.05$), intensities (minimum and maximum), formants (F1, F2, F3, F4 and F5), bandwidths (B1 ($p<0.05$), B3 and B4), number of pulse, number of period, mean period, unvoiced frames, degree of voice breaks, jitter, shimmer, mean noise to harmonic ratio (%) and mean harmonic to noise ratio (dB) were highly significant ($p<0.001$). Out of these only few acoustic features viz. formants (F1, F2, F3, F4 and F5), number of pulse, number of period and degree of voice breaks were observed to have significant difference for each and every individual dairy buffalo, hence only these features could be selected as the best suited acoustic features for discrimination of individual Murrah buffaloes from their herd. The mean call duration, 1st formant, periodicity and degree of voice breaks of adult lactating Murrah buffaloes were observed to be 2.15±0.05 sec, 900.11 ± 4.21 Hz, 95.31% (183.95 periodic pulses out of 192.99 pulses) and 20.78 ± 0.89% respectively. By using MFCCs the machine learning algorithm along with J48 classifier revealed maximum efficiency of accurate recognition of Murrah calves, heifers and adults with a recognition rate of 95.67% (k= 0.9515), 94.55% (k = 0.9378), and 94.50% (k = 0.937) respectively; while it could actually differentiate these with a recognition rate of 79.72% (k = 0.7727), 73.89 % (k = 0.702), by 74.21% (k=0.7037) respectively.

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Singh, Yajuvendra
UP Pandit Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go-Anusandhan Sansthan, Mathura, India
Lathwal, S. S.
National Dairy Research Institute, Karnal, Haryana, India

Vocalization a passive indicator of developmental stages of dairy animals

ABSTRACT Vocal differences within and between the individual animal was used as a basis for discrimination of calves, heifers and adult individuals of KF cows and Murrah buffaloes in present investigation. The vocal signals produced from ten individuals of each and every category were recorded and edited in order to prepare smaller stationary frames of 10 ms from a total of at least 50 vocal signals from each and every individual. Various vocal signals were analyzed in order to find out the best suited acoustic feature for identification of calf, heifer and adult stages of dairy animals. The vocal signals from calves, heifers and adults KF cows and Murrah buffaloes differed significantly ($p<0.001$) for acoustic features such as amplitude (maximum), total energy, mean power, pitch (Q50%, minimum, maximum and mean), intensity (mean, minimum and maximum), formants (F1, F2, F3, F4 and F5) bandwidth (B1, and B4), number of pulse, number of periods, mean period, unvoiced frames, degree of voice breaks, mean noise/harmonic ratio and mean

harmonic/noise ratio. Regression coefficient 'b' for linear trend line of resonance frequency curve was observed to be the best suited acoustic feature in discrimination of calf, heifer and adult stages of dairy animals. For pattern recognition MFCCs were extracted from all the frames of vocal signals and were utilized in preparation of training and test models for decision making using machine learning algorithm. The machine learning algorithm with J48 classifier was able to discriminate the calves, heifers and adults of KF cows and Murrah buffaloes with an overall rate of discrimination 87.91% and 87.20% respectively. Moreover calves of both the species could be discriminated with a higher rate of recognition (98.83 and 92.35% respectively) than those of heifers and adults. The efficiency of the machine learning algorithm for actual discrimination of calves, heifers and adults of KF cows and Murrah buffaloes was sufficient enough (k = 81.77% and 80.75% respectively).

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Souriau, Abel
Charles University of Life Sciences in Prague, Czech Republic

Asymmetrical song convergence in two hybridizing nightingales: The mystery of "doublespeaking" males

ABSTRACT Nightingale species are considered among the most skilful song performers of European songbirds, by both the diversity of their song and their learning abilities. The common nightingale (Luscinia megarhynchos) and thrush nightingale (Luscinia luscinia) are two closely related species sharing a recent sympatric zone across central Europe. Interestingly, many thrush nightingale males in this contact zone develop a "mixed singing" strategy, copying parts or sequences of songs from the other species' repertoire. Several hypotheses were proposed to explain the occurrence of such song convergence. First, evolution of mix-singing behaviour might be driven by female preferences for males with larger song repertoire, as shown in several other songbird species. Second, the two species have similar habitat preferences, and interspecific territoriality occurs in sympatry. Mixed singing may constitute an advantageous strategy if improved communication with common nightingales reduces the cost of competition between males. Last, mixed singing might simply result from misdirected learning of thrush nightingales, if not costly enough to be counter-selected. On the poster, we will present the first detailed comparison of the repertoire size between sympatric and allopatric thrush nightingale males, focusing on the song type diversity level. Apart from a direct additive effect of whole-song copying, analysis of song syllables show the integration of heterospecific syllables within typical thrush nightingale song types. Surprisingly, some sympatric males also display a higher rate of song improvisation, out of usual species repertoire. Furthermore, we will present spatial distribution of males in sympatric area and investigate the relationship between the extent of mixed singing and density of both species. Though the previous hypotheses would predict to find more mixed singers in close range of common nightingale locations, the actual territory partitioning seems more complex. We conclude by proposing some leads on further potential explanations for the occurrence of mixed singing.

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Sprau, Philipp
Dingemanse, N.
Ludwig Maximilians University, Munich, Germany and Max Planck Institute for Ornithology, Seewiesen, Germany

Plasticity or consistency? Individual differences in territorial defence along urban gradients in great tits *(Parus major)*

ABSTRACT Next to climate change the United Nations considers urbanisation the biggest environmental challenge of our time. In the coming decades the growth of urban areas is expected to attain unprecedented levels with detrimental effects on ecosystems. Whether wild animals will be able to survive in an increasingly urbanized world will depend on their capacity to adapt to these new environmental conditions. In this study we investigated the impact of a suite of environmental traits – i.e. noise, temperature, light, human activity and vegetation structure – that were quantified along urban gradients on territorial behaviour in an urban

great tit (Parus major) population. Using playback experiments we recorded male responses towards simulated territorial intruders. These intrusions were simulated repeatedly to reveal whether birds respond plastic to intruders depending on the environment or whether birds respond consistently across different environmental conditions. This study will show decisively how urbanisation alters behavioural patterns within and between individuals and thereby provides important insights into human-induced micro-evolutionary processes.

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Stepien, Anna E.
Canopoli, A.
Vyssotski, A.
Hahnloser, R.H.R.
University of Zurich and ETH Zurich, Switzerland

Syllable-specific rules in the microstructure of birdsong

ABSTRACT Male zebra finches learn their song by imitating the song of a tutor. After fledging they undergo a practicing period during which they display high variability in song structure. Once they reach adulthood, they sing a stable song that consists of a number of syllables produced almost always in the same sequence. How stable is the adult song? We find that in most birds the pitch of individual syllables during undirected song tends to follow a circadian pattern that is characteristic for that bird. Typical pitch fluctuations consist of higher pitch in the morning and lower pitch in the evening, with overnight discontinuities. Given the known daily variation in song tempo (syllable duration), we explored whether there existed correlations between tempo and pitch within a syllable and whether such correlations agreed with a simple stretching hypothesis according to which the pitch trace within a syllable is fully determined by song tempo, i.e., by the time-warped pitch trace of a reference syllable. Correlations between tempo and pitch allow us to identify different types of syllables. Some syllable types agree with the stretching hypothesis. But others, such as those involving down-sweeps, behave in anti-stretched manners. That is, in the latter syllable types, the pitch in shorter renditions of the syllable is higher than that in longer renditions. We also track whether the sign of correlation between pitch and tempo of song syllables is a feature inherited by juveniles from their tutors or can it be individually changed. Further, we explored the relationships between pitch/tempo fluctuations and brain temperature (above HVC, the ‚song-tempo generator') as well as air-sack pressure, both of which may independently exert influences on pitch and tempo. Project supported by the Swiss National Science Foundation Project 31003A_127024 and ERC-2010-AdG Project No 268911 VOTECOM.

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Stowell, Dan
Clayton, D.
Queen Mary University of London, U.K.

From raw audio to songbird communication networks: fully automating the analysis

ABSTRACT There has been recent progress and much interest in fully automatic bioacoustic analysis such as multiple species recognition. Full automation is important because any step that requires manual intervention (such as selecting regions of song) becomes a bottleneck in scaling up to big data scenarios such as sound archives or large acoustic monitoring programmes. Species detection and recognition give us very useful monitoring data, but beyond those „labelling" tasks we would like to extract details of inter-individual communication patterns such as contact calls and counter singing. We will describe recent work in machine learning methods for analysing songbird communication networks, using a case study with zebra finch recordings. This includes automatic call detection designed to handle multiple overlapping calls, and automatic inference of inter-individual communication tendencies from group calling patterns.

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Sueur, Jerôme
Muséum national d'Histoire naturelle, Paris, France

Ecoacoustics: echoes from a new discipline

ABSTRACT In the past few years, numerous works dealing with animal acoustics did not strictly consider sound as a research topic in animal behaviour but rather as a tool to tackle questions in ecology. Sound emanating from animals, whichever their identity or habitat, can be used as an indicator of ecological processes and thus as a material to investigate biodiversity monitoring, community ecology, landscape ecology, population biology, biogeography, and conservation biology. This new way to see, or better said to listen, animal sound mainly results from a change of scale and goes hand in hand with the development of autonomous recording methods, batch sound analysis tools and peculiar theoretical concepts. This new research can be formalised under a new discipline named ecoacoustics (Sueur & Farina, 2015). In the introduction to the session „Ecoacoustics: a change of scale in the study of animal sounds", I will try to briefly define ecoacoustics and to introduce the main challenges this new discipline will have to face in the future.

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Szymanski, Pawel
Osiejuk, T.S.
Adam Mickiewicz University, Poznan, Poland

Vocal communication behaviour as an indicator of changes in bird populations: a case study of farmland species

ABSTRACT The increasing risk of extinction of wildlife populations is caused to a great extent by human-driven habitat fragmentation. Therefore, it is crucial for conservation biologists to work out effective methods for monitoring and management of declining populations. Such methods should provide valuable information on current status of population which could serve as an early warning system when negative changes in a core population start to proceed. Vocal communication is essential for reproduction and any variation in functional significance can negatively affect individual fitness and population growth rate. Thus, incorporating the study of cultural traits in a conservation has been recently suggested as a novel way to monitor the diversity and status of animal populations. Here we explored the potential of sharing repertoire (a consequence of social learning behaviour) between territorial males as an indicator of changes in populations of Ortolan Bunting Emberiza hortulana - a farmland species undergoing steep declines in most parts of Europe. We showed that in an agricultural landscape of Western Poland the pattern of repertoire sharing varied between landscape plots and depended on habitat fragmentation. In two more fragmented populations, males (N=73) tended to share less repertoire with neighbors than with non-neighbors. On the other hand, in two populations with higher densities and smaller distances between males (N=66), Ortolan Buntings shared higher proportion of the repertoire with their closest neighbors than with non-neighboring males. Our results suggest that changes in vocal communication behaviour can reflect the emergent population status of species vulnerable for rapid decline due to habitat destruction. We emphasize that studying animal cultural traits in landscapes that are changing due to human activity can be more effective and informative than traditional methods based on long-term population monitoring.

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Tanttu, J.T.
Puhakka, L.
Ijäs, A.
Tampere University of Technology, Pori, Finland

Time-frequency analysis of the Marvellous Spatuletail *(Loddigesia mirabilis)* vocalizations

ABSTRACT Marvellous Spatuletail (Loddigesia mirabilis) is a hummingbird species endemic to Peru. The species exhibits lek behavior: during breeding season, individuals gather in lekking sites where the males perform so-called display flights to attract mates. During these display flights, the male raises its long spatule-like tail feathers to its sides and produces a high frequency clicking sound. This sound was originally suspected to originate from the tail feather shafts snapping against each other; however, high-speed camera footage recently obtained by the BBC has proved this not to be the case. We recorded Marvellous Spatuletail vocalizations (male song, bursts of display clicks produced by the males, and female song) in three lekking sites in Huembo, Northern Peru, in autumn

2011. The recordings were made using in the left channel of the recorder (Fostex FR-2) an ultrasound microphone (Laar 10-2) and in the right channel a 'normal' audio microphone (Sennheiser ME-66). We collected the recordings opportunistically, waiting at known lekking sites in the early mornings and late afternoons, and recording individuals that vocalized spontaneously. In this paper we present the results of an extensive time-frequency analysis of the vocalizations. Besides the traditional spectrograms we also apply the Wigner-Ville distribution to study the energy distribution of the sounds. This approach proved useful especially with the clicking sounds, which have very short time duration and contain a wide range of frequencies up to about 30 kHz. Based on this analysis we also discuss some potential production mechanisms for the high frequency clicking sounds.

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Thomsen, Heidi
Dabelsteen, T.
University of Copenhagen, Denmark
Balsby, T.J.S.
Aarhus University, Denmark

Individual variation and vocal matching by imitation in peach-fronted conures *(Aratinga aurea)*

ABSTRACT The peach-fronted conure, Aratinga aurea, lives in a fission-fusion social system, characterized by frequent changes in flock composition, during the non-breeding season. The inherent fluidity of their social dynamics presents peach-fronted conures with a unique set of challenges, such as frequent establishment of dominance hierarchies and fluctuating levels of competition for resources. Therefore, the ability to choose good group mates may be essential for individuals in order to reduce competition and aggression.During flock encounters, peach-fronted conures exchange loud contact calls just prior to fissions or fusions. During these vocal interactions peach-fronted conures will modify the fine-scale structure of their contact calls to imitate that of another interactant. Vocal matching by imitation has been suggested to be a flexible way to address specific individuals in dynamic communication networks and could thus be important in mediating selective associations during fission-fusion events in peach-fronted conures. In this study we conducted a semi-interactive playback experiment on peach-fronted conures in captivity. The study was conducted in order to determine if contact calls emitted during vocal interactions contain information about the identity of the vocalizing individual that could facilitate individual recognition during fission-fusion events. We found that the contact calls emitted as responses to our playbacks contained information about the identity of the vocalizing individual and that the individual distinctiveness persisted in interactions where the individual imitated the playback. The existence of such a robust individually distinctiveness could allow not only individuals taking an active part in interaction but also listeners extracting information from the interaction, to integrate the identity of the caller with social knowledge, such as memories of previous social interactions, that could be used in deciding who to group with during fission and fusion events.

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Tipp, Cheryl
The British Library, London, U.K.

Archiving the sounds of life on earth

ABSTRACT The British Library Sound Archive has one of the world's largest and most comprehensive collections of bioacoustic sound recordings. Founded in 1969, the collection now contains more than 200,000 catalogued recordings of wildlife and environmental recordings, many of which are unpublished and unique to the British Library. The wildlife collection was originally formed to serve as an international resource for bioacoustics research, providing copies of recordings to researchers and archiving field recordings for future generations to benefit from. Today, recordings are also provided for educational projects, exhibitions, private listening, artistic sound installations, musical compositions, broadcasting and commercial publications. Visitors to the British Library's Reading Rooms can engage with the collection in various ways. Digitised content can be accessed through dedicated terminals while analogue material is currently delivered through an appointment based service. Remote

access is available through British Library Sounds, an online resource which provides streaming access to thousands of hours of recordings from across the sound archive, including a range of wildlife and environmental sounds from 1936 until the present day. Soundcloud is another platform that is being increasingly utilised as a means of providing free, downloadable access to a growing number of recordings. In May 2015, the British Library was awarded a Heritage Lottery Fund grant of £9.5 million to help digitise the sound archive's most unique and at risk recordings. This grant will provide much needed digitisation of the library's analogue wildlife and environmental recordings, significantly improving both onsite and offsite access for the researchers of today, as well as preserving the collection for the researchers of tomorrow.

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Ueno, Adriana S.O.
Geraldi, M.
Monticelli, P.F.
University of São Paulo, Brazil

Barking in capybaras: more than just an alarm call

ABSTRACT Alarm calls can be subjected to the influence of the social, ontogenetic and environmental pressures. We investigated the influence of such factors in barking behavior, traditionally described as a warning social signal, in a captive group of capybaras, a species with a high level of sociality structurally organized by a linear dominance hierarchy, at least at the higher positions. We studied a group of 10 individually recognized animals (8 adults and 2 3-month-old juveniles) in a zoo in the municipality of Ribeirão Preto, Brazil, between February and May 2014. We sampled barking behavior during two-hour observation sessions, repeated twice a week. Whenever a bark was heard, we registered the identity of emissor (social status and name), the reactions of all the other members of the group, and the stimulus that triggered the emission. Our results showed that the dominant male barked more often than the other adults and almost in the same rate of juveniles; and that social status of the emitter correlated positively with its success in promoting defensive behaviors in the other members of the group. Furthermore, the bark was not exclusively used as an alarm call and, in fact, was never used in this situation by the pups. Three other stimulus evoked barks: stimulus associated with food delivery (elicited more barks by adults than by juveniles), with playing behavior (elicited more barks by juveniles), and the "standing up and moving away" behavior performed by social companions that were resting close to the emitter. Whether barking in these situations means the same thing or is a matter of maturing and learning skills, we still have to investigate. We suggest that the social status and age of the caller are recognized by the conspecifics through their bark and that it influences the response of the others

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Ulloa, Juan S.
Sueur, J.
Muséum national d'Histoire naturelle, Paris, France
Gasc, A.
Muséum national d'Histoire naturelle, Sorbonne Universités, Paris, France, Gaucher, P., CNRS USR 3456 Guyane, France
Aubin, T.
Université Paris-Sud, Orsay, France
Réjou-Méchain, M.
Université Paul Sabatier-ENFA, Toulouse, France

Temporal and spatial dynamics of a tropical soundmark: the song of the Screaming piha *Lipaugus vociferans*

ABSTRACT Acoustic monitoring has proved to be an efficient approach to monitor wildlife, notably in environments with limited visibility. Surprisingly, large bioacoustic monitoring programs focusing on tropical environments are rather rare. The coexistence of many tropical species generates a fascinating and complex acoustic environment, called soundscape, which remains poorly understood in its structure and dynamics. Here, we adapted signal processing techniques to reveal the spatio-temporal dynamics of a remarkable soundmark of the Amazon basin: the song of the Screaming Piha (Lipaugus vociferans). Using recordings made with an array of 24 microphones in the French Guiana lowland forest, we implemented and tuned a detection system based on spectrogram cross-correlation to

trace the vocalizations of L. vociferans. The system scanned nearly 960 hours of recordings, revealing novel ecological information and rising further questions about this species. We found that spatial patterns of lower activity corresponded to the zone with lowest trees—a known liana-infested forest patch—reflecting that habitat of the Screaming Piha is the mature primary forest. The sampling sites near the creeks had more detections than the sites further away, revealing that the lek mating arena could be distributed strategically to have a nearby source of water. We also found a marked temporal pattern. The lek was active during the whole day, from sunrise to sunset, with two peaks of activity shifted by more than two hours from the dawn and dusk chorus. This noticeable presence on the diurnal soundscape confirms its status of soundmark of the Amazon. Species associated with these iconic sounds could provide a focus for rising awareness and action; a flagship species in terms of conservation biology.

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van Boheemen, Sharina J.
Kauzal, O.
Samperi, F.
Cinerová, M.
Diblíková, L.
Petrusek, A.
Petrusková, T.
Charles University of Life Sciences, Prague, Czech Republic

Simple song doesn't mean low variability – individual variation in the Yellowhammer vocalization

ABSTRACT When studying wildlife ecology, it is often important to distinguish between different individuals. In some cases, acoustic monitoring, which is less invasive than traditional marking methods, could be used for that purpose. It is well known that songbirds can use song characteristics to distinguish between conspecifics; species with both simple and complicated songs typically differentiate between vocalizations of an unfamiliar bird and a known neighbour. This opens the question to what extent people (researchers in particular) are also able to detect individual-specific song structures in bird recordings and use them for individual identification. In species with very simple vocalizations, individuals may differ in frequency or temporal characteristics of songs; in those with complex songs, individual-specific characteristics can be found in repertoire composition. Our model species with a relatively simple song, in which we want to apply repertoire-based individual acoustic monitoring, is the Yellowhammer (Emberiza citrinella). In an extensive database of over 3000 recordings available from a citizen science project monitoring the distribution of Yellowhammer dialects throughout the Czech Republic, we observed a substantial variation in initial song phrases. Almost every male's recording, of a sufficient quality, contained a unique set of initial phrases, indicating a high variation among individuals. These results suggest that despite a relatively simple Yellowhammer song structure, the variation in initial phrases can be used in field research for recognition of males based on their vocalisation. To test whether such approach is indeed feasible, we repeatedly (multiple times a week) record colour-ringed males in a dense Czech population of Yellowhammers throughout the breeding season of 2015. Allowing us to evaluate the repertoire stability within individuals and among-male variation on a detailed temporal and spatial scale. On the poster, we will present the first results of this detailed pilot study.

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Vellema, Michiel
University of Southern Denmark, Odense, Denmark
Zsebök, S.
Université Paris-Sud, France
Bascones, S.
van der Linden, A.
University of Antwerp, Belgium
Gahr, M.
Max Planck Institute for Ornithology, Seewiesen, Germany

Prior singing experiences accelerate subsequent development of vocal skills

ABSTRACT Seasonally breeding songbirds such as the canary (Serinus canaria) need to re-acquire vocal skills each year during the early breeding

season. The detailed temporal dynamics of vocal skill development are not well understood however, and it is unclear in what way the initial development of song differs from the seasonal re-acquisition of song. Female canaries seldom sing under natural conditions, but administrating the hormone testosterone stimulates them to develop singing skills that are typically reserved for males. In this study we investigated the dynamic acquisition and re-acquisition of song after repeated testosterone treatments. The testosterone-induced song of female canaries went through the characteristic phases of song development known for male canaries: subsong, plastic song, and stable song. Although the syllable repertoire was established early during song development, both temporal patterning and frequency modulation of song syllables continued to develop, slowly consolidating over a period of five months. Song production was discontinued for three months by withholding testosterone, and subsequent re-application of testosterone resulted in songs with striking similarity in temporal and spectral organization compared to the initial songs, independent of exposure to singing conspecifics. Interestingly, the song structure consolidated much more rapidly after the second testosterone treatment than after the first, suggesting that canaries retain some of their vocal skills even in periods when no song is produced. It is unclear however, what constitutes this type of skill memory or where this memory is located. We observed that the hormone dihydrotestosterone (DHT), a metabolite of testosterone, did not stimulate naive female canaries to start singing. However, applying DHT to birds with previous singing experience did stimulate them to sing. These findings suggest that singing experiences irreversibly modify the hormonal responsiveness of brain and/or peripheral pathways that control song production, facilitating the rapid retrieval of previously acquired vocal motor memories.

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Villain, Avelyne
Bouchut, C.
Vignal, C.
Université Jean Monnet,Saint-Etienne, France
Fernandez, M.S.A.
Université Lyon/Saint-Etienne, EPI BEAGLE INRIA,France
Soula, H.A.
EPI BEAGLE INRIA, INSERM INSA LYON, France

Behavioural changes in response to background noise sign the importance of intra-pair communication at the nest in a songbird

ABSTRACT Intra-pair communication might play a key role in the coordination of behaviours between mates, which is a central aspect of the biology of monogamous pair bonds in birds. Surprisingly, little is known on the structure and function of this communication. If communication between mates participates in pair coordination during breeding, partners should show strategies to maintain information transmission even under difficult environmental conditions. We examined the effect of an increased level of background noise on intra-pair acoustic communication around the nest in the zebra finch. Using a playback of wind noise inside the nest box, we monitored how partners adapted their acoustic interactions. During incubation, zebra finch mates perform three types of structured call duets at the nest. When one mate returns to the nest and meets its incubating partner, a call duet is performed with two possible outcomes: the returning mate either relieves its partner and takes its turn incubating the eggs (relief duets), or leaves the nest at the end of the duet (visit duets). Other call duets are performed with one mate inside the nest and the other outside (sentinel duets). Despite the experimental noise constraint, mates still performed call duets but with several behavioural changes. Mates increased the number of visit duets, increased their spatial proximity during sentinel duets, and emitted louder, higher pitched and less broadband calls inside the nest box. Relief duets were particularly affected as partners increased regularity and precision in their response to each other in noisy conditions. This may sign the importance of relief duets in coordinating partners during the crucial moments of incubation shifts. Our results show that birds use several signal strategies to cope with noise during intra-pair communication and strongly suggest a role of vocal interactions at the nest in coordinating mates' behaviours. These data reveal how environmental noise might interfere with reproductive success by affecting intra-pair communication.

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Vokurkova, Jana
Ferenc, M.
Horak, D.
Sedlacek, O.
Charles University, Prague, CZE

Seasonality in singing activity of bird communities along elevational gradient of Mount Cameroon

ABSTRACT In relative comparison to the temperate zone, environmental seasonality in tropical areas is much lower. This applies in particular to the temperature and the length of the daylight. Environmental stability throughout the year is reflected in relatively stable food availability. It has been generally expected that tropical bird species can breed year-round and timing of breeding is influenced by less predictable environmental determinants such as precipitation or peaks of availability of food sources. Consequently, it is suggested that also annual cycles of singing activity may not be clearly defined in the tropics. However, such predictions are rarely supported by empirical studies so far. The newly developed bioacoustic approaches using automatic recording of sounds provide probably the easiest way how to obtain the data on a year-round singing activity of bird communities, even on long-term scales. In our study we focuse on seasonality in singing activity of forest birds along elavational gradient of Mt. Cameroon. We compare seasonality and diversity patterns between lowland (350m a. s. l) and upper montane rain forest (2200m a. s. l). Knowledge of the distribution of reproductive effort of bird species in the tropics are a key requirement for any considerations about the differences in the evolution of life histories along altitudinal and latitudinal gradient.

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von Merten, Sophie
Adam Mickiewicz University, Poznán, Poland
Hoier, S.
Pfeifle, C.
Max Planck Institute for Evolutionary Biology, Plön, Germany

The song of wild mice – acoustic divergence in natural populations of mice *(Mus sp.)*

ABSTRACT Mice produce ultrasonic vocalisation (USV) in a range of social contexts. To study a possible evolutionary impact of mate choice based on USV, we analysed the vocalisation behaviour of four populations of wild mice: two populations of the western house mouse (Mus musculus domesticus), one population of the eastern house mouse (M. m. musculus) and one population of the steppe mouse (M. spicilegus). We recorded and analysed the USV of males and females from all populations emitted in different social contexts. For acoustic analysis, we extracted several temporal and spectral features from the recorded songs and compared them between populations and sexes. Using a multivariate analysis, we found quantitative and structural differences in the USV between sexes and between different populations. These results suggest an acoustic divergence of natural populations of wild mice. We further investigated whether the USV show a syntactical pattern, analysing if different elements of vocalisation (syllable types) are arranged sequentially. Our results support the hypothesis that mice do not emit syllable types randomly but use syntactical structure in their songs.

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Zagkle, Elisavet
Greif, S.
Kaucic, R.
Goerlitz, H.R.
Max Planck Institute for Ornithology, Seewiesen, Germany

To buzz or not to buzz? Situation-dependent behavioural flexibility in bat biosonar during object approach

ABSTRACT Behavioural flexibility is the ability of animals to react to and adaptively adjust their behaviour in response to external stimuli. Bats navigate their dark environment with biosonar, a highly flexible sensory system that probes its environment by continuously emitting ultrasonic calls, whose spatio-spectro-temporal call parameters are constantly adapted to the task at hand. During object approach, however, insectivorous bats show

a stereotypic change in echolocation behaviour, called terminal phase, or buzz, characterized by decreasing call duration and increasing call repetition rate. Here, we tested the hypothesis that bats flexibly adapt the spectro-temporal call structure even during the terminal phase to their task and environment. We quantified the echolocation behaviour of three bat species (long-fingered bat, Myotis capaccinii; Schreiber's bat, Miniopterus schreibersii; greater horseshoe bat, Rhinolophus ferrumequinum) in two different contexts, namely when approaching a standard reflective object (prey, wall) and when approaching a water surface for drinking. Echolocation during drinking has been scarcely investigated, yet might be very different due to the unique specular reflection properties of water surfaces. We recorded the echolocation behaviour during object approach in three to six individuals from each species (871 approaches in total) and measured temporal and frequency call parameters in ten echolocation sequences per individual and context. When approaching standard reflective objects, the bats produced typical approach and terminal call sequences, with species-specific differences. For example, M. schreibersii continuously decreased its pulse interval and then emitted the buzz II part of the terminal phase. M. cappaccinii produced grouped approach phase calls and both a buzz I and II in the terminal phase. In contrast, most bats completely omitted any terminal phase calls when approaching water. Our results show that bats can control their biosonar emissions also during the last moments of object approach and flexibly adapt them to their sensory needs.

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Zaytseva, Alexandra
Volodin, I.A.
Lomonosov Moscow State University, Russian Federation
Ilchenko, O.G.
Volodina, E.V.
Moscow Zoo, Russian Federation

Estimating discomfort in a fat-tailed gerbil by ultrasonic joint-calls

ABSTRACT Ultrasonic vocalizations often attend discomfort states in rodent pups. For estimating levels of discomfort, only call number per time unit is commonly estimated, whereas other acoustic variables are often neglected. In this study, we applied the approach based on joint-calls, for estimating vocal discomfort of pups of the fat-tailed gerbil Pachyuromys duprasi. Calls of 35 pups from 9 litters were recorded a few times along ontogeny from 8 to 40 days. During a recording trial, a pup was initially isolated on the table surface for 4 min (isolation context), and immediately after this was handled for 4-5 min (handling context). We supposed that the handling context provoked stronger discomfort compared to the isolation context, so we expected that variables of ultrasonic calls might reflect the increase of discomfort at transition between these contexts. Only trials where pups produced ultrasonic calls in both contexts (n=73 trials) were included into analysis. Joint-calls were prepared for each context of each recording trial, by cut of intercall intervals. In total, 146 joint-calls contained 3955 ultrasonic calls. From each joint-call, we measured 4 power variables: the peak frequency and 3 quartiles, covering respectively 25, 50 and 75% of call energy. The values of the peak frequency and of all the three quartiles were significantly higher at handling compared to isolation context (repeated-measures ANOVA, $p<0.001$ for all comparisons). The most prominent differences were found between 20 and 32 days of life. These results, indicating higher values of power variables with increase of discomfort in ultrasonic calls of gerbil pups are similar to data obtained previously with the same method for audible joint-calls of fur-farmed red foxes Vulpes vulpes. Thus, power variables might encode discomfort in both ultrasonic and audible calls of mammals. Financial support: The Russian Scientific Foundation, grant No 14-14-00237.

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Zollinger, Sue Anne
Brumm, H.
Max Planck Institute for Ornithology, Seewiesen, Germany
Nemeth, E.
BirdLife Österreich, Vienna, Austria

Great tits stay on pitch even as vocal amplitudes and background noise levels increase

ABSTRACT For communication to occur, a signal must meet two criteria: it must be transmitted through the environment to reach a receiver, and it must encode information. A signaler may encounter trade-offs in the maintenance of these two criteria if the same vocal parameter is involved in both. For example, birds and mammals have been found to use a vocal phenomenon called the Lombard effect to flexibly adjust the vocal amplitude of their signals in response to fluctuating background noise levels, maintaining signal transmission through the noise. Frequently the rise in amplitude due to the Lombard effect is accompanied by a rise in pitch, which can also improve signal detection in noise. However, if signal frequency is an important part of the signals information content, then shifts in pitch could also hinder effective communication. In humans, the increase in pitch that often accompanies the Lombard effect is under voluntary control, and a singer can learn to stay on pitch at any vocal amplitude. We tested whether songbirds, like humans, are able to produce their songs at increasing vocal amplitude without also increasing song frequency. We recorded wild-caught adult great tits (Parus major) in quiet, sound attenuated rooms, and during playback of 70 dB(A) broadband noise. We then compared the amplitude and frequency of each song type produced in noise and no-noise conditions for each individual. We found that great tits did not increase the frequency of their songs even as their vocal amplitude increased during Lombard-induced songs. These results demonstrate that songbirds, like trained human singers, can decouple the link between amplitude and frequency to maintain signal transmission in noise without compromising song frequency. Moreover, our observation that the birds stayed on pitch despite a rise in amplitude may suggest that frequency is a critical part of the signal's information content.

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Zsebök, Sándor
Herczeg, G.
Blázi, G.
Laczi, M.
Nagy, G.
Török, J.
Eötvös Loránd University, Budapest, Hungary
Garamszegi, L.Z.
Estación Biológica de Doñana-CSIC, Seville, Spain

What does the hierarchical analysis of quantitative and qualitative song traits tell us about signal design and reliability?

ABSTRACT Bird song in some passerine species is extremely plastic sexual signal, which, beside the considerable between-individual variation, is loaded with a remarkable within-individual variation. However the theory of reliable signalling only assumes that features of song must consistently differ between individuals, while the role of the within-individual plasticity of song typically remains neglected. To get more insight on the importance of different components of variation in the song we studied how the repeatability of song parameters changes through different hierarchical levels (syllables, songs and song sequences) at different time scales (within-day, between-day and between-year) in the collared flycatcher (Ficedula albicollis). We recorded the songs of 51 males twice across different time windows, and characterized several variables to describe the physical and compositional structures of syllables, songs and song sequences by spectrographic analysis that was subsequently submitted to hierarchical mixed model analyses. For all variables, we found low within-song and within-song-sequence repeatability that was consistent across different time scales. However, at the level of song sequences, we found high repeatability for repertoire size and entropy, which declined over longer time scales. We also found evidence for changes in song composition, as high repeatability of repertoire size was associated with moderate levels of syllable turnover. We conclude that not necessarily the features of particular syllables or songs but potentially their longer sequence may code useful information on individual properties in this species. ■

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LIST OF PARTICIPANTS (A – Z)

A

Adreani Nicolas
MPI for Ornithology, Germany
mnadreani@orn.mpg.de

Agranat Ian
Wildlife Acoustics, Inc., U.S.A.
sales2015@wildlifeacoustics.com

Almunia Portoles Javier
Loro Parque S. A., Tenerife, Spain
secretaria.dir@loroparque.com

Amaya Juan Pablo
CRILAR, Argentina
juanentuculandia@gmail.com

Anichini Marianna
Humboldt University Berlin, Germany
mary.anichini@gmail.com

Araya-Salas Marcelo
New Mexiko State University, U.S.A.
marceloa27@gmail.com

Attia Joel
University of St. Etienne, France
attia@univ-st-etienne.fr

Aubin Thierry
University Paris Sud, France
thierry.aubin@u-psud.fr

Aumann Herbert
University of Maine, U.S.A.
herbert.aumann@maine.edu

B

Baier Leonie
MPI for Ornithology, Germany
baier@orn.mpg.de

Bakhturina Daria
Lomonosov Moscow State University, RUS
bakhturina.daria@yandex.ru

Bakker Antje
MPI for Ornithology, Germany
bakker@orn.mpg.de

Balakrishnan Rohini
Indian Institute of Science, Bangalore, India
rohini@ces.iisc.ernet.in

Balsamo Francesco
Dodotronic, Italy
effebal@gmail.com

Balsby Thorsten
Aarhus University, Denmark
thba@bios.au.dk

Barcante Ferreira Luciana
University of Salford, U.K.
lubarcante@gmail.com

Beeck Veronika
University of Vienna, Austria
veronika.beeck@gmail.com

Beme Irina
Lomonosov Moscow State University, RUS
irbeme@mail.ru

Benedict Lauryn
University of Northern Colorado, U.S.A.
lauryn.benedict@unco.edu

Bertucci Frédéric
CRIOBE, Moorea
fred.bertucci@gmail.com

Bhatt Dinesh Chandra
Gurukula Kangri University, India
dineshharidwar@gmail.com

Blum Christian
MPI for Ornithology, Germany
cblum@orn.mpg.de

Boucaud Ingrid
Université of St. Etienne, France
ingrid.boucaud@univ-st-etienne.fr

Bowling Daniel
University of Vienna, Austria
danielliubowling@gmail.com

Braulio Leon-Lopez
University of St. Andrews, U.K.
b_leon-lopez@hotmail.com

Brazao Protazio Joao Marcelo
Federal University of Para, Brazil
mprotazio@gmail.com

Briefer Elodie
ETH Zurich, Switzerland
elodie.briefer@usys.ethz.ch

Brumm Henrik
MPI for Ornithology, Germany
brumm@orn.mpg.de

Budka Michal
Adam Mickiewicz University, Poland
m.budka@amu.edu.pl

C

Campbell James
Leiden University, The Netherlands
jamesadamcampbell@gmail.com

Cardos Guilherme Sementili
Universidade Estadual Paulista „Júlio de Mesquita Filho“, Brazil
guisemcar@yahoo.com.br

Chabrolles Laura
University of St. Etienne, France
l.chabrolles@univ-st-etienne.fr

Chivers Ben
University of Lincoln, U.K.
bchivers@lincoln.ac.uk

Codarin Antonio
ARPA FVG, Italy
antonio.codarin@arpa.fvg.it

Collier Katie
University of Zurich, Switzerland
katie.collier@ieu.uzh.ch

Coquereau Laura
Institut Universitaire Européen de la Mer, Brest, France
laura.coquereau@univ-brest.fr

Cornec Clément
University Paris Sud, France
clement.cornec@hotmail.fr

Courvoisier Hélène
University Paris Sud, France
helene.courvoisier@u-psud.fr

D

D´Amelio Pietro
MPI for Ornithology, Germany
pdamelio@orn.mpg.de

Dadwal Navjeevan
Gurukula Kangri University, India
navjeevan.dadwal@gmail.com

Davis Jordon
University of Florida, U.S.A.
jordon.davis@ufl.edu

Derégnaucourt Sébastien
University Paris West, France
sebzf@yahoo.com

Desjonquères Camille
Museum national d‘Histoire naturelle, France
cdesjonq@mnhn.fr

Diniz Pedro
University of Brasilia, Brazil
pdadiniz@gmail.com

Dittrich Falk
MPI for Ornithology, Germany
dittrich@orn.mpg.de

Donatelli Reginaldo José
Universidade Estadual Paulista „Júlio de Mesquita Filho“, Brazil
rjdonat@yahoo.com.br

Dorado Correa Adriana
MPI for Ornithology, Germany
adorado@orn.mpg.de

dos Santos Manuel
MARE/ISPA, Portugal
manuel@ispa.pt

Dropková Kamila
MPI for Ornithology, Germany

kamila.dropkova@gmail.com

Dutilleux Guilaume
Cerema / Dter Est, France
guillaume.dutilleux@cerema.fr

E

Eckenweber Maria
University of Ulm, Germany
mariaeckenweber@arcor.de

Economou Chris
University of the Aegean, Greece
Economou@env.aegean.gr

Elemans Coen
University of Southern Denmark, Denmark
coen@biology.sdu.dk

Ey Elodie
Institute Pasteur, France
elodie.ey@pasteur.fr

F

Faragó Tamás
MTA-ELTE Comp. Ethol. Research Group, HUN
mustela.nivalis@gmail.com

Favaro Livio
University of Turin, Italy
livio.favaro@unito.it

Feng Ni
Cornell University, U.S.A.
nf82@cornell.edu

Ferhat Allain-Thibeault
Institut Pasteur, France
aferhat@pasteur.fr

Fernandez Marie
Université of St. Etienne, France
marie.fernandez@univ-st-etienne.fr

Firzlaff Uwe
TU München, Germany
uwe.firzlaff@wzw.tum.de

Fischer Julia
DPZ Göttingen, Germany
Jfischer@dpz.eu

Fitch W. Tecumseh
University of Vienna, Austria
tecumseh.fitch@univie.ac.at

Florentin Juliette
University of Mons, Belgium
juliette.florentin@umons.ac.be

Fonseca Paulo
University of Lisboa, Portugal
pjfonseca@fc.ul.pt

Forkosh Oren
Weizmann Institute of Science, Israel
oren.forkosh@gmail.com

Frankl-Vilches Carolina
MPI for Ornithology, Germany
frankl@orn.mpg.de

Frommolt Karl-Heinz
Museum fuer Naturkunde, Germany
karl-heinz.frommolt@mfn-berlin.de

G

Gahr Manfred
MPI for Ornithology, Germany
gahr@orn.mpg.de

Garcia Maxime
University of Vienna, Austria
maxime.garcia@univie.ac.at

Geberzahn Nicole
Université Paris Ouest La Defense, France
geberzahn@gmail.com

Gessinger Gloria
University of Ulm, Germany
gloria.gessinger@uni-ulm.de

Gingras Bruno
University of Innsbruck, Austria
brunogingras@gmail.com

Gill Lisa
MPI for Ornithology, Germany
lgill@orn.mpg.de

Goerlitz Holger
MPI for Ornithology, Germany
hgoerlitz@orn.mpg.de

Gogala Matija
Slovenian Academy of Sciences and Arts, SLO
matija.gogala@guest.arnes.si

Gomes Dylan
Smithsonian Tropical Research Institute, Panama
dylan_g_21@hotmail.com

Goncharova Maria
Lomonosov Moscow State University, RUS
goncharova.maria.v@gmail.com

Goutte Sandra
University Estadual de Campinas, Brazil
froggologist@gmail.com

Goyes Vallejos Johana
University of Connecticut, U.S.A.
goyes.johana@gmail.com

Goymann Wolfgang
MPI for Ornithology, Germany
goymann@orn.mpg.de

Gridi-Papp Marcos
University of the Pacific, U.S.A.
mgridipapp@pacific.edu

H

Hage Steffen
University of Tuebingen, Germany
steffen.hage@uni-tuebingen.de

Hall Michelle L.
University of Melbourne, Australia
hall.m@unimelb.edu.au

Hallerberg Sarah
MPI for Dynamics and Self-Organization, Germany
shallerberg@nld.ds.mpg.de

Hammerschmidt Kurt
DPZ Göttingen, Germany
khammerschmidt@dpz.eu

Herbst Christian
Palacký University Olomouc, CZE
christian.herbst@univie.ac.at

Hödl Walter
University of Vienna, Austria
walter.hoedl@univie.ac.at

Hoebel Gerlinde
University of Wisconsin-Milwaukee, U.S.A.
hoebel@uwm.edu

Hoeschele Marisa
University of Vienna, Austria
marisa.hoeschele@univie.ac.at

Hoier Svenja
MPI for Evolutionary Biology, Germany
hoier@evolbio.mpg.de

Hoiss Nicole
MPI for Ornithology, Germany
hoiss@orn.mpg.de

Honaiser Rostirolla Tomás
University Federal de Santa Catarina, Brazil
honaiser@gmail.com

Hrouzková Ema
University of South Bohemia, CZE
ema.knotkova@seznam.cz

Hügel Theresa
MPI for Ornithology, Germany
thuegel@orn.mpg.de

I

Ilina Irina
Lomonosov Moscow State University, RUS
ne-murka@list.ru

J

Jaiswara Ranjana
Indian Institute of Science Education & Research, India
ranjana.jaiswara@gmail.com

Jakubowska Aleksandra
Adam Mickiewicz University, Poland
olajak@amu.edu.pl

Janik Vincent
University of St. Andrews, U.K.
vj@st-andrews.ac.uk

Jansen Martin
Senckenberg Research Institute
Natural History Museum, Germany
martin.jansen@senckenberg.de

Jayasena Nilmini
University of Peradeniya, Sri Lanka
nilminijayasena@gmail.com

Jonsson Thorin
University of Lincoln, U.K.
tjonsson@lincoln.ac.uk

K

Kerchev Ivan
Inst. of Monitoring of Climatic & Eco. Systems, RUS
ikea86@mail.ru

King Steven
Western Kentucky University, U.S.A.
steven.king793@topper.wku.edu

Kipper Silke
TU München, Germany
silke.kipper@tum.de

Klenova Anna
Lomonosov Moscow State University, RUS
anna.v.klenova@gmail.com

Klenschi Elizabeth
University of Strathclyde, U.K.
elizabeth.klenschi@strath.ac.uk

Klimsova Vera
Czech University of Life Sciences, CZE
klimsova@ftz.czu.cz

Ko Maggie
MPI for Ornithology, Germany
mcko@orn.mpg.de

Koselj Klemen
MPI for Ornithology, Germany
koselj@orn.mpg.de

Krasheninnikova Anastasia
MPI for Ornithology, Germany
anastacia.k@web.de

Kriengwatana Buddhamas
Leiden University, The Netherlands
bkrieng@alumni.uwo.ca

Kriesell Hannah Joy
Centre Scientifique de Monaco, France
h.kriesell@gmx.de

Kruger Donnavan
North-West University, South Africa
donnavan.kruger@gmail.com

Krüger Frauke
Echolot GbR, Germany
frauke.krueger@buero-echolot.de

L

Labra Lillo Antonieta
University of Chile, Chile
a.l.lillo@bio.uio.no

Lachlan Robert
Queen Mary University of London, U.K.
r.f.lachlan@qmul.ac.uk

Ladich Friedrich
University of Vienna, Austria
friedrich.ladich@univie.ac.at

Lampe Helene M.
University of Oslo, Norway
h.m.lampe@ibv.uio.no

Lankau Hedwig E.
University of Alberta, Canada
hedwig@ualberta.ca

Larsen Ole N.
University of Southern Denmark, Denmark
onl@biology.sdu.dk

Laschober Monika
University of Vienna, Austria
moni.laschober@gmx.at

Laverde-R. Oscar
University de los Andes, Colombia
oa.laverde51@uniandes.edu.co

Le Maguer Lucille
University Paris West, France
lucille.lemaguer@sfr.fr

Leitao Albertine
MPI for Ornithology, Germany
leitao@orn.mpg.de

Leitner Stefan
MPI for Ornithology, Germany
leitner@orn.mpg.de

Lewanzik Daniel
MPI for Ornithology, Germany
dlewanzik@orn.mpg.de

Linke Simon
Griffith University, Australia
simon.linke@gmail.com

Linossier Juliette
University Paris Sud, France
linossier.juliette@gmail.com

Llusia Diego
Museum National D´Histoire Naturelle, France
diego_llusia@yahoo.es

Luis Ana Rita
MARE, ISPA - Instituto Universitario, Portugal
aluis@ispa.pt

Lossent Julie
France Energies Marines & IUEM Gipsa-lab, Brest, France
julie.lossent@gmail.com

Luo Jinhong
MPI for Ornithology, Germany
jluo@orn.mpg.de

M

Ma Shouwen
MPI for Ornithology, Germany
sma@orn.mpg.de

Maciel Israel
Federal Rural University of Rio de Janeiro, Brazil
ismaciel@ufrrj.br

Maigrot Anne-Laure
ETH Zurich, Switzerland
anne.maigro@usys.ethz.ch

Marchenko Alexandra
Lomonosov Moscow State University, R.F.
lagos93@list.ru

Marfull Reinaldo
Rijkuniversiteit Groningen, The Netherlands
r.s.marfull.castro@rug.nl

Martin Juliette
University of Edinburgh, U.K.
julietta.martin@hotmail.fr

Martínez Alvarado Dariel Andrés
University of Antioquia, Colombia
dariel04@gmail.com

Martínez-Serena Abigail
National Autonomous University of Mexiko, Mexiko City, Mexiko
serena13@ciencias.unam.mx

Martins Joao
Fiat Sonitus, Germany
mail@joaomartins.eu

Mathevon Nicolas
University of St. Etienne, France
nicolas.mathevon@univ-st-etienne.fr

Matrosova Vera
Engelhardt Institute of Molecular Biology RAS, RUS
v.matrosova@gmail.com

McLeod Logan
University of Alberta, Canada
lj.mcleod@gmail.com

Meigel Felix
MPI for Dynamics and Self-Organization, Germany
F.Meigel@gmx.de

Mélotte Geoffrey
University of Liège, Belgium
geoffrey.melotte@ulg.ac.be

Miller Jacqueline
Royal Ontario Museum, Canada
jmiller@rom.on.ca

Mishima Yuka
Tokyo University of Marine Science and Technology, Japan
yuka.mishima.0614@gmail.com

Miyammoto Yoshinori
Tokyo University of Marine Science and Technology, Japan

miyamoto@kaiyodai.ac.jp

Mizuguchi Daisuke
Kyoto University, Japan
mizuguchi@wrc.kyoto-u.ac.jp

Montealegre-Zapata Fernando
University of Lincoln, U.K.
fmontealegrez@lincoln.ac.uk

Montes-Medina Adolfo Christian
University Nacional Autónoma de México, México
adolfo.montes@st.ib.unam.mx

Moskalenko Viktoria
Lomonosov Moscow State University, RUS
vik.n.mos@gmail.com

Motes Rodrigo Alba
University of Oslo, Norway
almoro5@alumni.uv.es

Mouterde Solveig C.
University of California Berkeley, U.S.A
solveig.mouterde@gmail.com

Mundry Roger
MPI for Evolutionary Anthropology, Leipzig, Germany
roger_mundry@eva.mpg.de

N

Nemeth Erwin
University of Vienna, Austria
enemeth@orn.mpg.de

Njoroge Anastasia Wanjiru
International Center of Insect Physiology and Ecology, Kenya
anjoroge@icipe.org

Noriega Romero Vargas Maria Florencia
MPI for Dymanics and Self-Organization, Germany
flo@nld.ds.mpg.de

O

Odom Karan
University of Maryland Baltimore County, U.S.A.
kodom1@umbc.edu

Osiejuk Tomasz
Adam Mickiewicz University, Poland
osiejuk@amu.edu.pl

Oswald Julie
Bio-Waves, Inc., Encinitas, U.S.A.
julie.oswald@bio-waves.net

Ota Nao
Hokkaido University, Japan
nao_ota@mail.sci.hokudai.ac.jp

P

P. Amorim M. Clara
MARE, ISPA, Portugal
amorim@ispa.pt

Padilla de la Torre Monica
ETH Zurich, Switzerland
monica.padilla@usys.ethz.ch

Palhares Cíntia
University Federal de Vicosa, Brazil
cintia.meneses@ufv.br

Parks Susan
Syracuse University, U.S.A.
sparks@syr.edu

Pelicella Ivano
Dodotronic, Italy
dodotronic@gmail.com

Penna Mario
University of Chile, Chile
mpenna@med.uchile.cl

Pereira Chaves Patricia Alexandra
ISPA, Portugal, University of Saint Joseph, Macao
patxochaves@gmail.com

Petrusková Tereza
Charles University, Prague, CZE
kumstatova@post.cz

Pfeifle Christine
MPI for Evolutionary Biology, Germany
cpfeifle@evolbio.mpg.de

Pieretti Nadia
University of Urbino, Italy
nadia.pieretti@gmail.com

Popova Daria
Lomonosov Moscow State University, RUS
9yellowdragon9@gmail.com

Porteš Michal
Charles University, Prague, CZE
portes.michal@gmail.com

Prior Nora
University of St. Etienne, France
nora.prior@univ-st-etienne.fr

Ptacek Ladislav
University of South Bohemia, CZE
lptacek@prf.jcu.cz

Q

Quirós Guerrero Esmeralda
University of St. Andrews, U.K.
eqg@st-andrews.ac.uk

Quispe Rene
MPI for Ornithology, Germany
rquispe@orn.mpg.de

R

Ramenda Claudia
MPI for Ornithology, Germany
ramenda@orn.mpg.de

Ranft Richard
International Association of Sound and Audiovisual Archives (IASA), U.K.
rranft@iasa-web.org

Ravignani Andrea
Vrije Universiteit Brussel, Belgium
andrea.ravignani@gmail.com

Riebel Katharina
Leiden University, The Netherlands
K.Riebel@biology.leidenuniv.nl

Ringler Max
University of Vienna, Austria
max.ringler@univie.ac.at

Rivera Caceres Karla
University of Miami, U.S.A.
krivera@bio.miami.edu

Robert-Nicoud Daniel
University of Bristol, U.K.
bzxdr@bristol.ac.uk

Robillard Tony
Museum national d'Histoire naturelle, France
tony.robillard@mnhn.fr

Robotka Hermina
MPI for Ornithology, Germany
hrobotka@orn.mpg.de

Roch Marie A.
San Diego State University, U.S.A.
marie.roch@sdsu.edu

Rocha Diales Mariana
MPI for Ornithology, Germany
mdiales@orn.mpg.de

Rodriguez Rafael
University of Wisconsin-Milwaukee, U.S.A.
rafa@uwm.edu

Rosa Fernando
University of La Laguna, Spain
frosa@ull.es

Rowe Karen
Museum Victoria, Australia
karowe@museum.vic.gov.au

Rusfidra Rusfidra
Andalas University, Indonesia
rusfidra@gmail.com

Ryan Mike
University of Texas and Smithsonian Tropical Research Institute, Panama
mryan@utexas.edu

Rybak Fanny
University Paris Sud, France
fanny.rybak@u-psud.fr

S

Salinas-Melgoza Alejandro
University Autonoma de Tlaxcala, México
cuixmaloso@gmail.com

Salvin Pauline
University Paris West, France
salvinpauline@gmail.com

Sanluis Jose Carlos
University of La Laguna, Spain
jsanluis@ull.es

Sarria Fabio
University of Lincoln, U.K.
fsarria@lincoln.ac.uk

Scharff Constance
Free University Berlin, Germany
constance.scharff@fu-berlin.de

Schmidt Arne
University Graz, Austria
arne.schmidt@uni-graz.at

Schneiderová Irena
University of Life Sciences in Prague, CZE
schneiderova@fld.czu.cz

Schoeppler Diana
University of Tübingen, Germany
diana.schoeppler@web.de

Schöneich Stefan
University of Cambridge, U.K.
stefan-schoeneich@gmx.net

Sellar Patrick
President of IBAC, U.K.
patricksellar@skyfever.com

Seltmann Susanne
MPI for Ornithology, Germany
sseltmann@orn.mpg.de

Sibiryakova Olga
Lomonosov Moscow State University, RUS
osibiryakova@bk.ru

Sieving Kathryn
University of Florida, U.S.A.
chucao@ufl.edu

Simon Ralph
Friedrich-Alexander-University, Erlangen-Nuremberg, Germany
ralph.simon@fau.de

Slater Peter
University of St Andrews, U.K.
pjbs@st-andrews.ac.uk

Slocombe Katie
University of York, U.K.
katie.slocombe@york.ac.uk

Soma Masayo
Hokkaido University, Japan
masayo.soma@sci.hokudai.ac.jp

Souriau Abel
Charles University, Prague, CZE
abel.souriau@gmail.com

Sprau Philipp
Ludwig Maximilians University, Munich, Germany
psprau@orn.mpg.de

Stepien Anna Ewa
ETH and University of Zurich, Switzerland
stepien@ini.ch

Stowell Dan
Queen Mary University of London, U.K.
dan.stowell@qmul.ac.uk

Sueur Jerôme
Museum National D´Histoire Naturelle, France
sueur@mnhn.fr

Szymanski Pawel
Adam Mickiewicz University, Poland
pszyman@amu.edu.pl

T

Tanttu Juha T.
Tampere University of Technology, Finland
juha.tanttu@tut.fi

ten Cate Carel
Leiden University, The Netherlands
c.j.ten.cate@biology.leidenuniv.nl

ter Maat Andries
MPI for Ornithology, Germany
termaat@orn.mpg.de

Thiebault Andréa
Nelson Mandela Metropolitan University, South Africa
andrea.thiebault@gmail.com

Thomsen Heidi
University of Copenhagen, Denmark
hmthomsen@bio.ku.dk

Tipp Cheryl
The British Library, U.K.
cheryl.tipp@bl.uk

Trost Lisa
MPI for Ornithology, Germany
trost@orn.mpg.de

U

Ueno Adriana Sicuto de Oliveira
University of Sao Paulo, Brazil
adrianasicuto@gmail.com

Ulloa Juan
Museum National D´Histoire Naturelle, France
juan.ulloa@mnhn.fr

V

van Boheemen Sharina Jarmila
Charles University, Prague, CZE
sharinavanboheemen@gmail.com

Varkevisser Judith
Leiden Unversity, The Netherlands
judithvarkevisser@gmail.com

Vellema Michiel
University of Southern Denmark, Denmark
vellema@gmail.com

Vernes Sonja
MPI for Psycholinguistics, The Netherlands
sonja.vernes@mpi.nl

Vignal Clementine
University of St. Etienne, France
clementine.vignal@univ-st-etienne.fr

Villain Avelyne
University of St. Etienne, France
avelyne.villain@univ-st-etienne.fr

Villavicencio Camila
MPI for Ornithology, Germany
cvillavicencio@orn.mpg.de

Vokurkova Jana
Charles University, Prague, CZE
jankavok@seznam.cz

von Bayern Auguste M.P.
MPI for Ornithology, Germany
avbayern@orn.mpg.de

von Merten Sophie
Adam Mickiewicz University, Poland
sophievonmerten@gmail.com

W

Wadewitz Philip
Cognitive Ethology Laboratory, Germany
pwadewitz@dpz.eu

Werner Diana
MPI for Ornithology, Germany
dwerner@orn.mpg.de

Wojas Lucyna
Adam Mickiewicz University, Poland
lwojas@amu.edu.pl

Zagkle Elisavet
MPI for Ornithology, Germany
elisavet.env@hotmail.com

Z

Zaytseva Alexandra
Lomonosov Moscow State University, RUS
azaytseva@mail.ru

Zielinski Piotr
University of Wroclaw, Poland
piotr.zielinski@uni.wroc.pl

Zollinger Sue Anne
MPI for Ornithology, Germany
zollinger@orn.mpg.de

Zsebök Sándor
Eoetvoes Loràn University, Hungary
zsebok.s@gmail.com