

10th Symposium on the lacertid lizards of the Mediterranean Basin



2nd Symposium on the lizards of the Mediterranean Basin

Book of abstracts



Ministry of Science,
Technology and Space

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- Mr. Gavin Stark
Tel Aviv University, School of Zoology
- Prof. Amos Bouskila
Ben Gurion University of the Negev, Department of Life Sciences
- Dr. Boaz Shacham
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Symposium schedule

Sunday 17/6/18

07:00-12:00 Unofficial **field trip to Burgin** region (Judea plain)

14:00-18:00 **Registration** opens in the museum

**Monday
18/6/18**

**Tuesday
19/6/18**

**Wednesday
20/6/18**

08:00	Coffee & registration	Coffee	
08:15			
08:30	Opening words - Tamar Dayan, Shai Meiri	Raoul Van Damme - Plenary lecture	
08:45	Rick Shine - Plenary lecture		
09:00			
09:15		Simon Jamison	Coffee
09:30	Jelka Crnobrnja-Isailovic - Plenary lecture	Raquel Ponti	
09:45		Aleksandar Urosevic	Panayiotis Pafilis - Plenary lecture
10:00		Coffee break	
10:15	Coffee break		
10:30		Guy Sion (2)	Karin Tamar
10:45	Uri Roll	Boaz Shacham	Marco Sannolo
11:00	Emmanouela Karameta	Michael Stanner	Coffee break
11:15	Miguel Anrgel Carretero	Tania Bird - Plenary lecture	
11:30	Simon Baeckens		Ofir Levy
11:45	Guy Sion		Maayan Lev
12:00	Gilles De Meester		Hamutal Friedman
12:15	Lunch		Menelia Vasilopoulou-Kampitsi
12:30		Tour – Steinhardt Museum	Hector Tejero-Cicuendez
12:45			Lunch (& business session, if needed)
13:00			
13:15	Amos Bouskila - Plenary lecture		
13:30		Lunch	
13:45			Tom Haran
14:00	Mark Shein-Idelson		Pantelis Savvides
14:15	Michael Moses		Feodor Osipov
14:30	Coffee break		Yuval Itescu
14:45			Roy Talbi
15:00	Grigorios Kapsalas		Coffee break
15:15	Gopal Murali		
15:30	Rachel Schwarz		Gabriele Senczuk
15:45	Gorana Danon		Francois Druelle
16:00	Gavin Stark		Shai Meiri
16:15	Coffee break		
16:30		Field trip to the Negev dunes	Tour - Zoological garden
16:45	Jose Luis Rubio		
17:00	Colin Donihue		
17:15	Johannes Foufopoulos		Coffee break
17:30	Eliezer Frankenberg		
17:45	Charlotte Van Moorleghe		Aaron Bauer - Plenary lecture
18:00	Poster session & refreshments		
18:15			
18:30			Concluding remarks
18:45			Pizza & Beer
19:00			

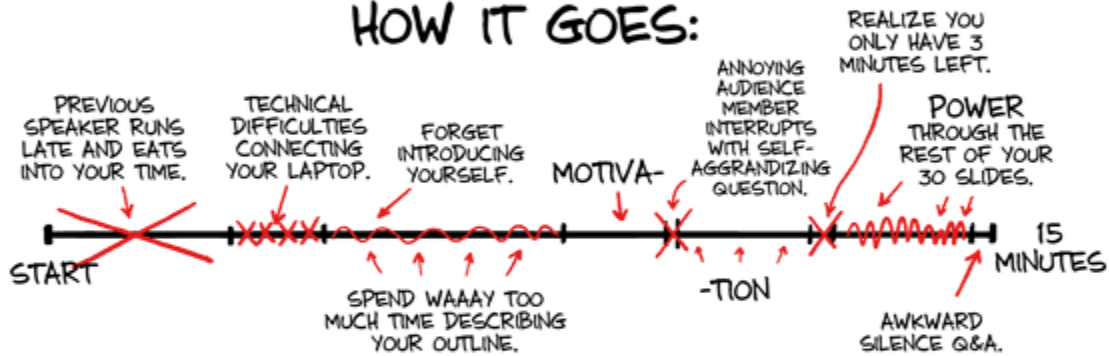
Thursday 08:00: Field trip to Mt. Hermon

YOUR CONFERENCE PRESENTATION

HOW YOU PLANNED IT:



HOW IT GOES:



Credit: <http://phdcomics.com/comics.php?f=1553>

Plenary lecture

Lizards as models for research on phenotypic plasticity

Rick Shine¹

¹ University of Sydney, Australia

An organism's phenotype is determined by genetics, environmental impacts, and the interaction between those two processes. One important form of plasticity involves the influence of developmental conditions that are experienced early in life. Lizards (especially oviparous species) have emerged as powerful model systems with which to explore that process, because incubation conditions in the nest or oviduct affect the trajectory of embryonic development – and thus, the phenotype of the hatchling – as well as the rate of development. I will review some of the ways in which studies of lizards have revealed insights about determinants of geographic variation in phenotypes, the nature of evolutionary transitions in major traits (such as mode of reproduction), and new approaches to conserving imperilled species. Lastly, I will identify opportunities for further research on this topic, exploiting the awesome opportunities offered by lizards.

Plenary lecture

Homage to Professor Milutin Radovanović: two stories on variability and distribution of lacertid lizards on islands in ex-Yugoslavia

Jelka Crnobrnja-Isailović^{1,2}

¹ Faculty of Sciences and Mathematics University of Niš, Serbia

² Institute for Biological Research “Siniša Stanković” University of Belgrade, Serbia

Fifty years ago, distinguished herpetologist Professor Milutin Radovanović, member of Serbian Academy of Sciences and Arts and internationally respected scientist, died in an air-plane accident in Namibia. Among the attractive topics of his scientific interest (neoteny in urodeles of the Balkan Peninsula, functional skull anatomy in venomous snakes, distribution and biogeography of herpetofauna in ex-Yugoslavia) were processes involved in allopatric speciation of lacertid lizards on the islands of Eastern Adriatic. Supported by Professor Plate, his mentor at Jena University in Germany, and later by Professor Hadži from University of Ljubljana, Slovenia, Radovanović started studies focused on island forms of lacertid lizards, their spatial distribution and variability on Eastern Adriatic islands. In 1956, Austrian Academy of Sciences published Professor Radovanović's monography “Rassenbildung bei den Eidechsen auf adriatischen Inseln”. In this study, he attempted to describe and explain the fauna and ecological conditions on more than thousand islands and islets of eastern Adriatic Sea, particularly focusing on populations of Dalmatian (*Podarcis melisellensis*) and Italian (*P. siculus*) wall lizards.

The scientific interest of Professor Radovanović on insular populations of lacertid lizards was revived in the last decade of XX century, by efforts of the newly established Department of evolutionary biology at the National Institute for biological research “Dr Siniša Stanković” University of Belgrade. The team lead by Professor N. Tucić, Professor M. Kalezić and Dr G. Džukić started an ambitious project focused on lacertid lizard community (*Algyroides nigropunctatus*, *Dalmatolacerta oxycephala*, *Lacerta trilineata*, *L. viridis*, *P. melisellensis* and *P. muralis*) on the archipelago of the Lake Skadar in southern Montenegro. Exploring insular lizard community of somewhat complex historical background, we did not record straight path toward speciation but, however, were witnesses of somewhat early phases of spatial – temporal isolation.

Who's who in Mediterranean Lizards?

Uri Roll¹, Anat Feldman, Rich Grenyer, Maria Novosolov, Allen Allison, Aaron M. Bauer, Rodolphe Bernard, Monika Böhm, Fernando Castro-Herrera, Laurent Chirio, Ben Collen, Guarino R. Colli, Lital Dabool, Indraneil Das, Tiffany M. Doan, Frank Glaw, Lee L. Grismer, Marinus Hoogmoed, Yuval Itescu, Fred Kraus, Matthew LeBreton, Amir Lewin, Marcio Martins, Erez Maza, Danny Meirte, Zoltán T. Nagy, Cristiano de C. Nogueira, Paul Oliver, C David L Orme, Olivier S.G. Pauwels, Daniel Pincheira-Donoso, Gary Powney, Glenn Shea, Roberto Sindaco, Oliver Tallowin, Omar Torres-Carvajal, Jean-François Trape, Enav Vidan, Peter Uetz, Philipp Wagner, Yuezhao Wang, Thomas Ziegler, Shai Meiri²

¹ Mitrani Department of Desert Ecology, Ben-Gurion University of the Negev, Midreshet Ben-Gurion 8499000

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In this work we explored patterns in lizard diversity across the five major global Mediterranean biomes. Our dataset comprised of all of those lizard species whose distributions (retrieved from www.gardinitiative.org) intersected to any degree with Mediterranean biomes (based on www.wwf.org). 707 species of lizards (or 11% of all lizards) call the Mediterranean biome their home, at least in part of their range. The Palearctic and Australian regions are the richest in lizard diversity. The Afrotropical and Australian Mediterranean regions have more lizard richness than expected by their area, and the Palearctic, Neotropic and Nearctic Mediterranean regions fewer. The Neotropic Mediterranean region has the highest proportion of endemic lizards. The Nearctic and Afrotropic regions have the smallest proportion of endemic lizards. Different lizard families dominant the lizard fauna in the different Mediterranean regions across the globe. Only skinks are an important component in the diversity in more than two regions (Afrotropics – 21%; Australian – 52%; Palearctic – 17%). *Liolaemus* dominate amongst Neotropic Mediterranean lizards (78%); true lizards the Palearctic (52%) and to a degree Afrotropic (13%); geckos are more dominant in the Afrotropics (33%) and other families comprise less than 15% of the Mediterranean lizard species diversity in their respective realms. The state of knowledge on threat for Mediterranean species, is better than the global mean (47%) with 55-60% of its species belonging to prioritisable categories (i.e. not NE, DD). The Palearctic and Afrotropic Mediterranean regions have 24% of their prioritisable species threatened by extinction, the Nearctic has the lowest percentage of threatened species - 15%. Of the 85 threatened Mediterranean lizards globally, 25 species (30%) have less than 10% of their range covered by a protected area. Altogether the Mediterranean lizard faunas of different realms have different characteristics and some species are in need of further conservation attention.

Evolutionary and Ecophysiological Divergence of a Mediterranean Lizard

Emmanouela Karameta¹, Natalia Gourgouliani², Danai Kouvari-Gaglia¹, Victoria Litsi-Mizan¹, Snir Halle³, Shai Meiri³, Petros Lymberakis⁴, Heinz Grillitsch⁵, Çetin Ilgaz⁶, Spyros Sfenthourakis⁷, Panayiotis Pafilis¹, Nikos Poulakakis^{4,8}.

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² Department of Evolutionary Biology and Environmental Studies, University of Zurich, CH-8057 Zurich, Switzerland.

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⁴ Natural History Museum of Crete, School of Sciences and Engineering, University of Crete, Knossos Avenue, 71409 Irakleio, Greece.

⁵ Herpetological Collection, Natural History Museum Vienna, Burgring 7, 1010 Vienna, Austria.

⁶ Department of Biology, Faculty of Science, Dokuz Eylül University, Tinaztepe Yerleskesi, 35160 Buca- İzmir, Turkey.

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⁸ Department of Biology, School of Sciences and Engineering, University of Crete, Vassilika Vouton, 70013 Irakleio, Greece.

Oceanic islands represent unique systems for the study of speciation and endemism. Placed at the intersection of three continents, Europe, Asia and Africa, Cyprus hosts a great number of endemic plant and animal species and various subspecies. The Roughtail Rock Agama, *Stellagama stellio* (L., 1758) is distributed along the Eastern Mediterranean countries and is represented in Cyprus by the endemic subspecies *S. s. cypriaca*. The main goal of this study was to evaluate the evolutionary (phylogenetic) and ecophysiological variation of *S. s. cypriaca*, by elucidating the phylogenetic relationships among *S. s. cypriaca* and the rest of the six morphological subspecies and by assessing its differentiation regarding two vital physiological functions: digestion and thermoregulation. For the first we performed several phylogenetic (Maximum Likelihood and Bayesian Inference), phylogeographic, species-tree (StarBeast) and species delimitation approaches using five gene fragments (ND4, 16S, NKTR, CMOS, MC1R). For the second, we compared apparent digestive efficiency (ADE) for lipids, proteins and sugars as well as efficiency of thermoregulation for mainland and insular populations, in a common garden experiment. We expected that climate and insularity would affect both of these functions. *S. stellio* is a well-supported monophyletic clade and the morphological subspecies correspond to separate evolutionary lineages. The separation of *S. s. cypriaca* is the basal split and took place around 4 MYA. The evolutionary relationships among the studied populations do not strictly dictate the observed eco-physiological variation. The Cypriot population exhibited higher ADE values in comparison to the Northern populations of Thessaloniki and Corfu and lower mean selected temperatures in comparison to all the rest. Thus, it seems that from phylogenetic and physiological point of view, the Cypriot group of populations consist of a distinct evolutionary entity, which could be elevated to species level (*S. cypriaca*), revealing the need for the taxonomic reconsideration of *S. stellio*.

Do wall lizard colour morphs differ in ecology? From realised to fundamental niche

Miguel A. Carretero¹, Verónica Gomes^{1,2}, Neftalí Sillero³, Guillem Pérez i de Lanuza¹

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Recent studies with lacertids are improving our understanding of the maintenance of alternative phenotypes in polymorphic species. While ventral colour polymorphisms are frequently interpreted in the light of sexual selection, the contribution of natural selection has often been neglected. *Podarcis muralis* encompasses up to three pure (white -W-, yellow -Y-, orange -O-) plus intermediate morphs whose frequencies vary across populations. Ecological models performed with >100 populations from E Pyrenees suggest morph divergence in realized niche associated to climate. The Y, YO morphs occupy a narrow niche space within the other morphs while O and WO show higher local frequencies in the most humid habitats. Indeed, such geographic patterns could derive from the spatial variation in the environmental context of sexual selection. However, an analysis of microhabitat in representative localities based on >1000 observations indicated that O morph is partially segregated relative to the others, tending to occupy more humid (vegetated, close to water) sites, suggesting divergence in fundamental niche. Here, we tested this hypothesis by analysing two ecophysiological traits, preferred body temperature (Tp) and evaporative water loss (EWL). Adult males from the three pure morphs (W,Y,O) underwent tests for Tp in a photothermal gradient (10 h) and EWL in sealed chambers (12 h). We detected diel variation in Tp but failed to find differences in mean Tp between morphs. However, when controlling for size, accumulated EWL was higher in O lizards. This suggests that geographical abundance and microhabitat use of O morph are at least partially constrained by its water ecophysiology. However, W and Y morphs did not differ in ecophysiology as they did not in microhabitat, suggesting an indirect relationship between climate and demographic parameters (sex-ratio, density). Overall, these findings depict a complex scenario of interaction between sexual and natural selection shaping colour polymorphism in space and time.

Evolutionary morphology of the lacertid chemosensory system

Simon Baeckens^{1,2}, Anthony Herrel³, Chris Broeckhoven¹, Menelia Vasilopoulou-Kampitsi¹, Katleen Huyghe¹, Jana Goyens¹, Raoul Van Damme¹

¹ Laboratory of Functional Morphology, Department of Biology, University of Antwerp, Universiteitsplein 1, 2610, Wilrijk, Belgium.

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Foraging mode plays a pivotal role in traditional reconstructions of squamate evolution. Transitions between modes are said to spark concerted changes in the morphology, physiology, behavior, and life history of lizards. With respect to their sensory systems, species that adopt a sit-and-wait strategy are thought to rely on visual cues primarily, while actively hunting species would predominantly use chemical information. The morphology of the tongue and the vomeronasal organs is believed to mirror this dichotomy. Still, support for this idea of concerted evolution of the morphology of the lizard sensory system merely originates from studies comparing only a few, distantly related taxa that differ in many aspects of their biology besides foraging mode. Hence, we compared vomeronasal-lingual morphology among closely related lizard species of the Lacertidae family. Our findings show considerable interspecific variation indicating that the chemosensory system of lacertids has undergone substantial change over a short evolutionary time. Although our results imply independent evolution of tongue and vomeronasal-organ form, we find evidence for co-variation between sampler and sensor, hinting towards an ‘optimization’ for efficient chemoreception. Furthermore, our findings suggest species’ degree of investment in chemical signaling, and not foraging behavior, as a leading factor driving the diversity in vomeronasal-lingual morphology among lacertid species.

Digit asymmetry and digit ratio (2:4) derived from brain laterality: The lizard *Ptyodactylus guttatus* as a model

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In humans, the morphometric trait of digit length ratio (2D:4D) is correlated with behavioral patterns i.e. financial risk, aggression and social status, derived from brain-laterality and hormone mediated. Eye asymmetry in some snakes correlates indirectly with risk behavior, via tail injury. In many lizards and in sphenodon, 4th-digit asymmetry of hind legs correlates with tail-injury. This study focuses on possible correlations between morphometric traits and asymmetric behavior presumably derived from brain laterality. The morphometric traits: right and left digit ratio as in humans; eye-size asymmetry and digit asymmetry of both, second and forth digits of the gecko *Ptyodactylus guttatus*; all hind legs. The asymmetric behavior: foot preference. Live lizards were caught on walls, measured and released in 2013 ($N=21$). Eye asymmetry was not correlated directly with digit ratio or asymmetry. However, foot preference was explained using a linear model, by eye-asymmetry, breathing rate and second digit asymmetry. Digit ratio of right foot was correlated with second digit asymmetry and digit ratio of left foot was correlated with forth digit asymmetry.

Foot preference correlated only with digit ratio of right foot and breathing rate did not correlate directly with any trait. The association between foot preference and morphometric traits presented in this study, may be derived from brain laterality as in humans. It can explain correlations of forth digit asymmetry from the literature as derived from brain laterality, thus, present a working theory to explain the correlation between asymmetry of behavior and morphometry, as in humans.

Learning with lizards: problem-solving skills in Lacertids from different environments

Gilles De Meester¹, Raoul Van Damme¹

¹ Department of Biology, Functional Morphology Group, University of Antwerp, Wilrijk, Belgium.

While reptiles have long been regarded as slow and inflexible learners, the last decade has witnessed a renewed interest in reptile cognition. Lizards and snakes are now known to show significant learning abilities, problem-solving skills and high behavioural flexibility. Nevertheless, basically nothing is known about the environmental forces driving the evolution of reptile cognition. In addition, there is currently a lack of standardized cognitive tests, making comparisons among species or taxa difficult.

It is often postulated that higher cognitive abilities evolve in response to more complex and more variable environments, in order to allow species to better exploit these complex environments. Indeed, a link between cognition and environmental complexity has already been demonstrated in fish, birds and mammals, but so far not in reptiles.

We compared the problem-solving abilities of two lacertid species: *Acanthodactylus boskianus*, a typical open-desert species, and *Podarcis muralis*, an inhabitant of densely vegetated or rocky habitats. Lizards from both species were given three cognitive tests: 1) the inhibitory control task, during which lizards had to eat from a transparent petri dish, 2) the lid-removal task, where lizards had to learn how to remove an obstacle to get a food reward, and 3) the escape box task, where lizards learnt to escape from a box by opening a door. Since *P. muralis* inhabits structurally more complex habitats than *A. boskianus*, we predicted that *P. muralis* would show better cognitive performance in all tasks.

Our study might contribute to a better understanding of how cognition, both in reptiles and in general, evolved in response to environmental complexity, and might stimulate further research on more reptile species using standardized cognition protocols.

Plenary lecture

Reproduction in Sinai chameleon: living on the edge, working hard to avoid the Concorde fallacy

Amos Bouskila¹, Reut Ein-Gil¹

¹ Department of Life Sciences, Ben-Gurion University of the Negev, Israel

Selecting a suitable location for egg deposition can be exceptionally complicated in the case of deep nesting species, because the selection process involves a high level of uncertainty, combined with high energy expenditure. Here we explore decision-making elements in the burrowing behavior of *Chamaeleo chamaeleon musae*, an arboreal lizard that excavates deep nests in sandy soils of the Negev desert, Israel. We located nests and nesting attempts by tracking chameleons during the egg-laying season. We excavated sealed nest burrows and abandoned burrows in search for differences between the two burrow types at the desertion depth in terms of thermal, hydric and physical features. Surprisingly, only burrow slope differed significantly between nests and abandoned burrows. The unique life-history of this semelparous species result in females that invest almost all of their resources in the production of eggs. The Relative Clutch Mass (gravid mass less postpartum mass divided by postpartum) is high ($\bar{x}=0.8$, s.d.=0.12, n=9) and females occasionally die before laying the eggs. Therefore, females have to identify situations in which it does not make sense to continue and excavate a nest with an angle too shallow. The lizards can use an inversion point in the gradient of soil temperatures to assist in estimating the burrow slope and decide to abandon unsuitable burrows.

A dragon's view on the evolution of sleep

Mark Shein-Idelson¹

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Sleep is a fundamental behavior in the animal kingdom, yet, sleep-associated activity patterns and the functions they sub-serve remain elusive. Comparative approaches have proven highly valuable for dissecting the function of biological systems by allowing one to study how different species developed partially overlapping solutions to similar problems, and thus, to separate the salient or fundamental from the transient or variable. However, neural representations during sleep were mostly studied in mammals and to a lesser extent in bird. These two classes show a clear division into two-states of sleep: rapid eye movement (REM) sleep and slow wave sleep (SWS). It has been hypothesized that this similarity is a result of convergent evolution brought about by similar pressures related to homeothermia. An alternative explanation, however, is that the common ancestor of amniotes already exhibited two sleep states. And yet, existing neurophysiological data from reptiles has not been able to support this hypothesis and different publications report contradictory results.

In my talk I will address this question by describing results from extracellular neuronal recordings in the brain of Australian Dragons (*Pogona vitticeps*) during sleep and wake states. These recordings indicate that during sleep, brain activity periodically alternated between two states with a cycle of ~80s. The first is reminiscent of SWS, with relatively higher power in the delta range (<4Hz), and the second is characterized by a flatter spectrum, which is closer to the awake spectral profile. Furthermore, video-analysis of eye-movements during sleep, show that eye-movements mostly occur during the second state, suggesting a close similarity to REM state encountered in mammals and birds. These results indicate that two-state sleep exists in *Pogona vitticeps*. This makes it more likely that such sleep patterns existed in the common ancestor of all amniotes, pushing back the emergence of two-state sleep to at least 300MYA.

Demographic factors and their effect on the body temperature of the Kotschy's gecko

Michael Moses¹, Yuval Itescu^{1,2}, Rachel Schwarz¹, Panayiotis Pafilis³, Shai Meiri^{1,2}

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³ Department of Biology, National and Kapodistrian University of Athens, Athens 157-84, Greece

Body temperatures strongly affect multiple aspects of lizard natural history, life history and behaviour. We examined the relationship between demographic factors such as age, body size (length, mass), sex, and gravidness, on lizard thermal biology in the field. We also examined the influence of a seldom tested factor: parasite infection. We captured over 600 Kotschy's geckos (*Mediodactylus kotschy*) across dozens of islands in the Aegean Sea, Greece during April – June of 2013-2016. We measured lizard body temperatures immediately after capture using a fast reading probe and examined the effect of the aforementioned factors on body temperature, correcting for ambient temperature. Body temperatures were strongly positively correlated with air and substrate temperatures. There were, however, no effects of body size, and juveniles and adults had similar body temperatures. There was likewise no significant difference between males and females, or between gravid and non-gravid females. Interestingly, males infested with either ticks or mites had significantly higher body temperatures compared to non-infected males (29.3 vs. 28.2°C), but no such effect was found for females. We suggest that this may be due to the outcome of the immunosuppressive effect of testosterone, which is associated with greater susceptibility of males to parasite infections. In turn, this may lead to males actively seeking higher temperatures in order to compensate for the cost of the infection on their bodies.

Does tail autotomy affect the sprint performance of lacertids? Preliminary results from the Greek members of the genus *Podarcis*

Grigoris Kapsalas¹, Thanos Georgakopoulos¹, Panayiotis Pafilis¹

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Tail autotomy, the voluntary shedding of the tail, is an effective anti-predator mechanism that many lizard species employ as a last resort: when all other defences have failed, lizards shed their tail and escape while the predator is distracted by the thrashing tail. Although successful as a strategy, tail autotomy has its cost on the fitness of the animal. Tail loss may result in a reduced social position within the population, affecting mate selection and territory defence, as well as diminish the ability to respond to future attacks from predators. The impact of tail autotomy on sprint performance, although studied for decades, has given contradicting results. In this ongoing project, we aim to comparatively study the effect of tail autotomy on the sprint performance of all Greek *Podarcis* lizards. The genus is represented by eight species in Greece, with the addition of the recently established *P. siculus*. These species differ on a number of ecological and behavioural characteristics and cover a wide geographic range: from the endemic *P. levendis*, which is confined on two tiny islets, to *P. muralis*, which is distributed throughout most of south and central Europe. We initially measured sprint and climbing speed on a purposely-built racetrack. We subsequently simulated a predatory attack in the laboratory in order to induce autotomy, and then measured sprint and climbing speed again. Our results so far have not revealed a consistent pattern. In five of the species studied, *P. erhardii* and *P. peloponnesiacus* seem to have reduced sprint performance after autotomy, but *P. cretensis*, *P. tauricus* and *P. siculus* appear unaffected.

Why the lizard got its stripes: Stripes in lizards as a defense against predation during movement

Gopal Murali¹, Ullasa Kodandaramaiah¹

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Animals rely on an impressive diversity of colour patterns to protect themselves against predation. Many lizards have bright (colourful) tails which are thought to work against predation by deflecting the predatory attacks towards the tails, which can be shed and regrown. Another striking coloration common among several lizards include the high contrasting longitudinal striped patterns. We posit that such contrasting stripes along the body of lizards also act to deflect the predator attacks during motion. This idea is based on the ‘motion dazzle’ hypothesis, which is a form of defensive coloration suggested to prevent successful capture during motion by causing predators to misjudge the direction or speed of prey movement. Firstly, we tested this hypothesis by employing a virtual predation experiment with humans and using a series of comparisons across differently patterned prey, we show that striped patterns on the anterior, increase attacks towards the posterior part of prey. Secondly, by utilizing a standardized adaptive psychophysical paradigm, we found striped prey are perceived to move slower, suggesting a possible mechanism that explains the deflective effect. Finally, by integrating an experimental and phylogenetic comparative approach, we also show that striped coloration might be effective in smaller lizards. Overall, the results suggest the possibility that striking longitudinal striped coloration in lizards might function against predation during motion.

A shift in reptile diversity and abundance over the last 25 years

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The south-facing slopes in canyons north of the equator are often hotter and drier, than north facing slopes, promoting differences in the biotic and abiotic characteristics of the opposing slopes. Between 1993-1994 Eviatar Nevo and colleagues studied the reptiles of lower Oren Stream (Carmel Mountains, Israel). They found 307 individuals belonging to 13 species from both slopes and the valley bottom. We surveyed the same locations during 2016-2018 using similar methods, survey area and effort, in order to study whether diversity and abundance patterns have changed during the passing 25 years. We found 319 individuals belonging to 14 species from the slopes and the valley bottom. The three dominant species in both periods were *Stellagama stellio*, *Phoenicolacerta laevis* and *Ptyodactylus guttatus*, but while the abundance of *P. laevis* remained the same, the relative abundance of *S. stellio* decreased by 67%, and that of *P. guttatus* increased by 79%. Six species, (including *S. stellio* and *P. guttatus*) were more abundant on the south-facing slope during both periods, among them, whereas *P. laevis* (only) was more abundant on the north-facing slope. *Chamaeleo chamaeleon*, *Hemidactylus turcicus*, *Platycephalus collaris* and *Testudo graeca*, however, which were equally abundant on both slopes or more abundant on the south-facing slope in the 1990's, were found more often, or even exclusively on the north-facing slope now. These results suggest that, although the overall diversity and the dominant species across slopes did not change, some changes occurred in the abundance of species between slopes and periods. Warming may have caused some heat-sensitive species to become scarce on the south-facing slope, while more heat-tolerant species survived and even thrived. These results however may also derive from better detection ability of some species over others between study teams.

Late ontogeny of sexual dimorphism in pileus shape: a case study of *Podarcis tauricus*

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We employed methods of landmark based geometric morphometrics to explore ontogeny of sexual dimorphism in pileus shape, as an approximation of sexual dimorphism in head shape of Balkan wall lizard *Podarcis tauricus*. To estimate the changes in the level and pattern of shape dimorphism over ontogeny, the differences in pileus shape were calculated for subadults and adults. Sex in both subadults and adults was determined according to the presence of the hemipenial bulges. All individuals with snout-vent length less than 52 mm for females and 53 mm for males were classified as subadults. To estimate ontogenetic trajectories of shape changes, the multivariate regression of shape variables on pileus size was performed. The trajectories of shape changes for females and males were compared. We found no significant sexual dimorphism in pileus shape for subadults, while for adults, pronounced sexual dimorphism was found. In comparison to females, males have relatively narrower pileus and shorter and narrower rostrum. In males, pileus elongation is especially pronounced in the parietal and anterior part of frontoparietal scales. Frontoparietal scales overlay the frontoparietal suture and observed elongation likely helps to compensate for the increased mechanical stress at the important mesokinetic joint. The calculated ontogenetic trajectories of pileus shape in females and males are homogenous, indicating that the main factor leading to sexual dimorphism in pileus shape of *Podarcis tauricus* are allometric, size related, changes in shape.

Cold and isolated ectotherms: drivers of longevity of lizards - Mediterranean and global perspectives

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Animal lifespan is determined by extrinsic and intrinsic mortality causes. According to the evolutionary theories of senescence when mortality pressures are low animals delay reproduction. This enables them to grow more slowly and selection against harmful mutations in adulthood can occur, in turn, selecting for longer lifespans. Lizard physiology is affected by temperatures, which affect their metabolic rates, hence intrinsic causes of mortality. Moreover, in highly seasonal regions lizards hibernate, reducing both metabolic rates (intrinsic mortality) and predation (extrinsic mortality). We assembled a dataset on the maximum longevity, phylogenetic relationships, and relevant eco/morphological variables of 746 lizard species. We compared our global dataset to lizard species from Mediterranean biomes worldwide (n=79 of which 49 are from the Mediterranean basin). Correcting for phylogeny, we found that body mass explains a small proportion of the variance in reptile longevity. Species living on islands, and in cold, seasonal environments, live longer. However, Mediterranean-basin lizard longevity was only related to body mass, and the other predictors were not significant. Correcting for mass, there were no differences in longevity between Mediterranean lizards (average maximum lifespan 10.5 years) and other lizards (10.4 yr., n=667). We suggest that, for lizard species globally, reducing extrinsic and intrinsic mortality pressures by living in environments promoting lower predation pressure, lower metabolic rates and shorter activity periods result in increased longevity. For Mediterranean lizards low statistical power may also be an issue. However, we think that factors such as annual temperature or seasonality, may not differentially influence longevity for lizards from the Mediterranean Basin, because they are relatively similar across the region.

Algyroides marchi niethameri* (Lacertidae) and other mistakes about the identification features of the Spanish *Algyroides

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In many general descriptions (field guides, encyclopedias, etc.) of the Spanish *Algyroides*, it is not rare to find some errors about different features of the Spanish *Algyroides*, *Algyroides marchi* Valverde 1958. After examining a large sample of specimens of this species, I considered of interest to point out three of them: the presence/absence of masseteric scale, the ventral color, and the gular color leading to the description of the subspecies *A. marchi niethameri* Buchholz 1964.

In this communication, I discuss the variation and characteristics of those features, and conclude: 1) the masseteric scale is present in most specimens of *A. marchi*, although there are exceptions, and this feature cannot be used as a diagnostic character for the identification of the species. 2) The ventral color of *A. marchi* is yellow, in spite of some seasonal variation of the color extension on the thoracic and gular areas. 3) The subspecies *Algyroides marchi niethamery*, diagnosed after an artifact gular blue color, is definitely not a valid taxon.

Mega-bites: Rapid increase in lizard bite force following replicated introduction to small Greek islets

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The “struggle for existence” is especially stark on small islands where selection strongly favors phenotypes that facilitate the acquisition or monopolization of scarce resources. For many animals, maximum bite force dictates the winners of this struggle, enabling access to food, shelter, and mates. Lizard bite force is highly variable between island and mainland contexts and is most often significantly higher in dense, small-island populations. However, studies demonstrating significant increases in bite capacity on islands are typically comparative, contrasting populations with unknown evolutionary histories. We initiated an island introduction experiment to directly investigate the dynamics of how the Aegean Wall Lizard (*Podarcis erhardii*) bite force changes over time following the colonization of small islands. We documented a substantial increase in bite force among five replicate lizard populations introduced to Greek islets in only three years. Furthermore, we found that changes in the allometry of bite force have caused adult lizards to have proportionately much harder bites as they grow larger. Contrary to predictions, however, hard bites did not provide a survival advantage for lizards *per se*. Our results suggest that introduction to these small-island ecosystems has driven a fundamental shift in the natural history of these lizards and demonstrates the rapidity with which lizard bite force can change to adapt to new ecological contexts.

Is the enemy of your enemy your friend? On the potential of lacertid lizards to control pests and protect plants

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Lizards are dominant elements of Mediterranean ecosystems and achieve high population densities across a broad range of natural and human-modified habitats. Despite their prominence, little is known on their functional role as mesopredators in affecting arthropod populations. Furthermore, ecological theory suggests that lizards can be drivers of trophic cascades, a phenomenon that has implications for crop protection in traditional agricultural areas. Conversely, some evidence suggests that lizard population densities may be determined by bottom-up effects, i.e. by local arthropod population sizes. Here we present the results from a combination of observational studies and experimental manipulations on the two-way relationship between lizards and the local food webs as well as the implications for low-impact agricultural practices.

Male multiple click calls of five species of the gecko genus *Ptyodactylus*

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The genus *Ptyodactylus* ranges through North Africa to Western Asia and the Persian Gulf. They all are vocalizing. We received recordings on cassettes made by the late Michael Rickert, who expertly was taking care of geckos in captivity. The recordings were transferred to digital sounds and multiple clicks calls of *P. puisuxi*, *P. guttatus*, *P. hasselquistii*, *P. ragazzii* and *P. oudrii* were analyzed using the programs "Audacity" and "Praat", standard programs used in studies of animal communication, and their structure compared. Each of the species have distinctive call features. We shall present playbacks of the calls of these five species and show the typical structure of each male call as related to their geographical distribution and to some aspects of their hearing.

Does the Dalmatian wall lizard (*Podarcis melisellensis*) have deprived chemical senses on islands compared to the mainland?

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Lacertid lizards are well known for their highly developed chemical senses which they use in a wide variety of contexts, among which is predator detection. How these senses evolve when in underuse is less well understood. For instance, island systems usually harbour fewer predators. These more simple ecosystems potentially do not require the lizard to have as highly developed chemical senses as their mainland counterparts. As the maintenance of a chemosensory apparatus (i.e. chemosensory behaviour as well as the underlying neuronal mechanics) may be costly, we expect a reduction in chemosensory system use at the behavioural and neuronal level in island populations. This was investigated for Croatian mainland and island populations of the Dalmatian wall lizard (*Podarcis melisellensis*, Braun 1877). We performed behavioural assays and micro-CT scanning of chemosensory brain areas to analyse both aspects of the chemosensory system. If island lizards have deprived chemical senses, this could imply a higher vulnerability to environmental changes. Such an environmental change is, for instance, the introduction of an alien predator, a case which is occurring on some of the Adriatic islands on which the lizard is present.

Plenary lecture

Lacertid lizards: renegades, or sticklers for rules?

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In an attempt to understand the bewildering geographical variability among and within species, naturalists have proposed a series of ‘ecogeographical rules’, that aspire to link environmental variation to variation in organismal characteristics, such as body size, body proportions, colouration and life history traits. The validity and applicability of these rules has been debated substantially. Authors disagree on the taxa and on the taxonomical scale to which the rules should apply, and on the nature of the environmental variables that promote changes in organismal traits. The exact mechanisms causing the relationships are also rarely understood. Still, with information on climatic conditions, species distributions and phylogenetic relationships now readily available, the rules’ cogency can be put to the test more rigorously than ever before. Here, I assess the validity of several ecogeographical rules in the lizard family Lacertidae.

Despite being among the oldest and most speciose families of lizards, lacertids tend to resemble one another relatively closely in many aspects of their biology. Their morphology, behaviour, thermal physiology and life history seems evolutionarily conserved. This is surprising, since lacertid lizards have conquered a wide variety of habitats and microhabitats and are distributed over a huge latitudinal gradient. In this study, I examine whether lacertids, at the species level and as a family, follow ecogeographical patterns of body size and proportions described for other taxa (and therefore constitute ‘sticklers for rules’) – or whether they flout those laws (and thus act as ‘renegades’).

If allowed the digression, I will try to answer related questions concerning the scientists that have used lacertids as study organisms.

Truth or rare: habitat preferences, distribution modeling and activity patterns of *Ophiomorus latastii*

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Ophiomorus latastii is a rare, fossorial, and understudied skink listed as “critically endangered” in Israel’s ‘Red List’. We studied this species’ distribution, habitat preferences and activity patterns by conducting field surveys in Israel during 2016-2017. Based on presence locations documented throughout 1959-2016 and 12 environmental variables, we constructed a predictive geographical distribution map using the maximum entropy method (Maxent) model.

We documented 250 sightings throughout the research. 60% of specimens were found in Lahav area (southern Judean foothills). The skinks were found predominately on, or near, rocky hills in flat and mildly sloped areas with aggregations of high porosity sediment (e.g. plateaus, valleys, saddles and south and east facing slopes adjacent to cliffs). The distribution model accurately identified the known distribution centers of this species and predicted new potential sites of occurrence, which we tested via field validation. During the field validation we authenticated 15 new localities. The model identified soil, precipitation and slope as the main predictors of the skink’s distribution.

Our data suggests that *O. latastii* is not as rare as previously thought. It prefers semi-arid grasslands and shrub-lands, specifically south and east slopes, where high rates of soil erosion and sediment aggregates can be found. Contrary to common knowledge, we found *O. latastii* to be active throughout the day during the summer in damp, porous soils. The model performed well in directing us to general and even precise locations where the species occurs. Within localities a good acquaintance of the biology of this species is nonetheless needed to locate it. Furthermore, despite having the greatest abundance, none of the sample sites in Lahav area are protected by law, an alarming problem that should be addressed promptly.

Waitin' on a sunny day: lizards pay steep thermal costs to hide from predators

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Most animals face predators in their daily life and have evolved antipredator strategies that promote survival and minimise escaping costs. For example, many animals hide into burrows or crevices into which their pursuers cannot access. Ectotherms rely on external sources of heat to raise their body temperature, and it can be expected that they pay costs in terms of heat loss when staying hidden. Indeed, refugia are often thermally more unsuitable than the external environment. Unfortunately, it is challenging to quantify ectotherms body temperature both before and after a predation attempt and the thermal costs of hiding. Here we took advantage of infrared technology to measure the body temperature of the Ocellated lizard *Timon lepidus* before individuals escaped and hid from a simulated predation attempt, and after they emerged back from the refuge. We quantify the drop in body temperature that lizards experienced while hiding and used multi-model inference to show that heat loss largely depends on the time spent in the refuge. In turn, the time spent hidden depends on the initial lizards' body temperature and the temperature inside the refuge. Warmer lizards or lizards hiding in warmer refugia spent more time hidden. All other variables considered did not contribute significantly to heat loss or time spent hidden. Thus, lizards perceive and evaluate the thermal quality of their refugia and integrate this information to react to predation attempts. Such findings have important implication concerning microhabitat choice and territorialism in lizards.

Static, ontogenetic and evolutionary modularity of cranial skeleton in Lacertid lizards

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There is a growing interest for studies of modularity and morphological integration in non-model organisms, and the need for these studies at multiple levels has often been pointed out. Our dataset, consisting of cranium shape data for 14 lizard species from the family Lacertidae, with substantial samples of hatchlings and adults, and their inferred evolutionary relationships, enabled us to perform multi-level assessment of modularity and morphological integration. The skull shape was quantified by landmark based geometric morphometrics, and five alternative modularity hypotheses of lizard cranium were tested using both allometric and non-allometric components of shape variation. At the static level, firm confirmation of cranial modularity was found for hypotheses which separate anterior and posterior functional compartments of the skull. At the ontogenetic and evolutionary level, the hypothesis based on developmental origin of skeletal elements (neurocranial versus dermatocranial) was confirmed. Also, the differences in the pattern of modularity for allometric and non-allometric component of shape variation were found. These results indicate that static modularity could be driven by functional demands and can be regarded as adaptive. The shared pattern of ontogenetic and evolutionary modularity indicates conservatism of modularity patterns driven by developmental constraints. The main implication is that there is a complex interaction of developmental and functional constraints, including allometry, in shaping cranial modularity pattern.

Varanidae teeth asymmetry is correlated with body size

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The body size is correlated with potential stress in many facets. One is the number of potential predators negatively correlated with the body size. Another parameter is food availability. The bigger the species, the bigger the food availability the size of the jaws can handle. The same applies both Inter and Intra-specifically in the size of the jaws, hence head length or skull size. Morphometric asymmetry of digit length was shown to be correlated with stress level both in Aves and Squamata. Recently the eye size asymmetry was correlated with stress level. We tested potential correlation between teeth asymmetry with skull size and with body size of eleven Sp. of Varanidae. We found that the bigger the skull or the body size (SVL) the asymmetry of the teeth (centroid size asymmetry) was more right biased. That was true for both inter and intra species. Also, it was consistent with both the average sum of centroid size asymmetry, and in the centroid size asymmetry of specific teeth. Since the asymmetry of teeth shouldn't be correlated with body size, we explain the result as resulted from stress due to body size. Since it is consistent with the results of digit asymmetry and stress in the literature, we suggest teeth asymmetry as derived from brain laterality as described in the literature for digit ratio, digit asymmetry, eye asymmetry and scutes asymmetry of both supra and infra labial.

This scheduled talk will not be delivered

Species delimitation and diversification patterns in the diurnal geckos of the genus *Pristurus*

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The life history and population biology of mainland and insular taxa of a specific radiation are fundamentally distinct. While the ecological complexity of mainland communities with most of the ecological niches filled and high levels of inter-specific competition are a limiting factor for an efficient niche expansion and morphological diversification, insular groups often experience great diversifications, as they move across the new adaptive landscape provided by islands (ecological opportunity) experiencing higher rates of phenotypic diversification and disparity than continental taxa.

In this study, we test this “island effect” hypothesis using a completely sampled mainland-island system, the genus *Pristurus*, a group of diurnal geckos mainly distributed across Arabia, the Horn of Africa, and the Socotra Archipelago. To such purpose, we generated a new molecular phylogeny of the group using multilocus coalescent-based methods for species delimitation and for inference of the species trees, on which we mapped body size, head shape and limb length. We then explored whether island and continental taxa shared the same morphospace and differed in their tempo and mode of evolution. Furthermore, in order to see if habitat use is correlated with morphological change, we reconstructed the ancestral habitat across the phylogeny and tested phenotypic disparity and differences in trait evolution rates between different structural microhabitats.

The main results reveal a complex scenario in which: 1) continental taxa present higher levels of morphological diversification compared to insular groups, highlighting the importance of taxon-dependent factors at determining patterns of phenotypic diversification (involving different trait evolvability among taxa); and 2) different characters may experience similar evolutionary patterns depending on microhabitat occupation, bearing out that reconstructing the ancestral habitat can provide insight into the evolution of associated traits within adaptive radiations and the structuring of this ecological communities (ecological specialization).

Effects of land-use changes on lizard communities and populations in the Loess plains of the northern Negev, Israel

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Loess plains of the Northern Negev have been under anthropogenic influence for thousands of years, mainly through grazing and seasonal agriculture. This dry shrub and grass landscape is considered one of the most unique and vulnerable ecosystems in Israel, with less than 5% protected by law. During the last three decades, wide-scale runoff rainwater harvesting management schemes were implemented on this habitat by plowing and planting of exotic trees, causing substantial changes in habitat structure. Since 2012, HaMaarag, Israel's Nature Assessment Program, monitors reptiles in three habitat types in loess plains of the northern Negev: natural shrub and grass steppe (NSS), runoff rainwater harvesting plantation (RRHP) and extensive traditional Bedouin agricultural wheat fields (ETBA). Results from the first two monitoring rounds (2012-2016) show that beta diversity homogeneity was significantly different between NSS and ETBA, whereas NSS and RRHP, and RRHP and ETBA were not significantly different. Rarefaction analysis revealed that higher species count relative to sample size was found at NSS plots, followed by RRHP, with ETBA showing the lowest values. Desert specialist lizard species were positively and significantly correlated with NSS while generalist lizard species were positively and significantly correlated with ETBA. The current results emphasize the significance of lizards as bioindicators for habitat quality and type. We stress the importance of protecting and conserving loess shrub and grass steppe habitats from further development. We also suggest monitoring continuation and giving special emphasis on the effects of livestock grazing, a significant practice in this area, for better understanding of reptile dynamics in the system.

Introducing the Mediterranean desert monitors of Israel

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The desert monitor (*Varanus griseus*) is a desert species adapted to harsh desert conditions. In the southern coastal plain of Israel desert monitors live under mild Mediterranean climatic conditions (annual rainfall of 500-600 mm). In the study area (southern coastal plain) 21 adult monitors (8 males and 13 females) were captured, marked and measured (total length= 62-102 cm, weight=239-1261 g, n=21). These morphometrics are larger than those of conspecifics from other areas, and were presumed to be the result of a high productivity in the study area. After examining specimens in zoological collections, this presumption was refuted and found to be inconclusive. The comparatively large body sizes were therefore alternatively related to anthropogenic factors – all of which is discussed. In the study area the monitors display distinct seasonal patterns of activity, being active from March-April to October-November and hibernating underground during the rest of the year. Peak activity is in May-June. There were pronounced intersexual differences of the seasonal activity patterns. Males start activity somewhat earlier than females and cease activity much earlier than females – all of which is also related to the high productivity in the study area. In the southern coastal plain of Israel adult *Varanus griseus* was inferred to be the top diurnal predator and the ecological equivalent of the Egyptian mongoose (*Herpestes ichneumon*). These assessments have both supportive and unsupportive argumentations, all of which are discussed.

Plenary lecture

Spatio-temporal trends in two lacertids in Mediterranean coastal dunes and the response to dune restoration

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Reptile diversity has been monitored on three dune types (mobile, semi-fixed and fixed dunes) in Nizzanim Dunes Nature Reserve, as part of the Long Term Ecological Research project in collaboration with the Israel Nature & Parks Authority for more than 12 years. This is the largest experimental habitat-manipulation ever conducted in Israel to create knowledge-based conservation management plans. Unlike most coastal restoration projects that seek to stabilize (fix) dunes, the attempt to restore Nizzanim's dunes involved vegetation removal to recreate more mobile-like dune states in two different ways; (1) intentional removal of vegetation across the whole dune and (2) removal of vegetation on the wind facing slopes. In addition, we monitored the consequences of passive vegetation removal due to disturbance caused by recreational vehicle usage.

We present the spatio-temporal changes among two lacertid species; *Acanthodactylus scutellatus* and *A. schreiberi* (in the older nomenclature), across different dune types, as well as the responses of these two species to the three different treatment types. *A. scutellatus* is a widespread desert psammophile (from Mauritania to Oman), mostly annual. In contrast, *A. schreiberi* is found in the eastern Mediterranean only, but in more diverse soil types and it reaches larger size and older age. In untreated (control) dunes, *A. scutellatus* is the only lacertid in mobile dunes, while *A. schreiberi* is the only lacertid in fixed dunes. Both species coexist on the semi-fixed dunes. Observations of *A. schreiberi* declined in response to wind-facing vegetation removal, which indicates a shift towards the target composition of mobile dunes. Meanwhile *A. scutellatus* appears to show no response to any vegetation removal treatments. The presence of both species in the disturbed dunes is similar to that in mobile sands, suggesting that some form of controlled disturbance may be beneficial to conserving *A. scutellatus* in coastal habitats of Israel.

Plenary lecture

Living on Mediterranean islets: saurian Crusoes adapt and survive

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Minimal masses of land surrounded by sea, Mediterranean islets – small, arid, poor - are the quintessence of insularity. Biodiversity indices are very low and lizards are the top terrestrial predators in most of them. Though diversity is limited, a hidden wealth is patiently waiting to be discovered: the impressive adaptations that these lizards adopted compensate for the scarcity of species. Relaxed predation regime, low food availability and restricted habitat heterogeneity (fewer shelters) shape most parameters of islet life. Dense populations, high intraspecific competition, imaginative resource exploitation, effective thermoregulation and extreme tameness are among the main responses to islet particularities. Here, a panorama of the behavioural, physiological and ecological strategies that lizards living on Mediterranean islets come up with is presented. Rather than a general, global norm, islet lizards seem to follow an idiosyncratic pattern that depends on the particular conditions of each single insular biotope.

Diversification patterns in the Socotra Archipelago – examples from *Pristurus* and *Haemodracon* geckos

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Intra-island diversification processes largely depend on the island's environmental heterogeneity to promote effective segregation of populations by divergent natural selection pressures and microhabitat specialization or by long-term gene flow restriction. The Socotra Archipelago in the Arabian Sea is considered one of the most isolated landforms on earth and an endemism hot spot, with reptiles constituting the most diversified group of vertebrates distributed on the archipelago's four islands: Socotra, Darsa, Samha and Abd al Kuri. Previous studies have suggested, focusing on the deep structure among species, different patterns of geckos' diversification in the archipelago in which species exhibit either phenotypic differentiation or climatic segregation. To deepen our understanding of these patterns in the Socotra Archipelago, we assembled geographically comprehensive datasets and used molecular, morphological and ecological data to elucidate the genetic diversity, phylogeographic structure and distribution dynamics of two sister species from two gecko genera – *Pristurus* (*P. sokotranus* and *P. samhaensis*) and *Haemodracon* (*H. riebeckii* and *H. trachyrhinus*). Our results suggest that both genera diversified *in situ* on Socotra Island during the Middle Miocene, with Quaternary dispersals to Samha and Darsa Islands by *H. riebeckii* and *P. samhaensis* facilitated, most likely, due to a lower sea level. *Haemodracon*'s divergence is associated mostly with remarkable body size and micro-habitat (vertical vs. horizontal surfaces) segregations and high genetic intra-specific diversity, with low levels of climatic and body shape differences within their sympatric distributions. We revise the phylogenetic structure and distributions of *Pristurus*, and confirm the occurrence of *P. samhaensis*, a previously Samha and Darsa endemic, on Socotra as well. We thus suggest that the two *Pristurus* species display an east-west parapatric segregation pattern on Socotra. These results exemplify how important components such as shallow genetic structure and micro-niche differentiation can shade light on ongoing diversification processes.

How does dehydration affect thermoregulation in ectotherms? A case study on lacertid lizards

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Climate change is negatively affecting many species. The increase in mean air temperature is often associated with distribution shifts, changes in phenology, and local extinctions. Other factors, like water and food shortage, only partially correlating with air temperature, may also contribute to the negative consequences of climate change. Lizards are receiving much attention in recent years since they are considered particularly vulnerable to climate change. However, the possible consequences of dehydration on lizard ecology, physiology, survival and conservation tend to be neglected. In a context of limited water availability, we predicted that lizards exposed to acute dehydration would thermoregulate less precisely than hydrated lizards. Furthermore, dehydrated lizards will be less active, change the daily pattern of thermoregulation and trade-off water balance against thermoregulation. We exposed four temperate lacertid species to thermal gradients with or without a source of water. We measured preferred body temperatures, daily pattern of thermoregulation, and the use of space. Dehydration negatively affected thermoregulation in all investigated species. Dehydrated lizards reduced their mean preferred temperature (but not the mode) and showed a species-specific pattern of hourly change in thermal preference. Furthermore, they more frequently used the colder parts of the gradients, as well as spent more time hidden. Lizards experiencing acute dehydration may suffer a reduction in survival and fitness because of poor thermoregulation. Similarly, dehydrated lizards may spend more time hidden, waiting for more favourable weather conditions. Such inactivity may have ecological consequences especially in those regions that undergo prolonged periods of droughts. Finally, lizards seem to trade-off thermoregulation and water balance, as these factors are physiologically intertwined, and should be approached simultaneously in the context studies focusing on the effects of climate change.

Metabolic depression during winter could mitigate impacts of climate change on lizards

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The impacts of climate change have been extensively studied in lizards. However, most studies have explored how warming may affect the potential for activity and subsequent growth and reproduction, while climate change may also affect overwintering lizards, by changing the length of winters and the conditions experienced during inactivity. In particular, although lizards may be able to begin activity and reproduction earlier under a warming climate, warmer winters will raise energy demands, increasing the risk of starvation and decreasing surplus energy for growth or reproduction. Thus, a better understanding of the energy demands of lizards during long inactivity periods is crucial for estimating risks of climate change. We tested whether thermal acclimation of metabolism enables animals to save energy during warm winters using a widespread group of lizards, *Sceloporus undulatus* complex. We combined an experimental study of metabolic rates with a model of seasonal energetics. In the lab, lizards from four populations were exposed to either a constant 12°C, a constant 2°C, or a linear decrease in temperature from 12°C to 2°C. After three weeks, we compared the metabolic rates of these when exposed to 2°C and 12°C to their rates prior to acclimation. For all populations, only lizards exposed to 12°C reduced their metabolic rate during the three weeks. Interestingly, lizards vary in their acclimation strategies based on their current climate. In particular, lizards from the relatively cooler populations (Colorado) reduced their metabolic rate only at the cooler temperature (2°C), and lizards from relatively warmer population (Arizona) reduced their metabolic rate only at the warmer temperature (12°C). Moreover, lizards from the population from New Jersey, which is characterized by an intermediate climate, reduced their metabolic rate under both 2°C and 12°C. These different levels of acclimation can affect the ability of lizards to mitigate impacts of global warming.

Lizard and snake remains in zooarchaeology: the Natufian site of el-Wad Terrace (Mount Carmel, Israel) as a case study

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Squamate remains are sometimes present at archeological sites but are rarely studied due to difficulties regarding recovery, identification and interpretation of micro-vertebrae remains. However, they may provide important information regarding ancient diet and paleo-environmental reconstructions, and thus can offer us a better understanding of past environments and cultures. The Natufian prehistoric culture in the Levant (15,000 – 11,600 years before present) has great importance as a transitional phase between the Paleolithic and Neolithic cultures. The current research focuses on the Natufian site of el-Wad Terrace, Mount Carmel, Israel, one of the first sedentary hamlets, just prior to the adoption of agriculture. El-Wad Terrace is a base-camp displaying a long occupational sequence, including stone structures, cemeteries and numerous zooarchaeological finds. We found a sharp increase in squamate (lizards and snakes) remains in the Natufian, compare to previous Paleolithic cultures, and thoroughly examined them through detailed taxonomic identification and taphonomic analysis. We hypothesize the squamate remains to be part of the expansion of diet breadth that occurred in the Natufian culture. The lizard assemblage in the site is rich and diverse and includes a variety of Mediterranean species (*Pseudopus apodus*, *Stellagama stellio* ssp., *Chamaeleo chamaeleon recticrista*, *Eumeces schneideri pavimentatus*, *Lacerta media israelica* and *Phoenicolacerta laevis*). The research compares accumulation patterns, species diversity and preservation of squamate remains in an intra-site space (the EWT architectural complex), as well through time (Early Natufian versus Late Natufian at el-Wad Terrace). Along with the reconstruction of the Natufian diet, the environment at the end of the Pleistocene in the Early and Late Natufian of Mount Carmel will be discussed.

Testing the niche expansion hypothesis in insular geckos

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The Niche Expansion Hypothesis (NEH) suggests that niche-breadth increases where interspecific competition is weaker, intraspecific competition is stronger, and prey availability is greater. This expansion can occur via increasing differences between individuals or expanding individual niches (or both). We examined how dietary niche breadths in island populations of *Mediodactylus kotschy* are affected by inter- and intraspecific competition, and prey availability.

We collected faeces of 206 *M. kotschy* geckos from 16 island populations in the Aegean Sea and two nearby mainland sites in the southern Peloponnese during May-June 2014-2016. On each island we estimated population density of *M. kotschy*, counted their competitor species, and placed 21 pitfall traps to estimate potential prey (arthropod) diversity and abundance. We sorted the samples and identified the prey remains to the order, or if possible, family levels, and counted prey items from each diet category for each gecko. To assess individual and population dietary breadths, we quantified three diversity indices for each: number of prey categories, Shannon–Wiener diversity index, and evenness (assessing how evenly prey items distribute among prey categories). We similarly processed and assessed the diversity of arthropods from pitfalls for each island.

Our analyses reveal that *M. kotschy* base their spring diet mainly on beetles, cicadas and ants. Mainland geckos have a wider dietary niche than insular ones. Prey categories per population negatively correlated with competitor richness. Prey availability and population density were unrelated to niche breadth at both the individual and population levels. We further found a positive correlation between the dietary evenness of individual and population level.

Although to some extent competitor richness constrains niche breadth as predicted, most of our results contradict the predictions of the NEH. This suggests a reconsideration of this theory is probably warranted. Whether these factors drive sexually-dimorphic niche breadth remains to be tested.

Balance control and locomotor adaptations in lizards living in Greek islets

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Microhabitat complexity is likely to be reflected in the challenges imposed on balance control during locomotion and, therefore, in the balance apparatus of the inner ear (vestibular system). Most likely, animals evolved to live in complex habitats (e.g. dense vegetation, rocks) will respond more accurately to perturbations in their locomotion, than animals adapted to living in less demanding habitats (e.g. open, sandy, flat), by possessing a rapidly responding vestibular system and as a result a higher sensitivity. Here, we investigate the maneuverability (and hence balance control) of the Aegean Wall Lizard (*Podarcis erhardii*). Five populations originating from one island population (sandy, open area), were introduced to five Greek islets of the Cyclades, characterized by different habitat complexity. Here, we compare the source population and one of the introduction islands with dense, grassy vegetation. We filmed the individuals running on a complex and on a non-complex racetrack (mimicking the habitat complexity), challenging their maneuverability and, as such, their balance. Our results suggest that head stabilization is crucial for balance during locomotion. We found that lizards from both populations stabilized their head more than their trunk while running, regardless of the type of racetrack, and this stabilization was even higher at higher velocities. If both head and trunk moved continuously during locomotion, keeping balance would be very challenging, because the vestibular system is located inside the skull. Hence, head stability is crucial for animals running in high speeds. Finally, forward velocity was not significantly different between racetracks or populations. This suggests that these lizards possess an intrinsic capacity of performing equally well in complex and non-complex habitats, or that more time is needed to adapt to the new environment.

High levels of cryptic diversity in the rock-dwelling geckos of the *Ptyodactylus hasselquistii* species complex

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An accurate comprehension of species diversity is critical for a wide range of biological studies from an evolutionary perspective. The development of molecular-based species delimitation methods has been greatly enhanced with the incorporation of coalescence theory, the conceptual advancements regarding the species concept and the abundance of DNA sequence data. Coalescence-based methodologies provide a rigorous framework for exploring boundaries between phylogenetic lineages and they have been used in a growing amount of studies in the last years, perhaps with a special interest when applied on morphologically conserved and/or allopatric species. That is the case of the *Ptyodactylus hasselquistii* species complex - a group of relatively large nocturnal geckos from northeastern Africa and large parts of Arabia in which recent studies have shown high levels of genetic variability that contrast with a conserved morphology. In this study, we assembled a geographically comprehensive set of samples covering the entire range of this complex, comprising broad molecular and morphological datasets, including six markers and more than 400 specimens measured. We analyze these datasets with coalescence-based methods and multivariate analyses in order to unravel their relationships and degree of phenotypic diversification. Our results suggest that, despite several taxonomic revisions, there is still a high level of undiscovered diversity within *Ptyodactylus*, especially in the mountainous regions of southwestern Arabia. We hypothesize that, unlike other Arabian geckos, the high level of specialization and adaptation to exploit the same rocky environments is a key factor to understand how diversity has been generated and maintained in this group of geckos.

Understanding the role of arm-waving in Lizards

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Many animals perform conspicuous displays that expose them to potential predators. Aside from social contexts, why animals use such seemingly dangerous displays is still unclear. Our goal was to assist reducing this knowledge gap by focusing on the conspicuous arm-waving behavior of the lizard *Acanthodactylus boskianus*. We hypothesize that arm-waving behavior aims to entice potentially concealed predators to move and reveal themselves while lizards are vigilant. To test this hypothesis, we filmed the behavior of foraging hatchlings and adults in the field using high speed imaging, and recorded the soil surface temperatures. We encoded the different behaviors using the software BORIS to establish a highly detailed account of the frequency and behavioral context of each arm-wave. We observed that arm-waves were displayed frequently – up to three times per minute – regardless of age or sex. Arm-waves were positively associated with surface temperature. They usually occurred almost simultaneously with tail-displays, and tended to occur right after stopping or immediately before resuming movement. Our results suggest that arm-wave behavior may be used by lizards for two main purposes – to reduce predation risk and as a thermoregulatory mechanism.

High shelter availability leads to ‘arrogant’ lizards

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Flight initiation distance (FID) and escape distance (ED) are useful tools for the evaluation of antipredator strategies under the context of escape theory. We checked FID and ED in three populations of the lizard *Acanthodactylus schreiberi* from Cyprus (from Akrotiri, Geri and Agros). Adult and juvenile individuals showed similar antipredator strategies despite differences in predator encounter frequency due to their different lifestyles. Antipredator behavior in the field appeared not be affected by predator diversity. The population with lower predator diversity (Akrotiri) exhibited higher FID and ED rates. Shelter accessibility seemed to be the main factor driving antipredator strategies, especially in populations with sparse shelter availability. Where shelters were abundant and predator diversity similar (i.e., Geri and Agros) the lizards exhibited similar FIDs and EDs. Our findings agree with previous work that highlighted the significance of shelter availability for the escape behavior of lizards.

Genetic structure and ecological characteristics of local populations of rock lizard *Darevskia dahli* in Armenia

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Based on specific allele combinations of microsatellite loci in 111 individuals of parthenogenetic species *Darevskia dahli* from 5 local populations located at a distance from 9.5 to 46.3 km from each other, 11 genotypes were identified. It was established that 72 individuals belong to the major clone, 21 individuals to the intermediate clone, and the rest form 9 rare clones that are represented by several individuals. The use of genotype-specific markers revealed the presence of at least 3 independent acts of hybridization between parental species. Ecological characteristics of populations with revealed clonal lines are given. Such characteristics as: altitude, average annual temperature and average temperature in the warm season, total amount of precipitation in the dry period and in the warm period of the year are not statistically significantly different by criterion Tukey HSD Post hoc ($P < 0.05$), i.e. *D. dahli* individuals in these populations live in similar ecological conditions. However, a comparative analysis of the ecological characteristics of *D. dahli* with parental species *D. portschinskii* and *D. mixta* based on 271 localities obtained from literature data and field research showed that there are significant differences between the species. The habitats of *D. portschinskii* are lower in altitude and higher in average annual temperature than *D. dahli* and *D. mixta*. The most humid habitats are preferred by *D. mixta* in comparison with *D. dahli* and *D. portschinskii*. In general, a statistically significant difference between *D. mixta* from other species and partial similarity of ecological parameters for *D. dahli* and *D. portschinskii* was shown. On the basis of complex statistical analysis and computer modeling, it was revealed that the formation of the multiclonal structure of the populations of *D. dahli* is largely associated with genetic factors, rather than with environmental factors. This study supported by the RFBR № 18-34-00361, № 17-00-00427.

Biotic interactions affect body condition of island geckos

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The fitness of animals is tightly related to their body condition. Individuals in good condition are more likely to survive and successfully reproduce than those in poor condition. Body condition is expected to deteriorate as predation pressure, inter- and intra-specific competition, and parasite infection increase, and where prey is less abundant.

We tested these predictions in *Mediodactylus kotschy* geckos on 33 islands in the Aegean Sea. We collected field and museum data on snout-vent length, body mass, and mite loads for more than 400 males. For each population we also estimated population density (as a proxy for intraspecific competition), terrestrial arthropod biomass (index for prey availability), predator species richness and predator abundance (indices for predation pressure), and competitor species richness (index for interspecific competition). We used a common index for body condition: the residuals of an animal's body mass\length regression; the larger the residual, the better the condition of the animal is.

Our results suggest that increased predation pressure (higher predator abundance) reduces body condition as expected. Surprisingly, however, we found that body condition is better for individuals with higher mite loads and deteriorates on islands where arthropod prey is more abundant. Competition (both inter- and intraspecific) seems unrelated to body condition.

We suggest that more mites could accumulate on individuals in good condition. The abundance of predators likely limits foraging time and increase the levels of stress hormones. The inverse relationship between body condition and prey abundance remains, for now, a mystery.

The impact of cattle egret on lizard community structures in Mediterranean woodlands

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Lizard communities in Mediterranean woodlands are shaped by various factors under the rapidly changing environment. Our recent observations on lizard predation by Cattle Egret (*Bubulcus ibis*), which often escort cattle in grazed woodlands, raised the question about the role of such predation on lizard community structures.

We combined data on lizard assemblages and egrets diet in Northern Israel by: (1) mapping the egret nesting colonies; (2) sampling lizards using direct observation in sites along a distance gradient from colonies; (3) monitoring egret activity in the field using direct observation and trapping cameras; and (4) exploring the diet of egrets during nesting seasons by sampling vomits in six large nesting colonies near woodlands.

The results have indicated that (1) nesting colonies are widespread; (2) there is low species richness and abundance of lizard communities in proximity to egret colonies; (3) there is a higher foraging activity in sites grazed by cattle in proximity to colonies; and (4) there is a substantial lizard representation in the egret food menu.

The present study demonstrated the high abundance and wide distribution of Cattle Egrets throughout Northern Israel, and their impact on lizard community structures in cattle managed woodlands. Action regarding colonies expansion should be addressed.

Phenotypic differentiation of *Podarcis* lizards of western Pontine islands (Italy), inferred by geometric morphometrics

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Islands are fascinating natural laboratory where to study speciation and evolution. Here, we investigated the variation of the head morphology of 374 individuals of *Podarcis siculus* from mainland Italy, Sicily and the Pontine Archipelago, using the geometric morphometric approach. We also included in the analysis samples of an extinct island population. Our results indicated a strong relation between the morphological differences and the phylogeographic structure basing on previously published genetic data, indicating that the western Pontine populations seem to be a case of incipient speciation and that additional information should be addressed to better define their taxonomic status. In addition, the extinct population of Santo Stefano Island clustered in all analyses with the western Pontine populations. This result not only involves the evolutionary history of *P. siculus*, but also entails broader taxonomic considerations and conservation aspects.

The impressive locomotor performance of *Acanthodactylus boskianus* when negotiating complex terrains

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Natural environments vary enormously in their structural characteristics, from different surfaces (sand, rocks, etc.) and different inclinations (level, uphill, downhill) to different levels of complexity (open, dense vegetation, cliffs, etc.). In this context, obstacle negotiation by running lizards has been well studied from an ecological perspective, but how these animals negotiate the complex terrains, i.e. where the conditions for each foot placement are unique, remains unknown. We examined the effects of running on complex terrains on the kinematics and performance of *Acanthodactylus boskianus*, which are fast running lizards. We quantified three-dimensional kinematics from high-speed videos (325Hz) of seven individuals running on 1) a flat racetrack, 2) a racetrack covered with aligned transverse hemi-cylinders [radius = 0.4 snout-vent lengths (SVL) for our sample], 3) a racetrack covered with the same transverse hemi-cylinders but spaced a distance of 0.8 SVLs with respect to each other, and 4) a racetrack covered with hemi-spheres (radius = 0.4 SVLs). Our preliminary results show that *A. boskianus* do not fall over and are able to keep a fast running gait in the desired direction. Their average running velocity is not affected by the different racetracks suggesting that the lizards have the capacity to keep all forces/moments and inertia in equilibrium in order to proceed steadily despite the perturbations imposed by the terrain. The vestibular system certainly plays an important role in this equilibrium control. Our results corroborate this: we observe a strong head stabilization with the pitching rotation being generally lower than the rolling and yawing rotations. The stabilized head can thus provide the frame of reference needed for accurate segmental movements to deal with terrain complexity.

Clutch sizes of lizards: to Ashmole's hypothesis and (a little) beyond

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A strong tendency for bird clutch sizes to increase with latitude has been known for decades. Often going by the name of Ashmole's hypothesis, it is generally ascribed to increasing seasonality in resources and predation pressures with latitudes. Although it was developed for, and mostly tested in birds, few of the suggested underlying mechanisms have feathers in them. But despite occasional local tests it is seldom examined in other taxa.

I used literature data to test how latitude, climate and other factors are related to clutch sizes across ~4850 lizard species. I found strong effects for phylogeny and positive association with body size, primary productivity, latitude and (separately), rainfall seasonality and temperature seasonality, as predicted. Clutch sizes decrease with temperature and, surprisingly with rainfall. Other factors that are associated with small clutches include nocturnality, herbivorous diet, insularity and scansoriality (inhabiting trees and rocks). Reproductive mode (viviparous/oviparous) was unrelated to clutch size, and neither, surprisingly, was the length of the activity season (for which, however, data only covered ~420 species). Analysing only species with maximum clutch sizes >2 (i.e., excluding most geckos and anoles as well as members of some other lineages), most of these relationships are retained. However, activity time and microhabitat choice become non-significant, and viviparous species emerge as having smaller broods. These results also hold when skinks, the largest, most varied lizard clade, are analysed separately, suggesting phylogenetic effects were not fully accounted for in the global model. These results suggest that Ashmole's hypothesis and several other well known or suspected mechanisms affect lizard clutch sizes. It also raises interesting potential reasons why geckos, anoles and other fixed clutch taxa are restricted to tropical climates, and abundant on rocks, trees, and islands, suggesting appealing avenues for future studies.

Plenary lecture

Historical patterns of gecko diversity across Mediterranean-type ecosystems

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Gekkotan lizards are highly asymmetrically distributed across the five Mediterranean-type ecosystems, despite generally favorable current conditions for their occurrence. This is explained, in part, by deep-time distributions of the seven extant gekkotan families. Diversity is lowest in the Americas, where only two and three species, respectively, occur in the Californian Mediterranean Zone and the Central Chilean Mediterranean Zone. The small Western Cape Mediterranean Zone and the much more extensive Australian Mediterranean Zone harbor one and four gekkotan families, respectively, and both areas are influenced by their proximity to adjacent gecko hotspots in more arid regions. The Mediterranean Basin itself is represented by three gecko families (four if the most expansive definition of Mediterranean climate is used), and its moderate diversity is achieved chiefly through its inclusion of peripheral populations of Levantine and Maghreb species, although there are several endemic species and even genera, including one ancient European lineage. Extensive radiations of gekkotans in Mediterranean-type ecosystems are limited to southwestern Australia where both pygopodids and diplodactylids are relatively diverse. In addition, Australia appears to have been colonized overwater by African gekkonids. The foundations for current distribution patterns were probably established in the Miocene, although events through the Pleistocene further refined the gecko distributions observed today. The “permissiveness” of Mediterranean zones facilitates the establishment of invasive species of geckos which, in the Anthropocene, are transported globally, and several of these areas now support exotic geckos. The Mediterranean Basin is a net exporter of geckos, with several of the most invasive of all geckos deriving from this region and establishing in a diversity of ecosystem types around the world.

Posters

Monday 18/06/18 18:00

P1	Vidan et al.	The biogeography of lizard functional groups
P2	Jablonski et al.	Mitochondrial diversity in the southern populations of <i>Pseudopus apodus</i>
P3	Slavenko et al.	Results of the first Herpetological Survey of Israel's Mediterranean islands
P4	Corti and Biaggini	Lizards in extreme habitat: on islets and rocks
P5	Zhao et al.	The effect of predation risk, food availability, and shelters on reproduction of lizards
P6	Semegen and Foufopoulos	Predation pressure as a determinant of locomotor performance: Lizards run slower on islands without predators
P7	Deimezis-Tsikutas et al.	Tail autotomy and social status in the Aegean wall lizard (<i>Podarcis erhardii</i>)
P8	Kapsalas et al.	Sprint performance of three Greek populations of the rougtail rock agama (<i>Stellagama stellio</i>)
P9	Gasso et al.	Populational and biochemical response of sand lizard to the influence of metal-working manufacturing
P10	Girnyk et al.	Polymorphic microsatellite loci and genotypic diversity in clonally reproduced parthenogenetic lizards <i>Darevskia unisexualis</i>
P11	Sion et al.	Asymmetric morphometry and behavior in <i>Mediodactylus kotschy</i> (Reptilia: Squamata: Gekkonidae)
P12	Sion and Tal	Body asymmetry correlates with body positioning in the lizard <i>Ptyodactylus guttatus</i>
P13	Sion et al.	How sympatric Lacertid lizards divide prey among species and between sexes
P14	Ljubisavljević et al.	Updated distribution and diversity of lacertid lizards (Squamata, Lacertilia) in Montenegro
P15	Danon et al.	Parasitaemia in two lowland <i>Podarcis</i> populations in Serbia
P16	Carretero et al.	Regulatory variation in pigmentation loci underlies polymorphism in <i>Podarcis muralis</i>
P17	Oskyrko et al.	Distribution of the invasive species <i>Podarcis muralis</i> (Laurenti, 1768) in the Odessa region, Ukraine
P18	Telea et al.	Age structure in isolated <i>Podarcis muralis</i> populations from Dobrudja region, Romania

P1 - The biogeography of lizard functional groups

Enav Vidan¹, Aaron M. Bauer, Fernando Castro Herrera, Laurent Chirio, Cristiano de Campos Nogueira, Tiffany M. Doan, Marinus S. Hoogmoed, Amir Lewin, Danny Meirte, Zoltan T. Nagy, Maria Novosolov, Daniel Pincheira-Donoso, Oliver J.S. Tallowin, Omar Torres Carvajal, Peter Uetz, Philipp Wagner, Yuezhao Wang, Jonathan Belmaker, Shai Meiri^{1,2}

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Understanding the mechanisms determining species richness is a primary goal of biogeography. Richness patterns of sub-groups within a taxon are usually assumed to be driven by similar processes. However, if richness of distinct ecological strategies respond differently to the same processes, inferences made for an entire taxon may be misleading. We deconstruct the global lizard assemblage into functional groups and examine the congruence among richness patterns between them. We further examine the species richness – functional richness relationship to study the way functional diversity contributes to the overall species richness patterns.

Using comprehensive biological trait databases we classified the global lizard assemblage into ecological strategies based on body size, diet, activity times and microhabitat preferences, using Archetypal Analysis. We examined spatial gradients in the richness of each strategy at the 1-degree grid cell, biomes & realm scales.

We found that lizards can best be characterized by seven ‘ecological strategies’: *scansorial*, *terrestrial*, *nocturnal*, *herbivorous*, *fossorial*, *large* and *semi-aquatic*. There are large differences among the global richness patterns of these strategies. While Australia is the major richness hotspot for all lizards, several strategies are richest in the Amazon Basin. Importantly, the global lizard assemblage exhibits a hump-shaped relationship between functional diversity and species richness, so that the highest species richness and highest functional diversity do not coincide.

The deconstruction of the global lizard assemblage along multiple ecological axes offers a new way to view lizard diversity patterns. It seems that local lizard richness increases through particular ecological strategies becoming hyper-diverse, and not because increased ecological diversity results in high species diversity. Thus maximum richness and maximum ecological diversity do not overlap. These results shed light on the global richness pattern of lizards, and highlight previously unidentified spatial patterns in understudied functional groups.

P2 - Mitochondrial diversity in the southern populations of *Pseudopus apodus*

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The Eastern Mediterranean is a region with extraordinary diversity of reptile fauna. Many Western Palearctic species are endemic to this region or have southern limits of their distribution here. This is also a case of the legless anguid lizards of the genus *Pseudopus* Merrem, 1820. Despite the species diversity of the genus since the Early Miocene, only one species, *Pseudopus apodus* (Pallas, 1775), has survived until the present time in a longitudinally oriented range that spreads from the coastal Balkans in the west through Anatolia, western Levant, the Caucasus Isthmus, the Black Sea, and the southern Caspian region to central Asia in the east. Only recently, phylogeography of the species revealed three main phylogenetic lineages that diverged during or shortly before the Pleistocene. Two of them more or less correspond to the known subspecies, and their low genetic variability suggests relatively recent dispersal and colonization of vast parts of the range. The third, southern and endemic, lineage is more geographically restricted and diversified than the other two. We investigated mtDNA diversity of the populations originating from Israel and southern Turkey. Our results revealed the highest haplotype and nucleotide diversity from the entire distribution range of the species. Interestingly, some of the haplotypes from central Israel are more distant from each other than populations from southern Turkey and northern Israel despite they occur in significantly smaller area. These results highlight the importance of Eastern Mediterranean for preserving high diversity of reptiles. The study was supported by the grant APVV-15-0147.

P3 - Results of the first Herpetological Survey of Israel's Mediterranean islands

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Islands in the Mediterranean often contain rich herpetological communities, comprised of both relictual populations from periods of lower sea levels, and species introduced by direct or indirect anthropogenic activity. Israel's few Mediterranean islands have long been of interest to conservation agencies due to their key role as nesting grounds for various bird species, but there is no knowledge of their herpetofauna.

We conducted the first herpetological survey of five vegetated Israeli islands during the spring seasons of 2017 and 2018. The islands range in size from ~0.002 to ~0.008 km², and are between ~40 and ~210 m away from the mainland. We recorded reptiles on four of the five islands, and five species in total. Species richness per island ranged from 0 to 4 species, and each island had a distinct assemblage. The most common species was *Hemidactylus turcicus*, which was present on all four islands on which we recorded reptiles, and one species (*Mauremys rivulata*) was non-resident.

The presence of these species on the islands remains puzzling. While some, such as *H. turcicus* may have arrived via anthropogenic introduction, some species such as *Acanthodactylus boskianus* are not commensal, and so may represent relictual populations. Further study, including molecular phylogenetics and phylogeography, may help resolve the open question of the origin of these insular populations.

P4 - Lizards in extreme habitat: on islets and rocks

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The importance of islands for biodiversity conservation is well known: each island is a unique ecosystem, often hosting populations characterized by exclusive morphological and/or ecological features. Tiny islands and rocks are particularly extreme ecosystems with few resources in delicate balance but often representing key elements for the survival of endemic species. Here we took in consideration two study systems of the Tyrrhenian Sea, La Maddalena Archipelago (NE Sardinia, Italy) and the islets surrounding Elba Island (Tuscan Archipelago, Italy), selecting only islets with area smaller than one hectare. Sixty-five islets were surveyed from 2011 to 2016: 51 belonging to La Maddalena Archipelago and 15 islets around Elba Island. On La Maddalena Archipelago 16 islets host 1 species (*Euleptes europaea* or *Podarcis tiliguerta*), 11 2-3 species (*Euleptes europaea*, *Tarentola mauritanica*, *Podarcis tiliguerta*, *Chalcides ocellatus*, *Hierophis viridiflavus*). Among the islets around Elba Island, 2 host 1 species (*Euleptes europaea*) and 3 2 species (*Euleptes europaea* and *Podarcis muralis*). Distances of islets hosting herpetofauna from the nearest main island range from few meters to over 2 km. On all these islets reptiles are the only non-flying vertebrates. In particular, *E. europaea* can survive on rocks with few plant individuals and very few arthropods while *Podarcis* require a bit more complex environment.

P5 - The effect of predation risk, food availability, and shelters on reproduction of lizards

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Reproductive investment, i.e. the average number of offspring produced by an organism, is one of the fundamental characteristics of a species. Among other things, it predicts a species' resilience to environmental disruption: taxa that produce more offspring are able to recover more quickly from environmental perturbations and survive long-term environmental change. Despite the clear importance of this trait, ecologists do not have a good understanding of the primary drivers shaping the reproductive investment of each species. To answer this question, we compared the reproductive efforts of numerous island populations of the Aegean Wall Lizard (*Podarcis erhardii*), which differed in multiple key environmental characteristics. We tested three hypotheses, namely that reproductive investment (measured as clutch size, clutch volume and mean egg volume) is: 1) positively associated with predation risk [*'Predation Risk Hypothesis'*]; 2) positively associated with the presence of reliable vegetation cover that provides shelter [*'Gravid Female Protection Hypothesis'*], and 3) limited by (and hence positively correlated) with food availability [*'Food Limitation Hypothesis'*]. Analysis of the data showed strong support for the Predation Risk Hypothesis. The result not only sheds light on which fundamental forces shape reproductive investment in island vertebrates, but can also help set conservation priorities by identifying which populations are most at risk of extinction based on easily quantifiable island characteristics (number of sympatric predator species).

P6 - Predation pressure as a determinant of locomotor performance: Lizards run slower on islands without predators

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Endemic reptile species confined to islands are both ecologically unique and more likely to be endangered. More than 60% of the species known to have gone extinct to date used to occur on islands (Spatz et al. 2017). While there are several reasons why island reptiles tend to be threatened, susceptibility to exotic species, such as invasive predators, is an important contributor. Earlier research has suggested that loss of antipredator defenses in island species is at least partially responsible for this. Locomotor abilities, including sprint speed and stamina, are traits that are essential to escape predation. Here we tested the hypothesis that island species that have evolved in predator-poor environments have lost their ability to run fast – a key trait for escaping invasive predators. We examined maximal sprint speed and maximal stamina in the Aegean wall lizard (*Podarcis erhardii*). The species is widespread throughout the Aegean archipelago (Greece, Mediterranean Basin) and is found on islands with varying levels of predation pressure making it an ideal study organism. We show that on islands with predators, lizards run at higher speeds relative to lizards on predator-free islands. Not all predator categories however are of equal importance: presence of mammalian - but not other - predators was significantly associated with higher sprint speeds in island lizards. In contrast to sprint speed, stamina was not related to predation environment suggesting that this is not a trait that is under selection by predators. Stamina may therefore be less useful for predicting endangerment by introduced predators. The results of this study suggest that conservation funding may be best allocated to protect the most susceptible wildlife populations that live explicitly on low-predation islands as well as on islands isolated for long periods of time.

P7 - Tail autotomy and social status in the Aegean wall lizard (*Podarcis erhardii*)

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Many lizard species use tail autotomy as a defensive mechanism against attempted predation. However, tail loss incurs severe costs associated with reduced survival, locomotor performance and reproductive success. There is strong evidence indicating that tail autotomy leads to loss of social status as well. Here we aimed to evaluate the social behaviour of the insectivorous lacertid *Podarcis erhardii* and to examine whether tail loss affects male social status in this species. In the laboratory, adult male lizards were grouped in pairs of same sized individuals (length and weight) in order to eliminate possible effects of body size on social rank. Encounters of 15 minutes were staged for each pair in a neutral arena equipped with a video camera. Agonistic behaviours were recorded and scored for each lizard, giving positive points for behaviours asserting dominance and negative ones for submissive behaviours. Therefore, the lizard with the highest score was identified as the dominant of the pair. Furthermore, the score of the subordinate individual was subtracted from that of the dominant one, resulting in a difference called social disparity. Subsequently, autotomy was induced only to the dominant lizard of each pair and the encounters were repeated two weeks later, once the tail stub was fully healed. New scores and social disparities were thus computed. According to our results, social disparity significantly decreased after the dominant lizards were autotomised. Moreover, all observed behaviours became scarcer, leading to lower individual scores for most pairs. Our findings suggest that tail loss affects male interactions and social hierarchy in *P. erhardii* lizards.

P8 - Sprint performance of three Greek populations of the rougtail rock agama (*Stellagama stellio*)

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Lizard life is characterised by constant movement: animals run to escape from potential predators, they have to be agile to catch their prey, they shuttle between microhabitats in order to thermoregulate, and so forth. It can thus be said that sprint performance contributes to the overall fitness of taxa. The rougtail rock agama (*Stellagama stellio*) is a robust agamid lizard distributed across the Eastern Mediterranean, Northern Africa and the Middle East. In Greece it has a discontinuous distribution, part of which may be the result of anthropogenic activities. In this study, we aimed to explore differences in sprint performance between Greek populations of *S. stellio* from habitats with varying population density and predation pressure, while taking into consideration the morphological characteristics of each population. Three populations of *S. stellio* were used: a mainland population from Thessaloniki and two insular populations from Delos and Corfu. Sprint performance was recorded on a two-meter racetrack with cork substrate, using a digital camera and high frame rate videos. Weight, snout to vent length (SVL), tail length and width, as well as 11 morphometric characters were also measured. Male and female sprint speed did not differ in each population and individuals from both sexes were pooled for subsequent analysis. The three populations showed significant differences in their sprint speed: the population from Delos was faster than the ones from Thessaloniki and Corfu, even after controlling for SVL and weight. This result could be attributed to population density and intraspecific competition, since the Delos population was denser and showed a higher percentage of regenerated tails than the other two.

P9 - Populational and biochemical response of sand lizard to the influence of metal-working manufacturing

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Lizards are still of low studied group from the viewpoint of environmental pollution influence despite recent increase of respective research. Heavy metals are priority and dangerous pollutants of global concern.

We studied 3 populations of the sand lizard (*Lacerta agilis* Linnaeus, 1758) inhabited ecosystems near the metalworking factory “Avtoshtamp” (Oleksandriia, Ukraine), which is characterised by annual toxic emission of 12.4 tons. The populations occupies sites in affected (polluted) zone at the factory, buffer zone (4 kilometres from the factory) and control zone (8 kilometres from the factory).

The highest density of the sand lizard population estimated by line transect method was observed in the control zone and averages up to 330 individuals per hectare. The population density in the polluted zone was about seven times less. Females mostly dominated in that population (up to 73%).

The content of Cd, Pb, Fe and Mn both in kidneys and liver of the sand lizard from the contaminated site was 1.4–4 times more compared to the animals from both the buffer and control sites.

The lizards from polluted zone had decreased content of total protein, albumins and globulins in the blood serum. At the same time, there were an increase in creatinine and aspartate aminotransferase activity. The lipid peroxidation (malondialdehyde) are twice intensive in the lizards' liver from contaminated and buffer zones compared with the animals in the control site. Thus, the lipid peroxidation was launched in lizards from buffer zone as well as in polluted one.

Our data testify to the pronounced effect of environmental pollution on the sand lizard both at populational and biochemical levels.

P10 - Polymorphic microsatellite loci and genotypic diversity in clonally reproduced parthenogenetic lizards *Darevskia unisexualis*

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Parthenogenetic lizard species represent ideal model organisms for studying the genetic and ecological basis of hybridogeneous speciation and evolution of genetic diversity. Caucasian rock lizard species of Lacertidae family were the first in which parthenogenesis was discovered. The lacertid genus *Darevskia* is of particular significance because parthenogenesis has arisen several times within the group. It includes 24 bisexual species and 7 parthenogenetic, diploid species of hybrid origin. *D. unisexualis* is one of the seven clonally reproduced species of the genus *Darevskia* that originated from the interspecific hybridization *D. valentini* and *D. raddei*. In this study, we genotyping 68 specimens of *D. unisexualis* from five Armenian populations, using four genomic loci containing microsatellites. Monolocus PCR allowed to reveal that the studied loci are polymorphic and represented by several allelic variants in studied populations. All individuals of *D. unisexualis* were heterozygous at the four loci and contained two alleles that differed from each other in length and structure of the microsatellite clusters and in single nucleotide variants in fixed positions of the flanking regions. Using allelic combinations of four loci individual genotypes were obtained for all 68 *D. unisexualis*. We detected 11 genotypes (presumed clones) that differed in their frequencies and population distribution. Among them three clones were abundant and geographically restricted in one or two populations. One clone was widespread but less abundant. All other clones represented typical rare clones that represented by a few individuals. The origin of clonal diversity in parthenogenetic *D. unisexualis* is discussed. The work was supported by the Russian Foundation of Scientific Researches (grant No 17-04-00396).

P11 - Asymmetric morphometry and behavior in *Mediodactylus kotschy* (Reptilia: Squamata: Gekkonidae)

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A correlation between eye and digit asymmetry to brain laterality was demonstrated in the gecko *Ptyodactylus guttatus*. It is thought that this is mediated via hormones that affect the brain laterality and body asymmetry during embryonic stages. After hatching, the digit asymmetry reflects hormone levels, thus it is predicted to be correlated with behavioral patterns such as risk-taking strategy.

We measured hind legs digits (second and forth) of nineteen Mediterranean bent toed geckos (*Mediodactylus kotschy*). We quantified risk-taking strategy by observing whether captive geckos tend to be under cover or exposed. We observed each individual twice and noted whether it changed location.

We found that digit asymmetries were correlated directly and positively with risk behavior (4th digit) and indirectly via shift of risk behavior (2nd digit). Controlling for tail length, the longer the right 4th digit (the more Right dominant) the higher the probability of finding geckos out of cover. The degree of R-dominance was also negatively related to the probability to shift between cover and out of cover positions. 2nd digit asymmetry was not associated with risk strategy, but was negatively correlated with the tendency to shift strategy.

A correlation between asymmetric morphometry of digit asymmetry and risk behavior was demonstrated only in *Homo sapiens* and *Ptyodactylus guttatus*. Thus, it is important to study it further on other vertebrates, to test if it is mere coincidence or a basic phenomenon in vertebrates along the evolutionary tree. Moreover, the novelty in strategy shift is, exposing new facets to the dichotomy of high/low risk-taking strategy. Creating a spectrum or continuum of behavior, may potentially contribute in more elaborated models of mixed strategies of game theory.

P12 - Body asymmetry correlates with body positioning in the lizard *Ptyodactylus guttatus*

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Asymmetric behavior such as social status or risk-taking strategy is correlated with morphometry of digit asymmetry in lizards since they both derived from brain laterality. In humans, the morphometric trait is digit ratio (2:4) and it is correlated with aggression, risk-taking strategy and social status. In humans it was long established to be derived from brain laterality, while in squamata it is recently proposed. In this study, we chose the lizard *Ptyodactylus guttatus* ($N=16$) to test potential correlation of body positioning with both digit asymmetry and digit ratio. The orientations for body positioning were the angle of the body: vertically/horizontally, head side: right/left, head positioning: up/down. Cognitive behaviors we tested were risk: in cover/exposed and shifting risk: yes/no. The risk was measured as presence under a cover (plastic sheet 26X13 cm) and shift was either from cover to be exposed or vice versa. We found, that asymmetry of second digit was correlated with being vertically, right biased tended to be more vertically than horizontally. The digit ratio of right-foot (bigger second digit than forth) was correlated with elevation of the head and with right turn of head side. The shifting of risk-taking strategy, was correlated with the body angle and with head positioning; i.e. up and vertically. The results are consistent with recent hypothesis that digit ratio and digit asymmetry reflects brain laterality. Moreover, the present data offer the first evidence of body positioning reflecting brain laterality in squamata and correlates with body asymmetry.

P13 - How sympatric Lacertid lizards divide prey among species and between sexes

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The co-existence of related species sharing the same food resources is problematic. This competition is both reflected and mitigated by inter-specific differences in the size of the jaws, hence head length. Intra-specifically the same applies to the sexes. Among insectivorous lizards, the sexual head-size difference is often accompanied by a sexual diet difference. Another mechanism presumably mitigating the competition for food, is the foraging mode. Carnivorous animals either actively search for prey, or ambush for it. Lizard families have been characterized as either actively foraging or ambushing. But among Lacertidae in the Kalahari both "widely foraging" and "sit-and-wait" species were discovered, and this recurs elsewhere. Moreover, in lizards of several families the foraging mode differs sexually, either sex being more active and presumably differing in diet. In this paper we explored whether and how the two mechanisms mitigating food competition inter-relate. Hypothetically strong competition may maximize both mechanisms, or one efficient mechanism may obviate the other. Therefore we tested the correlation, among 15 lacertid species inhabiting Israel and vicinity, of the degree of sexual head-size difference with the degree of activity of foraging. Head size we measured in museum specimens in the National Collections of Natural History at the Hebrew University of Jerusalem. Foraging activity had been quantified in the field as Percent-Time-Moving and as number of Moves-Per-Minute for few species, but is known as tightly correlated with relative tail length, available from the museum specimens. The two variables were significantly correlated, indicating that the lizards exploit both avenues to divide the food resources according to the intensity of the competition. We worried lest this could be a "fake correlation" deriving from each variable allometrically depending on body size. But sexual head-size difference did not correlate with body size; while the specific relative tail length was negatively correlated with the specific body size.

P14 - Updated distribution and diversity of lacertid lizards (Squamata, Lacertilia) in Montenegro

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The southern part of Montenegro has been pointed out as an area with outstandingly rich composition of herpetofauna. However, the systematic studies of distribution and diversity patterns of reptiles at the national level were lacking. Such studies are paramount in identifying areas of high conservation priority and planning conservation actions. The increased habitat loss and degradation due to rapid urbanization and tourism-related infrastructure development make studying and protecting biodiversity in Montenegro an urgent matter. So, in order to systematize the current knowledge base, we gathered a large dataset consisting of literature data and our previously unpublished records to assess distribution and diversity patterns of lacertid lizards in Montenegro. All data were mapped on 10 x 10 km national UTM grid. We found that eleven lacertid lizard species inhabit Montenegro (one treated as a species complex) and one additional species may be present. Six of eleven species are Balkan endemics, six reach margins of their distribution in Montenegro and three species have fragmented ranges. Lacertids were the most diverse in the Maritime biogeographic region of Montenegro, while areas of low diversity were along the state borders in the Mountain-valley region. The observed distribution is at least partly influenced by sampling bias, with areas in central parts and along the north-eastern border being largely data deficient. The eastern mountainous subregion had a distinct species composition compared to all other parts of the country. The East-Mediterranean chorotype was the most dominant represented by six species. The great diversity of lacertid fauna of Montenegro can be attributed to its specific topographic position with high influence of Mediterranean climate, heterogeneity of biomes, complex geological history and diverse relief. The Maritime region with its high species richness and eastern subregion of Montenegro with the most unique species composition are areas of high conservation priority.

P15 - Parasitaemia in two lowland *Podarcis* populations in Serbia

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We tested level of parasite infestation in relation to anthropogenic disturbance and habitat alteration on two lowland populations of *Podarcis* lizards in Serbia. The population of *Podarcis tauricus* (N = 90) was examined at the Hatarice pasture, a rather intact steppe habitat at the edge of Deliblato Sands nature reserve. The population of *Podarcis muralis* (N = 63) was examined at the Reva Lake, a suburban area outside of Belgrade subjected to high levels of anthropogenic disturbance – traffic, littering and intensive construction at the site.

Our research was conducted during the whole activity season, from April to October. The lizards were collected by noose or by hand, measured for snout to vent length (SVL) and body mass, to calculate body condition index. A small blood sample was collected from each individual. The animals were marked and released after short monitoring. They were showing no visible signs of stress. After preservation, blood smears were examined by microscope for signs of infestation with Apicomplexa.

Overall, the percentage of infestation was significantly higher in *P. muralis* population than in *P. tauricus*. For females only, the level of infestation was also significantly higher in *P. muralis* population while, for males, there were no statistically significant differences in infestation level. Infestation level between sexes for each species did not differ significantly.

P16 - Regulatory variation in pigmentation loci underlies polymorphism in *Podarcis muralis*

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Many lizard species exhibit alternative colour morphs co-existing in sympatry in variable frequencies across their distribution. These morphs are often connected to differences in life-history, behaviour and physiology, providing an excellent opportunity to investigate the evolution and maintenance of complex polymorphisms. In particular, the genetic basis underlying colour morphs in lizards remains unsolved: are multi-trait differences explained by a large number of genes (a 'supergene' architecture), or by a small number of large-effect loci? To tackle this question, we investigated the molecular basis of colour polymorphism in the common wall-lizard (*Podarcis muralis*), a species that exhibits three pure morphs differing in throat and belly coloration (orange, yellow and white) and two intermediate morphs (orange-white and orange-yellow). We carried out phenotypic (biochemical and histological) analysis and used a *de novo* reference genome assembly as a backbone to conduct genomic and gene expression analysis. We demonstrate that the genomes of the different colour morphs show residual differentiation, with the exception of very localized regions. Fine-scale analyses show that these difference map to small noncoding regions immediately upstream of pterin and carotenoid metabolism genes, explaining variation in orange and yellow colouration driven by pterin and carotenoid pigments, respectively. Gene expression analysis shows that down-regulation of these genes is responsible for both the orange and yellow phenotypes. Haplotype analysis indicates a deep divergence in the orange locus, with divergent haplotypes being shared by other species in the genus. This pattern is explained either by recent introgression or by long-term balancing selection. With this work we demonstrate that the covariance between coloration and other phenotypic traits is not explained by a supergene organization but is most likely driven by pleiotropic effects of pigmentation genes on other physiological aspects.

P17 - Distribution of the invasive species *Podarcis muralis* (Laurenti, 1768) in the Odessa region, Ukraine

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Due to global climate change, new species appear in many regions of the world. An interesting example is the introduced of the sub-Mediterranean common wall lizards of the *P. muralis* in territories outside the natural distribution area (Kraus, 2009). This species has been introduced in different places of Europe: Germany (Schulte et al., 2011), Czech Republic (Šandera, 2013), Poland (Wirga, Majtyka, 2013) southern England (Beebee, Griffiths, 2000), USA (Deichsel, Gist, 2001) and Canada (Allan et al., 2006). The species is at the northern limit of its range in Romania, occurring primarily along the Carpathian Mountains and in several sites in the Danube river and Dobruja (Cogălniceanu et al. 2013). On the territory of Ukraine this species was found for the first time in 2012 in the Odessa region (Matveev, 2012). The modern distribution of wall lizards in the Odessa region is not completely studied, that became the purpose of this work.

An expeditions was carried out in August 2017 to the southern part of the Odessa region. The research was conducted by the route method without harm to animals. Each animal was photographed. As a result, *P. muralis* was found in only 3 localities near Reni: abandoned complex opposite the sea port, first road turn across the city and the second road turn. Also, A. S. Matveev found this species on the territory of the Reni port in 2012. The second population of these lizards was found by him at a pumping station on the northwest coast of Cahul lake (Matveev, 2012), but during our expedition this species was not found there. In other localities near Cahul lake (Limanske and Orlovka villages) *P. muralis* was not registered. All findings allow to conclude, that lizards prefer biotopes with anthropogenic buildings and rocks near the water (concrete fences, blocks, walls of houses).

P18 - Age structure in isolated *Podarcis muralis* populations from Dobrudja region, Romania

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The European common wall lizard (*Podarcis muralis*) is a widespread anthropogenic species throughout Europe, with successfully introduced populations in North America. Despite its widespread range few studies have described the age structure of *Podarcis muralis*. Age related parameters have both species-specific characteristics and are influenced by external conditions like temperature, feeding patterns, predation, diseases and anthropic activities.

In the Romanian Dobrudja region the range is restricted to several isolated populations. We describe age and size related parameters from three isolated populations. Each captured animal was weighted, measured and a toe from the hind leg cut and stored in 70% alcohol. Age was assessed through skeletochronology, using the slightly modified protocols of Castanet and Smirina.

Preliminary results indicate that the most common age cohort is 3-4 years old, with a mean age of 3.80 and maximum estimated age of 7 years, with a snout-vent-length (SVL) range between 4.8-6.7 cm. Males are generally larger and older than females: female SVL range is between 4.8 - 6.5 cm, with a mean of 5.61, and age range between 2 - 5 years with a mean of 3.77, while the SVL of males ranges between 5.0 - 6.7 cm with a mean of 5.95 cm and estimated age between 2 -7 years old with a mean of 3.88. We found no significant differences for age and size related parameters between the three populations studied. In previous studies, the age for *P. muralis* has been found to be in the range of 2 to 5 years and the SVL between 5 to 7.5 cm.