ISA10
Paris 2019

10th International Seminar on Apterygota

17th to 21st June 2019
Paris, France

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Programme, Abstracts & Participants

General information

The International Seminar on Apterygota has taken place roughly every four years for more than 40 years. It aims to bring together researchers from around the world working on Apterygota. ISA offers the world-wide scientific community the opportunity to meet, exchange and discuss their research on the various aspects of the five basal hexapod taxa known as 'Apterygota', a paraphyletic group that includes the entognathans Collembola, Protura and Diplura and the ectognathans Microcoryphia and Zygentoma.

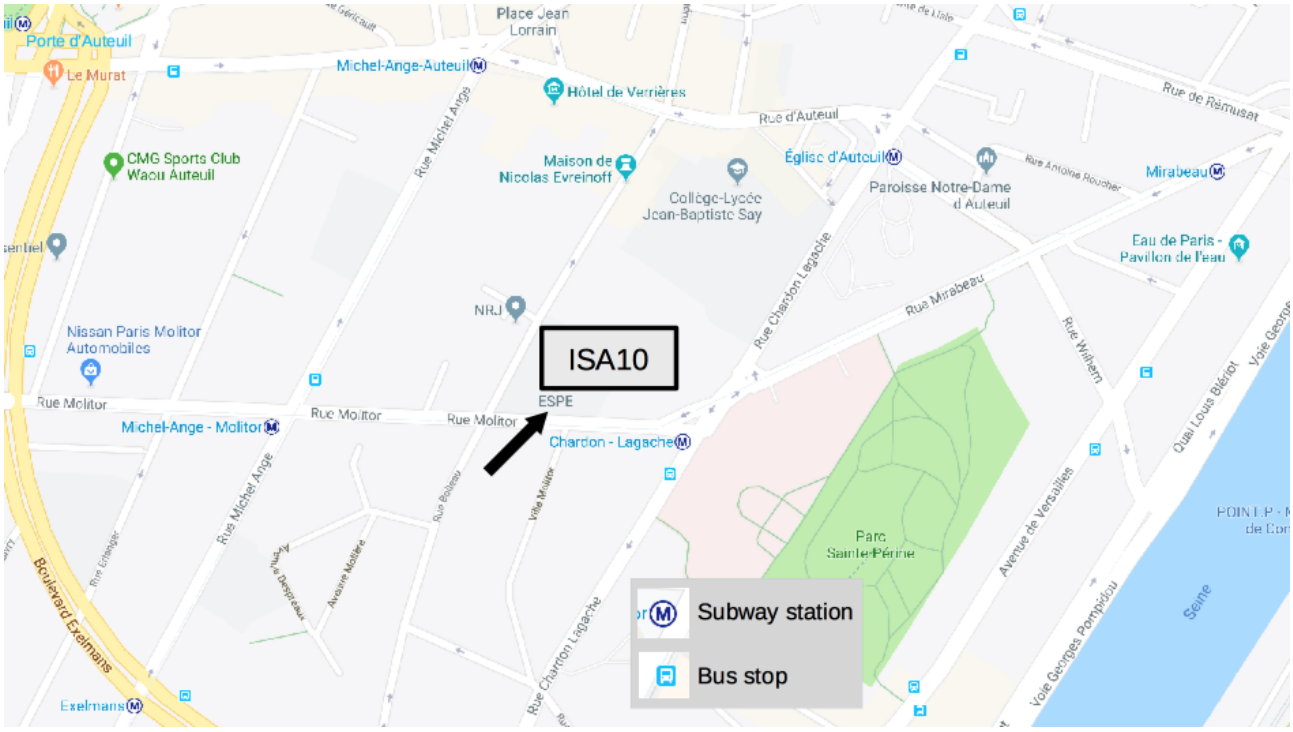
The topics covered in the oral communications and posters are varied: taxonomy, morphology, biogeography, evolution, ecology, physiology, genomics… These seminars provide an awaited opportunity to build, structure and reinforce our research community, which has a notable historical basis.

Venue

The 10th International Seminar on Apterygota is held at "Ecole Supérieure du Professorat et de l'Education de Paris" (ESPE de Paris).

The "ESPE de Paris" is the Paris Teacher Training College and belongs to the Faculty of Art and Humanities of the Sorbonne University. It is located in the 16th arrondissement of Paris, 10 rue Molitor. This institution has made available a large and modern auditorium to host the Seminar and the attendees will be able to use the cafeteria for lunch meals and coffee breaks and have the opportunity to enjoy the patio and the park surrounding the historical buildings.

Map of the ESPE's neighbourhood:



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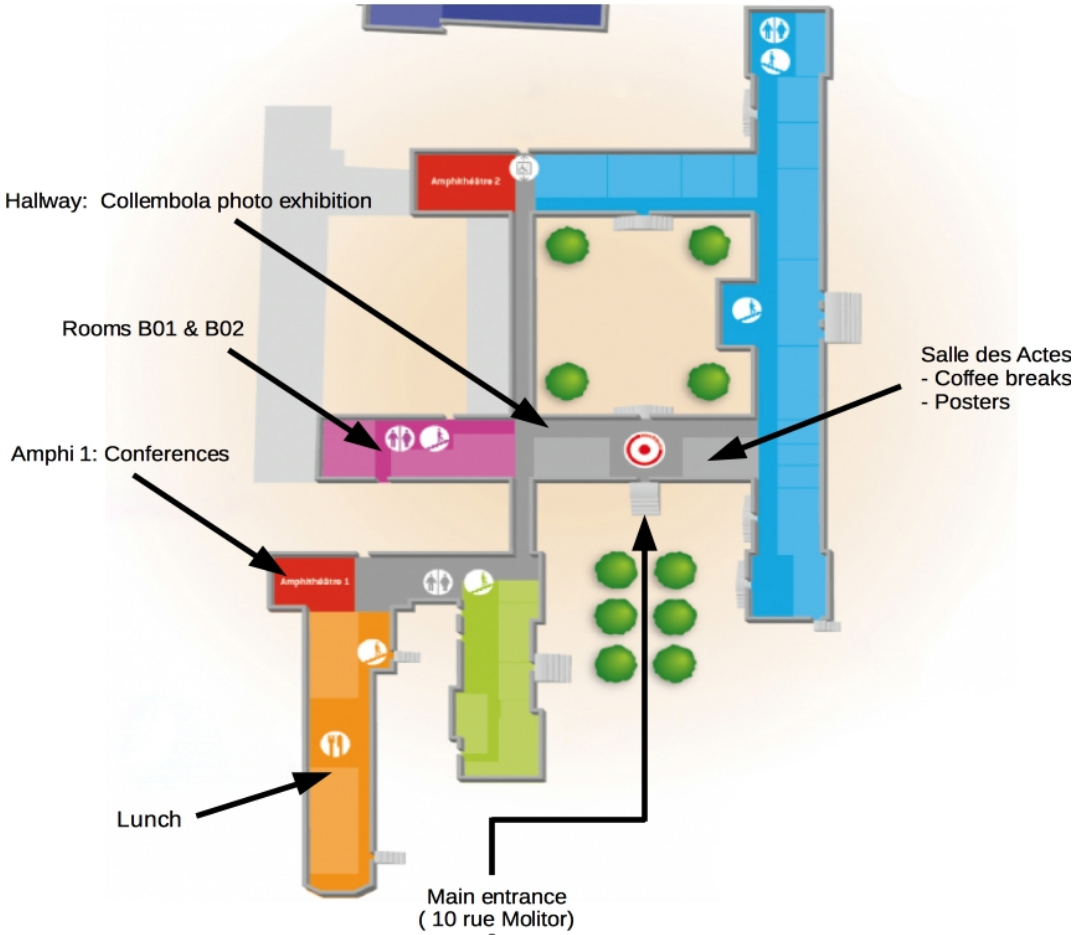
https://goo.gl/maps/WzvjMQQyDVWGnkT48

Map of the ESPE:



Transportation

The address of ESPE is “10 rue Molitor, 75016 Paris”.

It is very close to several subway stations: Michel-Ange Auteuil (line 9) and Eglise d'Auteuil (line 10). You can have more information there: https://www.ratp.fr/en/plans-lignes/plan-metro.

Buses are also an option with the lines 52 and 62 (bus stops with the same name as the subway stations: Michel-Ange Auteuil and Eglise d'Auteuil). You can find more information there: https://www.ratp.fr/en/plans-lignes/plan-des-bus.

A little further away, crossing the river, there is the RER C station Javel (15 minutes walk).

Lunches & coffee breaks

Lunches will be served at the ESPE canteen. Coffee breaks will take place in the “salle des actes”, near the main entrance. We encourage participants to watch the posters during the coffee breaks.

Registration desk

Registration and information opens on Monday, June 17th, 17:00, located Salle des Actes and continu on Tuesday, June 18th from 8:30 to 9:30.

Ice Breaker

During the registration time on monday, an Ice Breaker reception with beverages and sandwiches will take place.

Presentations & posters

Oral communications.

Speakers have 25 minutes to present their scientific work: 20 minutes maximum for the talk and 5 minutes for the questions. The official conference language of the 10th International Seminar on Apterygota is English. Please provide your presentation file (slides) preferably in pdf format (or powerpoint or impress format) to the organizers the day before your presentation or at the latest during the break before your session.

Posters.

Posters will be displayed in te corridors close to the Salle des Actes. Specific times are schedule for poster sessions. But since coffee breaks will take place in the Salle des Actes, these breaks can also be the occasion to discuss with the authors of the posters.

Evening activities

Monday: Icebreaker, 17:00-20:00.

Tuesday: Evening and diner in the ESPE park, 18:00-21:00.

Wednesday: free, go visit Paris!

Thursday: Conference buffet in the Parc Zoologique de Paris, 18:00-21:00.

Exhibitions, images

On the side of the Seminar, we took the opportunity to explain to the futur teachers working at the ESPE what are Apterygota with several pedagogical posters designed by Thomas Tully with the help of Cyrille D'Haese.

In addition, an exhibition of photos of Collembola made by Cyrille D'Haese and Sun Ticky (sun-tiky.wixsite.com/collembole) will be displayed in the hallway.

Finallly, a short film, "Collembola planet, the secret life of soil", by Philippe Lebeaux (www.animailes.com) will be presented on wednesday afte lunch break.

MNHN visit

On wednesday, the participants are invited to visit the "Grande Gallerie de l'Evolution" and "Galerie de Minéralogie et de Géologie" at the Muséum National d'Histoire Naturelle (MNHN) (the galeries close at 18:00).

Acknowledgments

We would like to thank Alain Frugière, director of the ESPE de Paris, for agreeing to host this symposium in the premises of the ESPE de Paris.

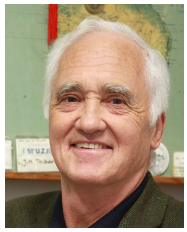
Many thanks also to Géraldine Vrolant, Isabelle Dubois, Anne-Sophie Beghin, Julien Bigot, Xavier Magnan, Juliette Hupert and all the staff from the ESPE for their invaluable help to organise this seminar.

We thank the iEES PARIS (Sorbonne Université) and MECADEV (CNRS-MNHN) laboratories for their financial support.

We also thank the Muséum National d'Histoire Naturelle for the visits of the "Grande Gallerie de l'Evolution" and "Galerie de Minéralogie et de Géologie".

Thanks for Jean-Paul Mauries (Arthropods lab, MNHN) for the drawing of the apterygots on the Eiffel tower displayed page 3 and in the visual on the last page of this booklet.

Organising committee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Programme

Registration, coffee breaks and poster sessions are located in the "Salle des Actes". Talks in the "Amphi 1" and working sessions in rooms B01 and B02. See map of ESPE above.

Monday, June 17		
17:00 19:50	Arrival, Registration and Icebreaker meeting	

Tuesday, June 18		
8:30	Registration and welcome coffee	
9:30	**C. D'Haese, T. Tully & J.-M. Thibaud**	Opening session, organisational remarks
10:00	**A. Sendra**	Our knowledge of Diplurans: past, present and future. (Page 14)
Ecology I		
10:25	**M. Montejo-Cruz**, J. Palacios-Vargas & G. Castaño-Meneses	Community structure of Isotomidae and Neanuridae (Hexapoda: Collembola) in four vegetational associations with different land use close to Citlaltepetl volcano, Veracruz, Mexico. (Page 15)
10:50	**N. Scheunemann**, R. Weniger & D. Russell	MediAN - Soil fauna communities in floodplain hardwood forests (Page 16)
11:15	**W. Susanti**, R. Widyastuti, S. Scheu & A. Potapov	Effect of rainforest conversion to plantation systems on community structure of soil Collembola. (Page 16)
11:40	Lunch	
13:00	Poster session	
Ecology I (continued)		
13:30	**J. Palacios-Vargas**, G. Castaño-Meneses, A. González & A. Contreras	Comparison of Collembola from Malaise Traps from two localities of Tlaxcala Mexico. (Page 17)
13:55	**A. Potapov** & T.-W. Chen	Predicting trophic niches of Collembola using ecomorphological traits and evolutionary patterns. (Page 18)
Taxonomy I		
14:20	**P. Shaw**	Updates on UK Collembola; invaders and rediscoveries. (Page 18)
14:45	**M. Shayanmehr**	Introduction to Iranian Collembola. (Page 19)
15:10	Coffee break	
15:40	**M. M. Vazquez Gonzalez**, J. Palacios-Vargas, D. Medina & K. Cooch	The Neanuridae family (Collembola: Apterygota) from Belize, Guatemala and South-East part of Mexico. (Page 19)
16:05	**M. Gaju**, M. Koch, C. Bach, L. Mendes & R. Molero-Baltanás	About the study of fossils of Microcoryphia in amber. (Page 20)

Anatomy		
16:30	**M. Koch**, R. Molero-Baltanás & M. Gaju-Ricart	Challenges and progress in the study of amber fossils of silverfish by microtomography. (Page 20)
16:55	**I. Panina**, M. Potapov & A. Polilov	Miniaturization consequences in the anatomy of the tiny springtail *Megalothorax minimus* (Collembola: Neelidae). (Page 21)
17:20	Poster session	
18:00 21:00	Evening and diner in the ESPE Parc	

Wednesday, June 19

Life History		
9:00	T. Parmentier, R. Molero-Baltanás & **M. Gaju**	Evolution of the association with ants in european silverfish of the subfamily Lepismatinae (Zygentoma: Lepismatidae). (Page 22)
9:25	N. Robin, P. Barden & **C. A. D'Haese**	Fossil amber reveals springtails' longstanding dispersal by social insects. (Page 22)
9:50	**M. Jüds**	Looking into Collembola guts - A metabarcoding approach. (Page 23)
10:15	Coffee break	
10:45	**M. Koken**, M. Talagas, G. W. East & L. Deharveng	Bioluminescence & Natural Fluorescence in Collembola. (Page 24)
11:10	**T. Tully**	Genetic and environmental factors of life and death in the springtail *Folsomia candida*. (Page 24)
11:35	**V. Zizzari**	The influence of climate warming on sexual chemical communication in a springtail species. (Page 25)
Method		
12:00	**C. Scholz**, P. Querner & A. Bruckner Alexander	Collembola in soil samples: Efficiency of extraction methods. (Page 26)
12:25	Lunch	
13:20	Film of **Philippe Lebeaux** (Amphi 1)	
13:35	**Working session...** Short presentations about Ecotaxonomy, Image analysis, Data analysis in Amphi1 followed by informal discussions in rooms B01(microscopes will be available) and B02. **Come with your data, specimens and slides, ideas and questions to discuss with colleagues and other specialists.**	
15:30	Transportation to the Muséum National d'Histoire Naturelle	
16:00	Visits of the MNHN's "Grande Gallerie de l'Evolution" and "Galerie de Minéralogie et de Géologie"	
18:00	Free evening	

Thursday, June 20		
Phylogeny		
9:00	**A. Carapelli**, Y. Bu, W.-J. Chen, F. Nardi, C. Leo, F. Frati & Y.-X. Luan	Molecular data applied for Protura phylogeny and species delimitation. (Page 27)
9:25	**T.-W. Chen**, J.-F. Chao, M. P. Berg, I. Schaefer & S. Scheu	Adding evolution to soil animal ecology-phylogenetic comparative methods for studying adaptation of Collembola life-form traits and reproductive mode. (Page 28)
9:50	**C. A. D'Haese** & M. Stevens	Giant Collembola phylogeny. (Page 28)
10:15	Coffee break	
10:45	**Ľ. Kováč**, M. Žurovcová, N. Raschmanová, A. Parimuchová, N. Jureková & V. Papáč	Northern range limit of troglomorphy in Europe - Miocene diversification of cave *Pseudosinella* (Hexapoda, Collembola) in the Western Carpathians. (Page 29)
11:10	**C. Leo**, F. Nardi, P. P. Fanciulli, F. Frati, R. Dallai & A. Carapelli	Mitogenomic and morphological data applied to review and further investigate evolutionary relationships of the main springtail lineages. (Page 30)
11:35	**M. Lukić**, T. Delić, M. Pavlek, J. Bedek, L. Deharveng & M. Zagmajster	Molecular phylogeny of the subterranean genus *Verhoeffiella* (Collembola, Entomobryidae) questions its disjunct distribution and reveals high diversification within the Dinarides (Western Balkans). (Page 31)
12:00	**C. Schneider** & C. A. D'Haese	Phylogeny and biogeography of the three most widespread species of *Megalothorax* (Collembola, Neelipleona). (Page 31)
12:25	Lunch	
13:30	**J. Shrubovych** & C. A. D'Haese	Phylogeny of Australian acerentomid fauna (Protura: Acerentomidae). (Page 32)
13:55	**Z. Xie**, X. Sun, D. Wu, S. Scheu & T.-W. Chen	Community phylogenetic structure of Isotomidae (Collembola) along elevation gradients in Changbai Mountain, China. (Page 33)
14:20	**D. Yu**, L. Deharveng, M. Lukić & F. Zhang	Revisiting the systematics of Tomocerinae (Collembola, Entomobryomorpha) by integrating molecular and morphological evidence. (Page 33)
14:45	Coffee break & Poster session	
Ecology II		
15:30	**A. Mawan**, D. Buchori, J. Drescher & S. Scheu	Abundance, diversity and community composition of arboreal Collembola along a land use gradient in Sumatra, Indonesia. (Page 35)
15:55	**P. Shaw**	Edge effects and relic populations among Corticolous Collembola in Richmond park, Surrey. (Page 36)
17:00	Transportation to the Parc Zoologique de Paris	
18: 00	Conference buffet and visit of the Parc Zoologique de Paris	

Friday, June 21		
Taxonomy II		
9:00	**S. Jantarit**, C. Satasook, A. Bedos & L. Deharveng	Diversity and troglomorphy of cave springtails (Hexapoda: Collembola) in Thailand. (Page 36)
9:25	**A. Parimuchová**, Ľ. Kováč, M. Žurovcová & V. Papáč	Genus *Deuteraphorura* Absolon, 1901 in the Western Carpathians – troglomorphy of cave Collembola (Hexapoda) on northern distributional limit in Europe. (Page 37)
9:50	**X. Sun**, M. Lukić & L. Deharveng	A second and highly troglomorphic species of the genus *Ongulonychiurus* Thibaud & Massoud, 1986 (Collembola, Onychiuridae) from a deep Croatian cave. (Page 38)
10:15	Coffee break	
10:45	**Md. M. Hossain**, Md. A. Rahman, B. Akthar & Md. Moniruzzaman	First record of Collembola and their diversity in the Charland of the Padma river at Rajshahi, Bangladesh. (Page 38)
11:10	P. Greenslade, Judith Najt & **W. Weiner**	The most anciant Collembola of the world - Collembola form the Devonian Rhynie. (no abstract)
11:35	Concluding remarks and final discussion; Proceedings, next meeting.	
13:00	Lunch	
14:00	Departure	

Abstracts:

Oral presentations

Review

Our knowledge of Diplurans: past, present and future

Alberto Sendra (1)

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The past was brilliant, the present not so much and the future depends on us. From the end of the nineteenth century to the middle of the last century, the Italian entomologist F. Silvestri settled the taxonomy of the group, a line of work brilliantly continued by a bunch of zoologists: R.T. Allen, J.R. Denis, J. Paclt, J. Rusek, P.R. San Martín, L. M. Smith and P. Wygodzinsky among others but with special effort made by two French entomologists, B. Condé and J. Pagés. More than nine hundred species and about 130 genera were described all over the world in every continent, except the Antarctic, in almost every piece of land in the Earth. In light of this vast sampling effort, one thousand papers were published. It is difficult to imagine how to do it again, it seems by any means almost impossible. Nonetheless, this worldwide collecting task was sometimes possible for a foul reason such as the imperial expansion of northern hemisphere countries "the empire on which the sun never sets". Diplura has two clearly separated suborders Rhabdura and Dicellurata, divided into ten well-defined families. The lion's share of diplurans belongs to two families, campodeid and japygid, with 83% of the biodiversity, but particularly important are also the modest parajapygids and projapygids, for their outstanding glands and sensorial equipment. In the middle of the last century in Switzerland, M. Von Orelli in and H. Gyger published two seminal biological contributions on the reproduction and growth of Campodeidae and Japygidae. Work continued excellently by among others the French biologist C. Bareth and also J. Pagés. All of them produced a brilliant knowledge of Diplura in many of the scientific fields, from systematics to behavioural studies. This level of scientific effort in Diplura has not yet been made in the present century. Nowadays, the biologists devoted to Diplurans are extremely scarce and only a little progress been made in the knowledge of subterranean species with exciting first steps in the use of molecular data for phylogeny analysis to support the Diplura relationship among Hexapoda and Insecta groups. Furthermore, the use of new neuroanatomical techniques for 3D reconstruction of anatomy has started to show interesting results. At the present time, much of the effort is dedicated to big scientific and multidisciplinary projects with overall objectives. Diplura has remained as a tiny forgotten group. Nevertheless, we think the contrary. Diplura is a truly amazing and interesting zoological group with a high scientific value because of several important facts. It is a primitive basal group for insects and so it is an important subject to understand the evolution of terrestrial arthropods in the struggle for land colonization. Also, it is worth remarking on its paleobiogeographical interest due to: their cryptic habitats, their vast distribution range and their poor dispersion rate. These traits are more evident in the most interesting diplurans, the troglobites. They occupy the isolated subterranean habitats, producing remarkable relict taxa in most of the karstic areas throughout the world. Their many unknown inspiring and bizarre receptors for sensorial perception and communication, will surely make them worthy of further scientific attention in the future. And finally, the key interest of diplurans in trophic communities of soils and subterranean environments, as decomposers and as predators; it is a field of ecological studies poorly addressed in the past.

Keywords: Diplura, Worldwide distribution, history, current knowledge.

Ecology I

Community structure of Isotomidae and Neanuridae (Hexapoda: Collembola) in four vegetational associations with different land use close to Citlaltepetl volcano, Veracruz, Mexico

Maira Montejo-Cruz (1), José Palacios-Vargas (1) & Gabriela Castaño-Meneses (2)

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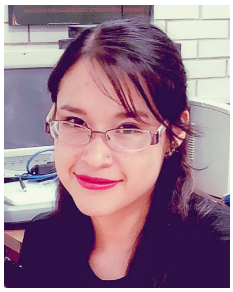

The present work was carried out during one year (four samplings were taken, one every three months) in a temperate forest that belongs to Pico de Orizaba formation, the highest elevation volcano in Mexico (5,675 m). Since a few ecosystems can be considered pristine, we compared four sites with different land use: 1) Preserved oak forest (OF), *Quercus* spp. forest with trees taller than 10 m. 2) Oak forest with introduced pine trees (OPF), dominate oaks but with pine trees that have been introduced since 2003, trees 5 m tall. 3) Secondary vegetation (SV), site cut down about 5 years ago, with annual herbaceous plants 1.5 m tall and 4) Pastureland (PG), original oak forest removed 10 years ago to place a paddock, dominated by grass and herbs which are not taller than 30 cm. For each sample, the following variables were measured: temperature, relative humidity, pH, and CO2. Since they are frequent in soil temperate forests with different feeding habits, only two springtails families were studied: Isotomidae and Neanuridae. The former is mainly omnivorous and the latter is both fungivorouos and predatory. Spatial and temporal variations in the structure community of those two families were studied, and the way that those variables were measured influenced the community structure, so did characters “leaf litter-soil” and “land use”. A total of 45,528 springtails were obtained; from which 25,739 were members of Isotomidae and 2,532 of Neanuridae. Isotomidae were represented by 20 species and Neanuridae by 16. The most abundant species were: *Isotoma viridis*, *Parisotoma notabilis*, *Pseudachorutes bifidus* and *Friesea miriabilis*. In general, the highest diversity was contained by SV (H '= 2.54), followed by OPF (H'= 2.25). According to the canonical correlation analysis (CCA) applied to the Collembola community, variables explain 65% of the variance, the CCA1 axis has 43% and is more related to pH (r = -0.7), while in CCA2 axis has 22% and is more related to "land use" (r = -0.72). The analysis of the environmental vectors indicates that also the leaf litter-soil variables along with temperature are significant for the community. When analysing the community in detail, it can be observed that pH affects abundance more than composition, for example: *Folsomia bisetosa* (r = -0.24, p = 0.03), *Folsomina onychiurina* (r = 0.23, p = 0.04) and *Friesea miriabilis* (r = -0.23, p = 0.04) are negatively correlated to pH and their abundances are usually higher in more acid soils, while *Palmanura ca. schusteri* (r = 0.24, p = 0.03) and *P. notabilis* (r = 0.25, p = 0.01) correlated positively to pH and they are more abundant in less acid sites. Within the CCA, most species appear in the center of the ordination, and close to the variable "land use", which indicates the preference of some species for certain sites. *Folsomia sensibilis* (r = -0.23, p = 0.04), *I. viridis* (r = -0.29, p = 0.0004) and *P. notabilis* (r = -0.34, p = <.0001) appear correlated and their abundances are higher in OF and OPF sites. These two sites contain the highest abundances for most of the species, they do not differ in composition, especially for the Isotomidae which share 10 species in the four sites, which indicates that the biotic and abiotic environmental factors are influencing more the abundances than the composition.

The variable "leaf litter-soil" is important for the community due to the presence of eudaphic species such as *Isotomiella minor* and *P. notabilis* whose abundances are higher in the soil.

Finally, the temperature variable was important for the community, especially for the PG site because it has little vegetation coverage and temperatures in some cases reached 40°C, this is reflected in the Neanuridae community which only registered five species with thirty-four individuals.

Keywords: Land use, Mexico, community, ecology, Collembola.

MediAN – Soil fauna communities in floodplain hardwood forests

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Floodplains fulfil several ecosystem functions, with their role as carbon sink and biodiversity hotspot being most important. The MediAN project focusses on establishing hardwood forest floodplains along the middle Elbe River (northern Germany). Within this project, soil Collembola and earthworm communities in regard to (1) hydrological situation, i.e. distance to the river and inundation frequency, (2) forest age, and (3) regional distribution are investigated. The main goal of this project part is to identify indicator communities of Collembola and earthworms for different floodplain forest successional stages. Further, small tributaries are investigated for their potential as a source of migration for Collembola towards the main river floodplain. The project began in 2018, and for three years soil samples will be taken every year in spring and summer. First results indicate that in spring 2018 Collembola densities were higher in old floodplains (behind the dike) than in the active floodplains or near tributaries, indicating negative effects of high soil moisture and inundation probability on Collembola densities. Differences in the Collembola community structure of the summer 2018 sampling are still being evaluated. The very dry summer 2018 may have reversed these results with higher soil moisture near the main river or tributaries preventing desiccation of soil and therefore decrease of Collembola densities. However, earthworm densities nearly dropped to zero in the summer sampling 2018, pointing towards a severe desiccation of soil at all investigated sites independent from their distance to the river. We suggest that the unusual summer drought in 2018 will likely influence earthworm as well as Collembola communities for years to come, and may therefore be an additional issue within the project.

Keywords: Collembola, floodplain hardwood forest, inundation frequencey, forest age.

Effect of rainforest conversion to plantation systems on community structure of soil Collembola

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Rainforest conversion and expansion of plantation systems is a common land-use change issue, particularly in Sumatra, Indonesia and associated with changes in ecological niches of animal species, and thereby with changes in ecosystem functioning. Collembolan community have been shown to vary in abundance and species composition according to changes in veg-

etation and soil conditions. Our research is aimed to investigate how soil Collembola respond to conversion of rainforest into rubber and oil palm plantations. Species composition, species richness and total abundance of collembolan communities varied according to land use and landscape properties. Total abundance and species richness had positive correlation. Overall, total abundance of collembola was higher in Bukit Dua Belas than in Harapan Landscapes. In two landscpapes, total abundance of Collembola in soil layer did not differ significantly between land use systems (rainforest, junggle rubber, rubber and oil palm plantation), whereas total abundance and species richness differ significantly in litter layer between land use systems. Total abundance and species richness in rainforest were higher than that in jungle rubber, rubber and oil palm plantation. Although total abundance did not differ significantly between systems in soil layer, abundance of collembola in oil palm plantation was higher. Collembola community in the study area was strongly dominated by Isotomidae (genus *Folsomides* and *Isotomiella*). *Pseudosinella* sp. can be found in all land-use systems and be important species and more adapted in the environmental changes as affect of rainforest conversion. Asocyrtus cinctus also can be found in the high abundance in all land-use systems, especially in rainforest and rubber plantation. Overall, rainforest conversion alters abundance, richness, and community composition of soil Collembola, except some species which more adapted from environmental changes.

Keywords: springtail, community structure, rainforest transformation, agricultural plantation.

Comparison of Collembola from Malaise Traps from two localities of Tlaxcala Mexico

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Springtails (Collembola) from two temperate forests in Tlaxcala state (Mexico) were sampled monthly by Malaise Traps. Collecting was carried out during the end of 2015 to middle 2017 in both sites, as a result there were obtained 45 samples from “Santuario de las luciérnagas” (SL) and 51 from “Ejido los Búfalos” (EB). Although the specimen's abundance showed very high (10,464 at first locality, 27,651 at the second), the species richness was low (12 spp). Nevertheless the different abundances recorder in both sites, no significant effect of locality and sampling date were found on this variable, according with two way ANOVA unbalanced test (Locality: $F_{1,73}= 0.64$, $p>0.05$; date: $F_{17, 73}= 1.23$, $p>0.05$), due the high variance between the recorded data, the mean and standard deviation for SL was 249.14 ±543.11, and for EB was 544.78±1661.87. Shannon diversity index to SL was H'=1.08 and for EB was H'=0.61, significant differences were found in diversity of both sites ($t_{15933}= 39.76$, $p<0.05$).

Most abundant genera obtained were members of Entomobryidae: *Americabrya* (2,860 and 6,214), *Seira* (2,424 and 2,191) and *Willowsia* (852 and 19), and few of other families as Neanuridae: *Pseudachorutes* (169 and 241), Isotomidae: *Proisotoma* (3 and 2), and Dicyrtomidae, that was only found in SL: *Pthenothrix* (31) and Katiannidae: *Sminthurinus* (6) and the entomobrid *Lepidocyrtus* (4).

To our knowledge, this is the first time such number of springtails are collected with Malaise traps. A comparison was made with data obtained from other localities and it seems that Entomobryidae is the most common family in many places but it is to notice that in Tlaxcala Neanuridae also is an important element of the community even they have a more specialized food habits.

Keywords: Malaise traps, temperate forests, climbing sprintails, ecology.

Predicting trophic niches of Collembola using ecomorphological traits and evolutionary patterns

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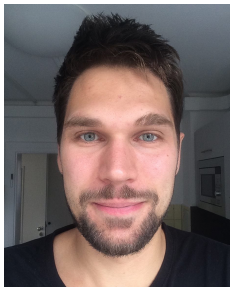

Collembola is an evolutionary old lineage of arthropods that shows remarkable morphological and functional diversity in contemporary communities. Different species of Collembola have different position in food webs, ranging from algivores and herbivores to detritivores and fungivores, and even carnivores. Trophic niches of these cryptic arthropods can be assessed with stable isotope analysis of C (reflecting basal resources) and N (reflecting trophic level). However, to predict trophic niches we need to get a mechanistic understanding of factors that shape them. Here we aimed at assessing the contribution of inherent parameters, such as morphological traits in shaping the trophic niches of collembolan species considering that these species are not evolutionary independent. We compiled data on 10 core ecomorphological traits and stable isotope composition for 81 species from temperate ecosystems, that were placed on a phylogenetic tree reconstructed based on 28S RNA and COI genes. All tested traits affected 15N and/or 13C concentrations suggesting that these traits may be trophically adaptive. Phylogenetic regressions showed that both trophic niche and morphological traits are related to phylogeny, but some traits were more evolutionary conserved than others. The best model predicting the trophic positions included both less conserved adaptive traits (traits, related to vertical stratification) and highly conserved adaptive traits (the presence of molar plate). Our study indicated evolutionary adaptations that allowed Collembola species from different branches to exploit specific food resources, and demonstrated that trophic adaptations in Collembola can be both evolutionary conserved and labile.

Keywords: springtails, feeding habits, stable isotopes, life form, morphology, phylogenetic signal, evolutionary inertia, adaptation.

Taxonomy I

Updates on UK Collembola; invaders and rediscoveries

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Collections of Collembola by a network of UK enthusiasts (mainly macro-photographers) have added records of putative invaders, as well as native species last collected in the UK by Richard Bagnall in the 1930s. I record new/first UK appearances of at least ten Collembola (*Bilobella brauneri*, *Entomobrya* cf. *imitabilis*, *Lepidocyrtus nigrescens*, *Dicyrtomina violacea*,

Heteromurus major, *Calvatomina* (Jordanothrix) *superba* and *C. rufescens*, and at least three other undescribed Symphypleona. Additionally, inter-tidal collections by ST along the southern UK coastline have led to the first collections since pre WWII of *Friesea acuminata* and *Axelsonia littoralis*. They also added nine new records of the strand-line entomobryid *Mesentotoma dollfusi*, including a population from loose shale (Kimmeridge) with a unique shale-coloured local coloration. Collections from Welsh caves appear to be an endemic species of *Folsomia*, not *F. agrelli* as previously named. *Coecobrya tenebricosa* has now been collected in UK caves, but is also sold on the web to reptile collectors.

Keywords: Invasive, Collembola, inter, tidal, troglophile, endemic, *Entomobrya*, *Lepidocyrtus*, *Bilobella*, *Calvatomina*, *Mesentotoma*, *Friesea*, *Axelsonia*.

Introduction to Iranian Collembola

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Iran is a country in southwest Asia with several different climatic zones and biomes, therefore the diversity of animals is high and this presumably also applies to those living in soil as well as Collembola. The first report of Iranian Collembola was performed by Farrahbakhsh (1961) who reported *Sminthurus viridis* Linnaeus, 1758 from wheat and alfalfa fields in Khuzestan (Southern Iran). Later, the study on Collembola was carried out by Cox (1982) who travelled to Northern, West and Central provinces in Iran and collected and identified 70 species of 30 genera and five families. A catalogue of Iranian Collembola has been published recently by Shayanmehr et al. (2013) in which they reported 112 species belonging to 18 families and 78 genera. After this year, faunistic investigations on Collembola in Iran were increased dramatically. So, Nowdays by addition new taxa, there are 95 known genera and 225 known species of Collembola in Iran. But still many area in Iran were not investigated and the number of species will increase in the future. In this paper, the taxa of Collembola with needs and problems to identify were discussed.

Keywords: Springtails, soil fauna, Iran.

The Neanuridae family (Collembola: Apterygota) from Belize, Guatemala and South-East part of Mexico

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The family Neanuridae embrace the group of Collembola which inhabiting the most degradated layer of litter and soil surface in tropical and temperate forests. In between of the genera of this Family are *Palmanura*. This genera it's very well represented in tropical forests in Belize, Guatemala and in the South-East part of Mexico. It was carried out a study of soil fauna from litter and soil of two regions in Belize and one in Guatemala as well as in the south part of Mexico in the border between Mexico and Belize in Quintana Roo state. The material collected

allowed the description of a new species from Belize P. klompeni (Palacios-Vargas & Vázquez, 2018). The genus *Palmanura* it's very well represented in temperate forest of south part of Mexico, in tropical forest of Belize, specially in riparian forest, as well as in the mountains of the south of Mexico and Guatemala. More exemplars belonging to new species of *Palmanura* from Belize and Guatemala are in process of description.

Keywords: Neanuridae, tropical forest, Belize, Guatemala, México.

About the study of fossils of Microcoryphia in amber

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In recent years several studies of amber samples containing Microcoryphia specimens have been published in high-ranking journals. Microcoryphians have a particular anatomy with some exclusive characteristics that make them unique among the insects. In some of the recent publications we have detected conspicuous errors in anatomical interpretations that currently cause improper concepts in cladistic analyses. Although still in progress the taxonomy of the microcoryphians is basically well established, using particular characters for distinguishing families, genera and species. We demonstrate that the recently published studies of amber fossils disregard the established approach by describing a new genus solely on the basis of species-specific characters, and by describing new species solely on the basis of juvenile individuals while ignoring that sexually dimorphic characters of males occur in almost all known species and develop gradually in postembryonic instars. The publication of such flaws reveals an astonishing lack of expertise for microcoryphian morphology both among authors, referees, and editors of scientific journals. The correction of such flaws is currently hampered by the difficulty of gaining access to the respective amber pieces due to apparent restrictions by Museums of providing samples by mail.

Keywords: Archaeognatha, amber fossils, anatomy, taxonomic impediment, morphology, systematics.

Anatomy

Challenges and progress in the study of amber fossils of silverfish by microtomography

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Taxonomic studies of amber fossils are subject to difficulties in several aspects such as the accessibility and low number of recorded specimens for a given species, and investigative limitations caused by the amber itself and by the variable preservation of the respective specimens. We demonstrate these difficulties for a silverfish in Baltic amber that was formerly interpreted as an extinct species of the Lepismatidae. Reconsideration of this fossil by X-ray micro-computed tomography (μCT) revealed several characters that were overseen and/or misinterpreted in previous optical studies. Our data raised by μCT not only support its unambiguous identification as *Lepidotrix pilifera* (Menge, 1854) but also allow an emendation of its original description. Based on our current insights we present a systematic revision of the silverfish family Lepidotrichidae and highlight both the advantages and limits of modern imaging techniques for the study of amber fossils.

Keywords: Zygentoma, Lepidotrichidae, morphology, anatomy, taxonomy, 3D reconstruction.

Miniaturization consequences in the anatomy of the tiny springtail Megalothorax minimus (Collembola: Neelidae)

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There have been many studies on miniaturization effects of insects, including detailed descriptions of external and internal morphology, scaling of organs and changes in cognitive abilities, and these studies have shown trends of particular changes due to the smaller body size. Even so, little is known about other arthropods. Collembola is the most abundant taxa among Apterygota, and many species tend to evolve towards the small size. However, only a "linear" species (Panina et al., 2019, in print) has been studied in the sense of miniaturization. The organization of internal organs of *Megalothorax minimus* Willem, 1900 (body length 0.3-0.5 mm) has been previously studied by Willem (1900), where he described general morphology of *M. minimus*. Nevertheless, many questions remained open about muscular and excretory systems and glands, as well as detailed investigation of other systems, not to mention possible miniaturization effects. Therefore, we have studied the anatomy of one of the tiniest "globular" species, M. minimus, using scanning, confocal, and light microscopy and 3D computer reconstruction. In our work, we provide the comprehensive detailed anatomy of *M. minimus* and a comparative analysis of data from our study of *M. minimus* and the anatomy of larger collembolans. Moreover, we discuss possible miniaturization effects together with comparison of such effects that were found in other microarthropods. Some anatomical features of *M. minimus* resemble anatomy of larger species, such as symmetrical reproductive organs and three types of head glands (tubular glands, antennal nephridia, and salivary or acinous glands). The unusual digestive system of M. minimus is known for its peculiar midgut, occupying most of the thorax and abdomen and consisting of four spherical compartments, separated by transversal folds of the intestinal wall. The muscular system remains complex to a certain degree, including well-developed muscles of the mouthparts and stout muscles of the furca. Some other muscles are absent, for example, muscles related to the endoskeletal structures. Considerable reduction of endoskeletal structures, absence of organs of circulatory system, absence of midgut musculature, and extension of the third thoracic ganglion into the first abdominal segment are other indications of small size effects, which were also found in microinsects. Further research on the anatomy of minute springtails can add to the knowledge of miniaturization of animals and increase our understanding of the collembolan morphology.

Keywords: Anatomy, body size, miniaturization.

Life History

Evolution of the association with ants in european silverfish of the subfamily Lepismatinae (Zygentoma: Lepismatidae)

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A diverse group of species of the subfamily Lepismatinae Mendes, 1991 is associated with ants. Within European species a gradient of specialization in ant-association can be recognized, ranging from accidental associated in species such as *Allacrotelsa kraepelini* to strict ant associated species as found in several species belonging to the genus Neoasterolepisma. Inside this genus, we can make a further distinction between generalist species such as *N. curtiseta*, which target nests of several genera of ants, and specialist species, which usually live in colonies of one genus of ants (for example, *Messor* specialists such as *N. lusitana* or *Aphaenogaster* specialists such as *N. delator*). We studied which behavioral and chemical (mimicry of the host recognition cues) strategies are used by the different types of silverfish along the ant specialization gradient. The comparison of the cuticular profiles of the silverfish species with those of their host ants shows that, except for very occasional species such as *Lepisma saccharina*, all silverfish have developed chemical mimicry, although the acquisition of the odor of the ants is more perfect in specialists. Interaction tests show that species with a more perfect mimicry are exposed to lower levels of host aggression. The most advanced mimicry and behavior is found in Messor specialists, which do not avoid contact with their Messor host, whereas other ant-associated silverfish tend to hide or escape.

Keywords: Myrmecophiles, host specialization, chemical mimicry, behavior, Lepismatidae.

Fossil amber reveals springtails' longstanding dispersal by social insects

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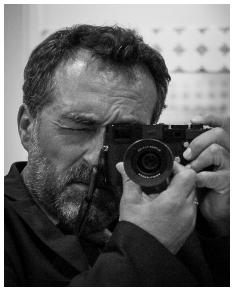

Reported since the Devonian, Collembola are thought to have primarily emerged in subterranean environments (soils), which may have acted as an intermediate medium between water and air in the evolution of arthropods. As wingless hexapods, Collembola are thought to disperse as "aerial plankton" and by water transportation on the basis of occasional reports and experiments in Poduromorpha and Entomobryomorpha. Despite their substantial ecological impact, it is surprising to notice that springtails are in fact rarely described in association with other animals.

Among Collembola, Symphypleona are reported since the early Cretaceous with genera distributed on every continent, implying an ability to disperse over oceans. However, these animals have never been reported in marine water and appear too sensitive to dehydration for long-distance aerial transport. Interestingly, some Symphypleona occasionally have been doc-

umented attached to other invertebrates from Cretaceous and Cenozoic amber deposits. These fossil associations correspond to cases where Symphypleona were attached to different parts of larger arthropods' bodies by the antennae (e.g. legs). Remarkably, such instances of putatively phoretic habit have no known modern counterpart, which is very rare for repeated fossil behaviours.

Here, we document the case of a ~16 Ma old fossil association: a winged termite and ant displaying not some, but 25 springtails attached or closely connected to the body. The Collembola exhibit rare features for fossils, reflecting their courtship and phoretic behaviours. From this observation, we question the record of phoresy in modern Collembola through hidden evidence of modern springtails in association with other invertebrates. By documenting modes of attachment and comparing the antennal morphology of phoretic springtails as well as their positions on all reported fossil arthropods, we infer a – so far unsuspected – persistent mechanism for dispersal in Symphypleona and propose an explanation to its invisibility in extant fauna. By synthesizing (1) modern springtail associations with other invertebrates, (2) new compelling assemblages of fossil springtails and (3) the drastic increase of eusocial insects' abundance over Cenozoic (ants and termites comprising more than the third of the total insect biomass in Miocene amber), we stress that attachment on winged social insects living closely in soil may have been a mechanism for worldwide dispersal in this mite-size ametabolian group – one of the oldest terrestrial arthropod lineages living today.

Keywords: Fossil, behaviour, Dominican amber, dispersal, phoresy, Symphypleona.

Looking into Collembola guts - A metabarcoding approach

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The majority of net primary production enters the soil, which is inhabited by a variety of microbes and animals. Energy transfer through the system is best identified by analyzing soil food webs. Fungi and bacteria often live in symbiosis with plants and are of crucial importance for ecosystem processes such as leaf litter decomposition, carbon sequestration and nutrient cycling. However, they also function as food resource of soil dwelling invertebrates including microbivores and detritivores. Fungi are considered to be the major food source of microbivores such as Collembola channeling carbon to higher trophic levels. Therefore, feeding on fungi by soil invertebrates may have consequences for ecosystem processes. Fungi in soil comprise saprotrophic and mycorrhizal species with ectomycorrhizal (EM) fungi predominating in temperate forest ecosystems. However, the fungal taxa preferred by fungal feeders and changes in their foraging behavior in presence of other fungal species is little known. The use of DNA metabarcoding - targeting the ITS gene region - allows to detect a broad range of fungi in the diet of Collembola. We selected six species of Collembola with different life histories spanning from euedaphic (soil dwelling) to hemiedaphic (regular migration between soil and litter) to epedaphic (litter dwelling) species for being analyzed for their gut content using Illumina MiSeq (2 x 300 bp) sequencing platform. For eliminating contaminations by fungal hyphae and spores on the body surface we tested 17 different protocols for their efficiency of removing environmental DNA from body cuticle. We intentionally contaminated starved and frozen animals with Chaetomium globosum under controlled conditions and analyzed the efficiency of these protocols to clean up the body surface. Additionally, we inspected effects of the cleaning protocols on the degradation of DNA in the gut of fungal feeders.

Keywords: Collembola, Metabarcoding, Fungi.

Bioluminescence & Natural Fluorescence in Collembola

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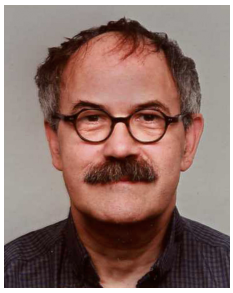

Bioluminescence, the light production by living organisms is a quite common phenomenon in the world's oceans where about 70% of all that lives between -150 to -1500m emits light. However, on land this "living light" is quite rare. It is thus far only described in about 120 mushrooms, 40 earthworms, two mollusks, a few bacterial species and ... in several thousand arthropods. These are mainly beetles belonging to the Elateridae and Lampyridae families, a few species of millipedes, diptera and ... some collembola. In 1987, one of us (GWE), observed "Timber that I lifted off the path & placed to one side revealed many tiny, briefly lit "twinkling stars"". The animals were isolated with assistance of Terry Lynch (Quitman (MS) USA) and identified by Dr. Wanda M. Weiner (Krakow, Poland) to be *Anurida granaria* (Nicolet, H., 1847), a common cosmopolitan collembola. Although a few collembola species have been described in the very old literature as luminescent, to the best of our knowledge only two species produce light for sure, *Anurida granaria* and a *Lobella* sp. from Japan. However, these old literature species should be traced back and eventual light production confirmed. I think that many more springtails might emit light and should therefore be tested systematically for light emission, an endeavor I would like to propose to the Apterygota community. Another widespread light phenomenon in living organisms is natural fluorescence; transformation of a pigment pattern into a longer wavelength color motif. The very nice color patterns present in certain groups of collembola just cry out for a thorough investigation of the eventual use of fluorescent signaling in collembola. Here we will review the little knowledge on light production in this group and present some preliminary data about the localization of their photo-sites and their stimulation.

Keywords: Anurida granaria, natural fluorescence, bioluminescence.

Genetic and environmental factors of life and death in the springtail *Folsomia candida*

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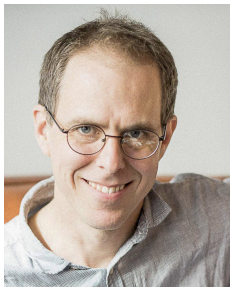

Senescence can be defined as the inexorable and progressive deterioration of an adult organism with advancing age. Senescence is generally interpreted as the consequence of the progressive decline with age of the force of natural selection acting against the accumulation of mutations with deleterious late acting effects. The patterns of senescence and the life expectancy are known to vary dramatically across the tree of life, between distant or closely related species. Within a single species, individual differences in lifespan can be due to genetic differences, to environmental differences or to stochastic processes. Some environmental conditions such as diet restriction (DR) are known to lower the mortality rate, to delay or slow down senescence and as a consequence to increase the average lifespan of many organisms.

Little is know on Collembola lifespan, their range, genetic variance and plasticity. We report here a study on the lifespan of the Collembola *Folsomia candida* and we address the following questions:

- What are the average and range of lifespan of the Collembola *Folsomia candida* in an environment protected from extrinsic causes or mortality?
- What are the effects of dietary restriction on the survival patterns in this species?
- How large is the genetic variation of the life expectancy in this species?
- Can we detect genetic variability on the characteristics of aging processes and their sensibility (plasticity) to environmental conditions (here the level of food provisioning)?

To address these questions, we have studied and compared 11 clonal line of *Folsomia candida*. More specifically, we raised 220 isolated Collembola from birth to death in constant temperature but in two environments with contrasted food provisioning: one where food is provided ad libitum, the other where food was only provided one day a week (dietary restriction regime).

We first studied the genetic and environmental effects on the mortality process using a non-parametric Cox model. In a second step, an estimate of the heritability of longevity and its plasticity was performed. Finally, non-parametric survival analysis was supplemented by parametric analysis by adjusting and comparing four parametric survival functions in continuous time. This then made it possible to specify the form and the differences of forms of the risk functions associated with each of the groups of identified individuals.

We found large differences in the mean lifespan between the clonal lines, and observed that on average springtails raised in dietary restricted environment lived longer. We also found large genetic differences in the plasticity of lifespan: while some lineages are able to dramatically extend their lifespan when raised under restricted conditions, the average lifespan of other lineages are more constrained.

Keywords: Senescence, mortality, dietary restriction, phenotypic plasticity, ageing.

The influence of climate warming on sexual chemical communication in a springtail species

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Sex pheromones are particularly important for animal reproduction. They are not only a primary means of contact between mates, but they also mediate mate assessment. Thus, chemical signalling plays a crucial role at different levels of sexual communication. Yet, there is a substantial gap in the knowledge of how chemical communication between sexes could be impacted by climate warming. An ideal species for studying this largely unknown aspect of the consequences of thermal stress is the collembolan *Orchesella cincta*. Like several soil arthropods, *O. cincta* has evolved an indirect way of sperm transfer in which males deposit sperm droplets (spermatophores) in the environment for females to pick up, guided by the spermatophore scent. In this species, a choosy female relies solely on the sperm-associated sex pheromone, making olfaction the most important sensory modality involved in reproductive decisions. Experimental evidence indicates that in *O. cincta* stress temperature affects pheromone communication at different stages of the pheromone journey, from synthesis to persistence. Specifically, males exposed to thermal stress produce less attractive sper-

matophores to females, suggesting that male exposure to heat affects the spermatophore pheromone biosynthetic pathway. Moreover, high temperature has negative effects on scent composition and/or durability, as females of *O. cincta* are less attracted by heat-stressed spermatophores. Overall, these results suggest that changes in environmental conditions can disrupt sexual communication in those species that rely on pheromone signals for mating.

Keywords: Collembola, spermatophores, sex pheromone, mating disruption, thermal stress.

Methods

Collembola in soil samples: Efficiency of extraction methods

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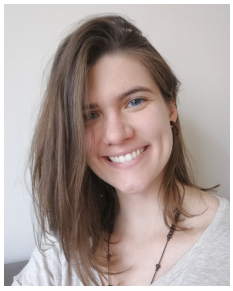

A key task of Soil Zoology is the extraction of soil animals from the substrate. Several methods for this purpose have been developed over the years, but there is evidence that an unknown proportion of animals remains unextracted and undetected in the samples and the true composition of the assemblages unknown. Here, we compare the suitability for the detection of Collembola and Oribatida and the efficiency of four popular extraction methods to identify potential abundance, species richness, and composition biases: Berlese-Tullgren and Macfadyen funnels, heptane flotation and pitfall traps. It is tested whether the choice of the extraction process has an influence on recognized species richness, total abundance and if species-specific behavior influences the efficiency of the extraction. Samples were taken from two sites of widely differing character: An acid spruce forest and a semi-dry grassland located in lower Austria. For Collembola, first results show that there are considerable differences among the methods. In both sites, the largest number of individuals was detected with pitfall traps, the smallest with heptane. The ranking of Berlese-Tullgren and Macfadyen among the methods was influenced by location. For the estimation of species richness, Berlese-Tullgren and Macfadyen were most efficient at the forest site and pitfalls at the grassland site. Heptane flotation extraction showed the least efficient results at both sites. So far, we have no evidence of a general bias of any of the investigated methods, but still need to characterize species assemblage patterns for a final conclusion. The analysis of Oribatida data is currently in progress.

Keywords: Pitfall, flotation, Heptane, Macfadyen, Tullgren, Berlese, extraction methods, Collembola, traps, Oribatida.

Phylogeny

Molecular data applied for Protura phylogeny and species delimitation

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Proturans are tiny, primitively wingless, soil-dwelling arthropods, usually connected with the early diversification of hexapod lineages. Due to their bizarre and enigmatic morphology, i.e., the primitive lack of antennae and wings, the absence of eyes and tentorium and the anamorphic post-embryonic development, their phylogenetic position within the hexapod tree is still questioned. Besides, their limited dispersal capability and their euedaphic lifestyle have greatly complicated species-level identification. In this study, mitochondrial and nuclear markers have been applied to investigate and review proturan systematics at different hierarchical levels. Furthermore, we have analyzed the molecular features of two new mitogenomes obtained from the proturan species *Acerella muscorum* (Acerellidae) and *Acerentomon microrhinus* (Acerentomidae) and used these data to test whether nucleotide sequences and gene order arrangements are informative with respect to the placement of Protura within the arthropod tree. Mitochondrial and nuclear loci were also applied in order to revise the intraclass systematics, recovering three proturan orders and most of the families/subfamilies as monophyletic, with the exception of the subfamily Acerentominae. At the species level, the taxonomic status of most morphologically described species was confirmed using molecular markers, with some exceptions, and the advantages of including nuclear, as well as mitochondrial, markers and morphology were discussed. At all levels, an enlarged taxon sampling and the integration of data from different sources resulted to be of significant help in solving open questions that still persist on the evolutionary history of Protura.

Keywords: Hexapods, phylogeny, coneheads, mitogenomics, species-delimitation, Pancrustacea.

Adding evolution to soil animal ecology-phylogenetic comparative methods for studying adaptation of Collembola life-form traits and reproductive mode

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Phylogenetic niche conservatism and adaptation are evolutionary processes that promote species diversification and thus explain diversity from another perspective beside ecology. In soil animals the evolutionary patterns are less investigated. Using phylogenetic comparative methodsáwe explored evolution of two commonly used traits of Collembola: life form (as predicted by the morphological characters) and reproductive mode. Since parthenogenesis is common in euedaphic species and prevails in the habitats where resources are easily available, little structured or replenished quickly, we specifically tested whether the changes in morphological characters and reproductive mode were associated with habitat preference in evolutionary history of Collembola. Our results indicate that there were evolutionary associations between reproductive mode and morphological characters, including body size, presence of ommatidia and pigmentation. Further, living on the ground or dwelling in the soil were evolutionarily associated with reproductive mode, together with all the tested morphological characters. However, species preference for stable or disturbed habitats likely evolved independently from any of the traits included. Our study demonstrated why and how evolution can be added in the contemporary predominant trait-based studies on Collembola, and calls for a need of "tree thinking" in soil animal community.

Keywords: adaptation, Collembola, evolution, phylogenetic comparative method, phylogeny, trait.

Giant Collembola phylogeny

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Collembola are often regarded as inconspicuous fauna inhabiting, but not restricted to, soils, leaf litter, and rotting wood. Within the latter, there are numerous species that play an important role as saproxylic decomposers in forest ecosystems in their contribution to nutrient cycling and some are amongst the largest known Collembola.

Here, we compared species across relevant subfamilies within Neanuridae and outgroup representatives with a focus on the 'giant' Collembola from the subfamily Uchidanurinae within a phylogeny using four genes (mtDNA COI, 16S, 18S rDNA, D1-D5 of 28S rDNA). Interspecific variability in gross morphological characters was high. Because of this variability, and in order to characterize the subfamilies more fully, we suggest characters and provide a comparison of these characters with the other genera within Uchidanurinae. The genera and species relationships within the subfamily Uchidanurinae do not form a natural group, it is hereby dissolved and we discuss the placement of all genera involved based on morphological and molecular characters.

Keywords: Collembola, biodiversity conservation, biogeography, saproxylic communities, Neanuridae, phylogeny, Uchidanurinae.

Northern range limit of troglomorphy in Europe – Miocene diversification of cave *Pseudosinella* (Hexapoda, Collembola) in the Western Carpathians

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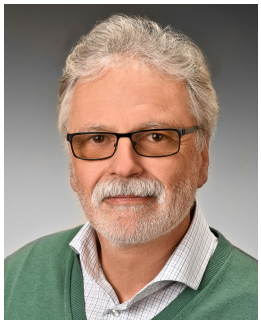

The recent speleobiological studies revealed that the Western Carpathians, a part of the Carpathian mountain chain, is the northernmost region in Europe with the occurrence of the troglomorphic cave fauna. The collembolan genus *Pseudosinella* Schäffer, 1897 is a polyphyletic taxon derived from the genus *Lepidocyrtus* Bourlet, 1839 from which it was artificially separated only by reduced number of eyes. It covers 347 species with predominantly Holarctic distribution, of which about 50% are closely associated to caves, and about 30% show distinct troglomorphic characters. We studied the morphology and molecular traits to delimit cave species of the genus *Pseudosinella* occupying the Western Carpathian caves and clarify their phylogenetic relationships. Based on morphological traits we hypothesized that *Pseudosinella aggtelekiensis* (Stach, 1929) and *P. paclti* Rusek, 1961 are descendants of the different phyletic lineages, the former species lacking morphologically related edaphic species. On the other hand, several species related to *P. paclti* were found in caves, superficial subterranean habitats and in the soil. Molecular phylogeny analysis has shown two distinct groups of cave species following allopatric distribution pattern. The first group consisted of *P. aggtelekienis* populations from the Slovak Karst and an undescribed species from a small, fragmented and isolated karst in eastern Slovakia. In the second group different populations of *P. paclti* occupying caves of the central karst regions were incorporated together with a new, highly troglomorphic species confined to a small karst area. Following an estimate of the geological timing of the species isolation (RelTime), the two distinct *Pseudosinella* lineages diverged 9.54 Mya followed by subsequent diversification in *P. paclti* lineage 8.36 Mya, and in *P. aggtelekiensis* lineage 6.99 Mya. i.e., during the Late Miocene. The study contributed to assumption that the Western Carpathian Mts played an important role as a speciation centre of the obligate cave fauna in Central Europe. The contribution was supported from projects VEGA 1/0346/18 and APVV-17–0477.

Keywords: Subterranean Collembola, *Pseudosinella*, cave, troglomorphy, genetic divergence, speciation centre, Western Carpathians, Slovakia.

Mitogenomic data applied to review and further investigate the evolutionary relationships of main springtail lineages

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Collembola are one of the most abundant lineages of basal hexapods, widespread and adapted to all the damp and various ecosystems on Earth - from mild habitats to the more extreme ones of Antarctica and Himalaya - dwelling in soil environment or leaf litter, and on vegetation. Collembola can be classified into four taxa: Entomobryomorpha, Poduromorpha, Symphypleona and Neelipleona. Although Collembola monophyly has never been questioned, the internal evolutionary relationships among the various lineages are not resolved yet. Their systematics has been frequently challenged on morphological ground, e.g. according to: mouthpart axis orientation and metamerism (Paclt, 1956; Salmon, 1964); chaetotaxy (Yosii, 1961); furcula development, mouthparts type, metamerism and neuroendocrine system (Cassagnau, 1971); morphological character states applied for cladistic analyses (D'Haese, 2003). Even from a molecular point of view, intra-class systematics has been questioned: Poduromorpha resulted monophyletic but not basal to all the other Collembola taxa (thus, rejecting a semi-aquatic origin of springtails); Entomobryomorpha generally paraphyletic (D'Haese, 2002; Xiong et al. 2008); Symphypleona sometimes monophyletic (Gao et al. 2008, Xiong et al., 2008), some other paraphyletic (D'Haese, 2002; Luan et al. 2005). The inclusion of Neelipleona in molecular phylogeny is very limited and usually leads to their sister group relationship with Symphypleona or to all the other springtails (Gao et al. 2008; Xiong et al. 2008). Most of the morphological and molecular data so far collected are highly biased towards the taxa Entomobryomorpha, Poduromorpha and Symphypleona. For example, only 15 complete or almost complete mitochondrial genomes (mtDNAs) are recorded on public databases. Among them only two mtDNAs are available for Symphypleona (i.e. *Sminthurus viridis* and *Bourletiella arvalis*) and still none for the Neelipleona. To further investigate evolutionary relationships among the main springtail lineages, we sequenced two mitochondrial genomes from the species *Dicyrtomina saundersi* (Symphypleona) and *Neelus murinus* (Neelipleona). Moreover, our mtDNA data were combined with those newly obtained in other studies not focused on springtail phylogenetics: e.g. that of *Parisotoma notabilis*, *Lepidocyrtus curvicollis*, and *Megalothorax minimus*. Mitogenomes were then applied for phylogenetic inference using an enlarged data set, inclusive of the four springtail main lineages. These results are then integrated with morphological data usually applied for collembolan systematics.

Keywords: Collembola, phylogeny, systematics.

Molecular phylogeny of the subterranean genus Verhoeffiella (Collembola, Entomobryidae) questions its disjunct distribution and reveals high diversification within the Dinarides (Western Balkans)

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Subterranean habitats are inhabited by numerous specially adapted taxa, which typically have limited distribution ranges on both specific and generic level. They are generally bound to narrow geographical areas, yet there are exceptional lineages exhibiting large and disjunct distributions. One of the cases is the subterranean collembolan genus *Verhoeffiella* that occurs in five remote karstic regions, from 150 to 1000 km apart (Dinarides, Jakupica in North Macedonia, South-eastern Calcareous Alps, Southern Catalonia and Cordillera Cantabrica). We tested the monophyly of *Verhoeffiella* and explored its relationship with the surface and presumably related genus *Heteromurus*. Further, using species delimitation methods and time divergence estimation, we explored hidden diversity and temporal diversification. Our results show that the genera *Verhoeffiella* and *Heteromurus* are paraphyletic, with lineages of *Verhoeffiella* intermixed with lineages of Heteromurus nitidus. Discovery of highly diversified subterranean group with closely related surface relatives represents an exceptional case within the subterranean fauna of temperate regions. Species delimitation methods revealed increased molecular divergence and overlooked diversity within both genera. The highest increase was noted in *Verhoeffiella* populations in the Dinarides, where the number of MOTUs (N=79) exceeded the number of described species by eight times. When put on the time scale, most of cladogenetic events coincide with Messinian salinity crisis (5.96-5.33 MA), while speciation events with the age of Pleistocene (2.5 MA - 11.7 k years ago), indicating that paleogeographic changes could be one of the main triggers of diversification within *Verhoeffiella*.

Keywords: Toglobionts, Iberian Peninsula, Heteromurini, species delimitation, species range, hidden diversity.

Phylogeny and biogeography of the three most widespread species of Megalothorax (Collembola, Neelipleona)

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Megalothorax minimus Willem, 1900 (sensu Schneider & D'Haese 2013), *M. laevis* Denis, 1948 (sensu Schneider et al. 2018) and *M. willemi* Schneider & D'Haese, 2013 are showed to be most widespread species of *Megalothorax.* They also share an extremely similar morphology, related to an edaphic ecology and without any clear difference in functioning. Each of those species is distributed across several continents and strives in different habitats, which is a stunning fact for those minute springtails (~0.5 mm). To unveil how those species spread throughout the world and compete with each others, we draw a broad picture of their natural history, bringing morphology, molecular phylogeny and geography together.

Keywords: Collembola, soil organisms, cryptic species, introduced species, phylogeny.

Phylogeny of Australian acerentomid fauna (Protura: Acerentomidae)

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Little is known on Protura distributed in Australia, and not much either throughout the Gondwanian region. The proturan fauna of Australia comprises 33 species, 23 of which belong to the family Acerentomidae and exclusively to subfamily Berberentulinae. The same observation can be made for South and Central American proturan fauna, where all 25 acerentomid species belong to Berberentulinae. Concerning the Australasian region, the majority of species analysed have been recorded in Australia with 5 species only presenting a wider distribution, mainly in the Gondwanian region. According our genetic analyses based on several loci both nuclear and mitochondrial the members of Berberentulinae form a monophyletic clade, where the species of *Acerentulus* genus are well separated from other genera. The genus is most diverse and widespread within Acerentomidae fauna and closely related with other Berberentulinae genera with narrow distribution, such as South American *Andinentulus* genus, Tasmanian *Tasmanentulus*, Australian *Amphientulus* and *Australentulus*, and with genera *Gracilentulus* and *Baculentulus* which are also distributed in Australia. The Berberentulinae genera are mainly distributed in tropical regions and are characterized by different degrees of reduction of morphological characters (e.g. labial palpi, striate band, number of setae on abdominal legs and on sternite VIII) compared to the members of other Acerentomidae subfamilies. The degrees of reduction of morphological characters are clearly visible in Australian aceretomid fauna along phylogenetic line *Acerentulus* – *Australentulus* – *Tasmanentulus* – *Amphientulus*. All Australian *Australentulus*, *Tasmanentulus* and *Amphientulus* are characterised by hook-shaped design of the striate band. Tuxen (1981) mentioned, that hook-shaped design does not seem to be a genetic character, but rather characteristic of almost all gondwanian species (Brasil, Madagascar, Southern India, Australia, New Zealand). Therefore, we could agree with statement of Tuxen (1967) that Australian acerentomid fauna confirms a fact which is already known from many other animal groups, there is a very sharp distinction between Australian fauna and whole world one, even with South-East Asia fauna.

Keywords: Protura, phylogeny, Australia.

Community phylogenetic structure of Isotomidae (Collembola) along elevation gradients in Changbai Mountain, China

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Mountains provide a unique natural experimental system to test ecological and evolutionary hypotheses, since a wide range of environmental gradients is concentrated within a small geographical range. Species occurring at different elevations are likely to possess different traits allowing them to adapt to specific environments. In this study, we applied phylogenetic and trait-based approaches to study the assembly processes of Isotomidae communities in Changbai Mountain, northeast China, along an elevational gradient ranging from 800 to 2150 m. Using mitochondrial genome sequences we reconstructed a phylogenetic tree for 30 species occurring in the sampling region. Species richness and phylogenetic diversity of Isotomidae were compared across different altitudes. Phylogenetic relatedness and trait similarity of local communities were measured to infer assembly processes, i.e., environmental filtering and niche partitioning, that may differently structure Isotomidae communities at different elevation. Our study provides the first evidence of community assembly mechanisms in soil and litter inhabiting Isotomidae. However, further studies on evolutionary patterns of functional traits related to environmental selection and biotic interactions are needed to validate the assumption of phylogenetic conservatism in traits, especially when phylogenetic approaches are used to study assembly processes in soil animal communities.

Keywords: Functional trait, soil animal, evolution, phylogenetic diversity, mitochondrial genome.

Revisiting the systematics of Tomocerinae (Collembola, Entomobryomorpha) by integrating molecular and morphological evidence

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This presentation is to report our new progress in resolving the long-lasting systematic problem of Tomocerinae. We have conducted a phylogenetic reconstruction using five genetic markers (COI, 16S, 18S, 28S D1-2, 28S D7-10) and more than 50 species belonging to 6 (out of 9) previously defined genera. Our preliminary result supports the basal division of Tomocerinae into three main branches as *Plutomurus*, *Pogonognathellus* and other genera, while the last and largest branch is further divided into several subclades, which are also supported by morphological synapomorphies. The most problematic genera *Tomocerus* s. s. and *Tomoceri-*

na are revealed not to be monophyletic groups. Therefore, on the basis of molecular and morphological evidence, and also for the convenience of classification and identification, we suggest to redefine some existing genera, and propose to establish several new supraspecific taxa.

Keywords: Supraspecific taxa, morphological characters, molecular phylogeny, Tomoceridae.

Ecology II

Soil biodiversity in agricultural fields across Europe as affected by farm-based soil management practices and regional constraints

(communication cancelled)

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Soil biodiversity is pivotal for delivering food, fiber, biofuels, clean air, drinking water and carbon storage to the society. However, our understanding of the link between soil biodiversity, soil functions and ecosystem services is still limited. Future cropping systems need to increase agricultural productivity while keeping production sustainable. In order to reach this goal, we need to better understand and valuate the relationships between soil biodiversity, soil functions and ecosystem services in the context of agricultural management practices. The presented project forms part of the European Science Foundation project "SoilMan", aiming at deeper understanding of the interrelationship between soil management, soil biodiversity and ecosystem services. To achieve this goal "SoilMan" is quantifying soil ecosystem functions and multiple ecosystem services based on biodiversity parameters in representative agricultural systems across Europe. The project focusses on two soil management regimes, tillage and crop rotation. In the framework of "SoilMan" we focus on collembolan diversity as a function of land use characteristics and regional habitat conditions. Samples were taken from long-term experimental field sites and farms in Germany, France, Spain, Romania and Sweden. We expect that soil biodiversity in agricultural fields is determined by farm based soil management practices and shaped by regional constraints.

Keywords: Tillage, Collembola, soil biodiversity, ecosystem services.

Population dynamics of springtails (Hexapoda: Collembola) in three different ecosystems in Kermanshah province (Iran)

(communication cancelled)

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The population dynamics of Collembola were investigated in three different ecosystems: agricultural, oak woods and grassland in tow cities of Kermanshah province (Paveh and Eslam abad-e- Gharb) monthly from June 2016 to May 2018. In each site, 10 soil samples collected from an area of 100 cm2 and a depth of 13 cm. Then, the population of collembolan was counted to species level. Diversity and species richness were calculated using Shannon, gamma, and Jaccard Sorenson indices. Totally, 74 species belonging to 36 genera and 15 families were identified. Totally, 33 species were identified that the species richness of forest was higher than the agricultural and grassland in two different cities. In Paveh, the species richness of agricultural was higher than the grasslands and there was no significant difference compare to grassland in Eslam abad-e- Gharb countie. This difference could be due to various reasons such as soil compaction and the rocky grasslands, overgrazing, transforming the grasslands to agricultural lands and leaving them unsown. Comparison among the two cities showed that biodiversity of Eslam abad-e- Gharb was higher than the other. The results of monthly counting and habitat suitability modeling showed that the abundance population of most species was occurred in November to May.

Keywords: Population dynamics, biodiversity, Collembolan fauna.

Abundance, diversity and community composition of arboreal Collembola along a land use gradient in Sumatra, Indonesia

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Tropical forests belong to the most complex ecosystems on the planet. While we know that arthropod communities in tropical forests constitute the majority of the aboveground animal biomass and biodiversity, most of that knowledge is based on well-known taxa or broad analyses with low taxonomic resolution. Here, we present an in-depth, species level analysis of arboreal springtails (Collembola) along a transformation gradient from rainforest to rubber and oil palm plantations in Sumatra, Indonesia. Collembola are important members of the decomposer system, and are essential in providing tropical canopies with pockets of fertile soil, which in turn is the basis for a rich invertebrate ecosystem of many epiphytic plants and animals living therein. Using canopy fogging, we sampled arboreal Collembola from 8 locations each in lowland rainforest (referred to as forest), jungle rubber (extensive rubber cultivation), and monoculture plantations of rubber and oil palm, based on the nested plot design of the EFForTS project in Jambi Province. Overall, we collected 65,691 specimens belonging to 68 species from 10 families of Collembola. Our data suggests that the arboreal Collembola community in central Sumatra is dominated by a few species from the families Entomobryidae and Paronellidae, constituting 97% of all specimen. Specifically, two morphospecies from the Lepidocyrtinae subfamily and one morphospecies from *Willowsia* (all Entomobryidae), and two morphospecies of *Salina* (Paronellidae) are exceptionally abundant (73%). Our analysis demonstrates that average Collembola abundance is highest in jungle rubber (1,430.5 ± 911.9 per plot,), while abundance in forest, rubber and oil palm doesn't significantly differ from each other (435.6 ± 516.7). Collembola species richness, however, is similarly high in both forest and jungle rubber but almost half in rubber and oil palm. Lastly, community composition differs significantly between the land use systems, with rainforest and jungle rubber communities being much more similar to each other, than communities inhabiting rubber and oil palm monocultures. Overall, our study represents the first study of arboreal Collembola in Sumatra to that taxonomic depth, and highlights the need to understand more about the community change of Collembola in the face of agricultural intensification in the Asian tropics.

Keywords: biodiversity conservation, community structure, arboreal arthropods, landscape change.

Edge effects and relic populations among corticolous Collembola in Richmond park, Surrey

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Edge effects are thought to affect many woodland life forms, but there are few studies on edge effects in corticolous Collembola (Springtails). We report vacuum-collections of Collembola from tree bark (1-2m elevation) to test for edge effects along 64m transects in four plantations within Richmond Park over four 4 seasons. The biggest factor affecting collembolan populations was found to be season (with numbers peaking in winter), along with the depth of bark crevices (with highest numbers in the deepest crevices). The two commonest Collembola, *Orchesella cincta* (L.) and *Entomobrya albocincta* (Templeton), showed significant woodland-edge avoidance We collected far more specimens of *Entomobrya corticalis* (Nicolet) (128) than all previous reliable UK records combined (24), almost entirely off old oaks *Quercus robur* L. Unexpectedly we collected almost no specimens of the locally dominant (putatively invasive) corticolous species *Entomobrya intermedia* Brook were collected, instead finding many *Entomobrya nivalis* (L.). These findings are the first report of an edge-effect in corticolous Collembola, and also suggest that the woods of Richmond Park are harbouring a relic springtail community, isolated by the extensive acid grassland around them.

Keywords: *Entomobrya*, *Orchesella*, edge effect, bark community, seasonality.

Taxonomy II

Diversity and troglomorphy of cave springtails (Hexapoda: Collembola) in Thailand

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Diversity surveys, taxonomic knowledge and biogeographical data for cave Collembola in Thailand have experienced a rapid increase these last years, through the sampling of many new caves and karst areas. In this work, we analyze the collections of Collembola from more than 170 caves of northern, western and southern Thailand. A total of 4 orders, 9 families, 23 genera and at least 110 species (including morphospecies) are reported. In each cave, one to eleven species were collected, with only a few caves without Collembola. The results confirm that Collembola are among the most common and diverse invertebrate group in caves, and by

far the most diverse of the terrestrial cave Arthropods in Thailand and in SE Asia caves. Most collected species are unknown to science and seem to be endemic to karst units of limited extent. Many species exhibit strong morphological adaptation to cave life (troglomorphic traits). The most remarkable in this respect are *Coecobrya* spp, *Cyphoderopsis* spp., *Lepidonella* spp. and *Troglopedetes* spp. which are narrow cave-restricted endemics. The presence of such a number of several highly troglomorphic species was unexpected and provide the evidence that morphological modifications in tropical cave Arthropods may be as strong as, or even stronger for some characters like antennal elongation, than in caves of temperate regions. This high level of troglomorphy and probably endemicity of subterranean Collembola in Thailand raise concerns on their vulnerability, and point to the need higher than initially expected to document more thoroughly their distribution in a conservation perspective, in the face of the increasing human pressure experienced by karst habitats in the country. Such investigations are essential to provide information for developing sound cave conservation strategies in Thailand as well as for increasing awareness on the vulnerability of the subterranean ecosystem.

Keywords: Adaptation, inventory, karst, springtails, subterranean environment.

Genus *Deuteraphorura* Absolon, 1901 in the Western Carpathians – Troglomorphy of cave Collembola (Hexapoda) on northern distributional limit in Europe

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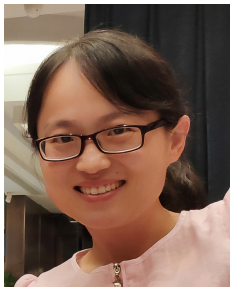
A new species of *Deuteraphorura* from the Western Carpathians is described. *D. muranensis* sp.nov. belongs to species with 4 pso at hind margin of the head and possesses highly troglomorphic features. It is conspicuous by distinctly elongated claws and long hair-like body chaetae. Status of new species was confirmed based on mitochondrial COI marker. Molecular, morphological and geographical data were applied to species delimitation among cave *Deuteraphorura* in the Western Carpathians. Populations of *D. kratochvili* (Nosek, 1963), the most widespread *Deuteraphorura* species in Western Carpathian caves were studied. Despite indistinct morphological differences, tested populations are well isolated both geographically and genetically, thus are consider to represent a cryptic species. Troglomorphy of cave Collembola on the northernmost border of distribution of cave-adapted species in Europe is discussed. The study was supported by the Slovak Research and Development Agency (APVV-17-0477), Scientific Grant Agency (VEGA1/0346/18) and grant providing by the Pavol Jozef Šafárik University in Košice (VVGS-PF-2018-796).

Keywords: Geography, COI, integrative taxonomy, cryptic species.

A second and highly troglomorphic species of the genus *Ongulonychiurus* Thibaud & Massoud, 1986 (Collembola, Onychiuridae) from a deep Croatian cave



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The genus *Ongulonychiurus* Thibaud & Massoud, 1986, so far only known by the species *O. colpus* Thibaud & Massoud, 1986 from Spain, can be easily recognized from other genera of Onychiuridae by a combination of highly troglomorphic traits, such as large body size, long antennae, heterochaetosis, long legs and claws, and complex sensory organ of Ant. III. These characters are assumed to be related to the special habitat of the species which were found only in the deep cave. Comparing to other groups of troglomorphic Collembola, this genus is one of the most remarkable cave restricted Onychiuridae, together with the relictual monospecific genera *Absolonia* Börner, 1901 from Slovenia and *Pilonychiurus* Pomorski, 2007 from Algeria. We report here a new species, the second record of the genus *Ongulonychiurus*, found in a deep Croatian cave on Biokovo Mt. It has the same troglomorphic characters as *O. colpus*, but can be separated easily from it by pso formula on head and body, number of pso on the legs, number of guard chaetae and papillae of AIIIO, dorsal cephalic chaeta d0 absent, number of vesicles of PAO, number of p-chaetae between the two medial posterior pso on head and number of chaetae in the distal whorl of tibiotarsi.

Keywords: *Ongulonychiurus*, troglomorphy, heterochaetosis, Croatia.

First record of Collembola and their diversity in the Charland of the Padma river at Rajshahi, Bangladesh

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Abstract: In this study nine hundred ninety nine individual collembolans were collected during February to August 2016. The collected specimens that contain four families; Entomobryidae, Isotomidae, Hypogastruridae and Poduridae. They were viz. *Isotomina* sp., *Entomobrya griseolivata*, *Entomobrya gisini*, *Isotoma viridis*, *Hypogastrura armata*, and *Podura aquatica*. Among them, highest population was *Isotomina* sp (229) and lowest population was *Podura aquatica* (70). In our study the morphological parameters were different in each species. According to total length they were; *E. griseolivata*> *P. aquatica*> *Isotomina* sp> *I. viridis*> *H. armata*> *E. gisini* corresponding to 708.82, 700.95, 694.32, 619.76, 492.10, 472.80μm respectively. However, the highest antennal length found in *E. griseolivata* (204.34μm) and lowest was in *E. gisini*

(62.33µm). The highest Shanon-Weiner diversity index of Collembola was 1.750 in the month of April and the lowest was 1.674 in July. This study identified Collembola species are diversified in Charland soil have important roles in soil fertility may help to understand the ecological aspect in these habitats.

Keywords: Collembola, springtails, insect survey, diversity, Rajshahi, Padma River.

Current status, diversity and distribution of Apterygota fauna in India

(communication cancelled)

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The present communication is updated information about Apterygota fauna in India. Apterygota, a paraphyletic group that includes the five clades of basal hexapods (Collembola, Protura, Diplura, Microcoryphia and Zygentoma). A total of 345 species of Collembola under 113 genera grouped in 20 families were recorded from India. Out of which, 309 species belong to 98 genera of order Poduromorpha & Entomobryomorpha and 36 species belongs to 16 genera of order Symphypleona (Mandal, 2018). Collembola fauna from North East India (except Assam), Andhra Pradesh, Uttar Pradesh, Uttarakhand, Himachal Pradesh, Jammu & Kashmir, Andaman & Nicober Islands, Jharkhand, West Bengal, Kerala and Tamil Nadu were published. The gap areas for further study or exploration for collembolan fauna are states like- Bihar, Chattisgarh, Delhi, Madhya Pradesh, Maharashtra, Odisha, Assam, Gujarat, Goa, Haryana, Punjub, Karnataka and Telengana. Protura fauna presently known 20 species under 10 genera of 3 families from India. Out of 20 species, 16 species under 8 genera of family Acerentomidae and one species under the single genus of family Protentomidae, 03 species under single genus of family Eosentomidae. All the species are recorded from Kerala state only. Rest of Indian states, Protura fauna is totally unexplored. So, there is an ample scope to explore from rest of India and further study of this very minute group of hexapods. Diplura is represented by 19 species in 9 genera of 4 families- Anajapygidae, Japygidae, Projapygidae and Campodeidae from India and their distribution is restricted to eastern and southern parts of India. There is a huge gap area for further study or exploration from rest of India of this very minute group of hexapods. Microcoryphia represented by 10 species belonging to 6 genera and 2 families- Machilidae and Meinertellidae from India and their distribution is Uttarakhand, Himachal Pradesh, Jammu and Kashmir, Manipur, Meghalaya, Kerala, Andhra Pradesh and Andaman & Nicober Islands. Rest of the Indian states are unexplored and gap areas for further study. Zygentoma represented by 29 species belonging to 16 genera and 3 families- Lepismatidae, Ateluridae and Nicoletidae from India and found in West Bengal, Tripura, Sikkim, Odisha, Assam, Uttar Pradesh, Uttar Pradesh, Himachal Pradesh, Jammu and Kashmir, Manipur, Meghalaya, Maharashtra, Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, Andaman & Nicober Islands and Delhi. Remaining states are totally unexplored and there is ample scope for further study. Use of chemical fertilizers and pesticides, shifting cultivation, over cultivation, deforestation, soil erosion, overgrazing, open cast mining, underground mining, radioactive fall-out, solid waste disposal were potential threats for Apterygota fauna. All these activities are disturbing the upper mineral soil horizons and affect the diversity, numbers, and activities of Apterygota fauna that are important for maintenance of soil fertility.

Keywords: Diversity, Apterygota, India.

Abstracts:

Poster presentations

Anatomy

Anatomical Ontology for the class Collembola Lubbock, 1980 (Hexapoda: Entognatha)

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The morphological complexity and diversity present in Arthropoda are recognized as a remarkable trait in its biological success. Describe this morphology implies the utilization of huge amount of anatomical terminology, which makes difficult the communication and comparing of morphological data. The ontologies contain a set of objects, whose relationships are expressed through vocabularies and parsable for a computer; a methodological tool that allows the standardization of anatomical language employs in morphological descriptions. Ontologies in Arthropoda are represented in few taxon (Hymenoptera Anatomy Ontology, HAO), model organisms (*Drosophila* development, FBdv), and anatomical systems (Ontology of Arthropod Circulatory Systems, OArCS) while in Entognatha these do not exist. The main goal of this work is showing an anatomical ontology for the class Collembola (Collembola Anatomy Ontology, COLL). The design of this ontology contains the following general steps: 1. Recopilation of anatomical terms from morphological and taxonomical descriptions published in Collembola, 2. Construction of concepts and definitions, 3. Expression of ontologies through statements RDF (Resource Descriptions Framework), and 4. Design and construction through ontologies editor Protégé 5.5.0. Until now, Colllembola Anatomy Ontology includes 998 classes and 13 object properties for the external (including chaetotaxy) and internal anatomy (muscular and nervous systems) with the formalization of chaetotaxy systems in a hierarchy tree (partonomy). This ontology is directed to recognize similarity and obtaining of taxonomic characters, which is complementary to taxonomic work in Collembola.

Keywords: Ontology, Collembola, resource description framework, anatomy.

BIOfid: Advancing biodiversity research with taxonomic and anatomical ontologies

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A new online platform called BIOfid has recently been established by an interdisciplinary team of librarians, computer scientists and biologists to foster global accessibility of biodiversity data hidden in historical and contemporary literature. A key facet of this platform is the provision of new text-mining tools enabling user-specific semantic search queries. The foundation of these tools are domain ontologies that represent available information on the systematics and anatomy of selected taxa in semantic web language and express various types of conceptual relationships as ontology-based annotations. The taxa are prioritized by a target group of

the German community of biodiversity researchers and currently focus on vascular plants (Tracheophyta), birds (Aves), as well as moths and butterflies (Lepidoptera). The SENCKENBERG bioinformatics team now aims at expanding the development of such ontologies onto the soil arthropod taxa represented in the edaphobase repository for the mobilization and evaluation of soil-ecological data, including apterygote hexapods. In order to promote this project, we present our general workflow from literature acquisition over software development to data availability on the BIOfid web portal (https://www.biofid.de) and the implementation of our project into existing platforms. We place a special focus on our newly developed anatomy and phenotype ontologies (LepAO, FLOPO). These are integrated in the larger framework of the Open Biological and Biomedical Ontology (OBO) Foundry, which aims at providing a family of modular and interoperable ontologies for the life sciences. BIOfid is supported by the LIS (Scientific Library Services and Information Systems) programme of the German Research foundation (DFG).

Keywords: Specialized Information Service, text mining, information technologies, semantics, soil fauna.

Ecology, Community Ecology, Population Ecology, Land invasion, Interactions

Studies on the Biology of *Seira lateralis* (Hexapoda : Collembola)

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Seira lateralis laids eggs singly. the embryonic development was completed in 3 days at 30±1°C and in 6 days at 25±1°C. First instar animals were transparent and white in colour. From second instar the scales and pigmentation went on appearing more and more up to fifth instar. Sexual maturity was attained at the sixth instar. The post-embryonic development was completed within 9 days at 30±1°C and 16 days at 25±1°C. The individual life span was 148 days on average, comprising 27 molts. Cannibalism was observed under the condition of over-crowding and food shortage. The regeneration of antenna was noticed but any line of demarcation between the regenerated part and the original part was absent.

Keywords: Collembola, life history, temperature, tropics.

Life cycle and population dynamics of *Brachystomella gabrielae* (Collembola: Brachystomellidae)

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In order to know the life cycle and population dynamics of *Brachystomella gabrielae*, alive specimens were obtained from Nabor Carrillo lake (Texcoco, Mexico State) soil samples. Samples were processed by Berlese funnels, springtails were obtained in 35 ml glass jars with activated carbon and gypsum in a 1: 9 ratio medium. Cultures were kept under constant laboratory conditions of temperature (27.5 + 1 ° C), humidity (90%) and photoperiod (12 hours of light and 12 of darkness). They were fed with bread yeast pellets (6/week). Beginning with 19 parthenogenetic females, after 72 days, 373 individuals were obtained from an average of 3 egg laid per female, with a fecundity of 11.31 + 3.51 eggs per female and an average hatching and survival of 70%. In average, eggs took 10 days to hatch, when they are just lay out their color is white hyaline, and after 7 days eyes patches can be distinguished clearly. Adults have a gregarious oviposition behavior preferring the medium pores and walls of jars. The life cycle lasts approximately three months and during the same time, they show 35 molts in average. First report of *B. gabrielae* life cycle is presented here and it is accomplished in a relatively short time under laboratory conditions when compared with other species under natural conditions. Population growth is constant but is relatively slow compared *X. grisea* or *F. candida* in laboratory cultures.

Keywords: *Brachystomella gabrielae*, laboratory cultures, population dynamics.

Subterranean communities of Collembola (Hexapoda) along a microclimatically inversed scree slope of a deep karst gorge

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Vertical distribution of collembolan communities along the inversed microclimatic gradient was studied at the forested karst scree slope in the Zádiel Gorge, Slovak and Aggtelek Karst, Slovakia, during May-October 2018. In this mesovoid shallow substratum (MSS) habitat, Collembola were collected using subterranean traps filled with propylene glycol fixative solution at depths of 5-95 cm. Collembola were sampled at two sites in distance ~100 meters, at bottom and upper part of the slope, which considerably differred in microclimate regime. A forested slope at the gorge bottom (near Blatnický Creek) was characterized by dense vegetation cover, relatively high moisture content, low soil temperature (daily temperature means ranging from -0.1 to +12.0°C), and high carbon content along the depth profile. In the contrary, the warmer upper part of the slope represented bare scree with sparse leaf litter cover and markedly higher temperatures (daily temperature means ranging from +9.1 to +23.0°C), and slightly lower carbon content along the scree profile. Effect of soil microclimate and soil-chemical parameters on activity and diversity pattern of subterranean collembolan communities will be detailly assessed. Generally, soil microclimate and the organic carbon content are crucial factors determining diversity and vertical distribution of subterranean Collembola in scree habitats. Cold microclimate in low-altitude scree slopes of the Western Carpathians supports high diversity of Collembola occupying soil and SSH habitats. These karst habitats represent valuable refugia of wider spectrum of relict fauna, thus considered a critical component of effective conservation of subterranean biodiversity. The study was supported from the projects VEGA 1/0346/18 and APVV-17-0477.

Keywords: organic carbon content, microclimate, scree slope, MSS habitats, Collembola, refugia, Western Carpathians.

Collembola under drought stress - Evidence from wheat fields

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Climate change models predict altered rainfall patterns including more frequent and severe drought events in Europe. Accompanied by increased overall temperature this will result in decreased soil moisture, especially during the growing season, putting pressure on soil fauna by increased drought stress. Agroecosystems are of particular relevance for food security and at the same time facing a decrease in biodiversity due to increased land-use intensity. In the BiodivERsA project SoilClim we investigated the effects of reduced rainfall on soil biodiversity and ecosystem services in winter wheat fields across a European climatic gradient with field sites in Sweden, Germany, Switzerland and Spain. We experimentally simulated reduced precipitation using rainout-shelters with a partial interception of natural rainfall (65 %). We developed a new rainout-shelter design which minimizes potential shelter artifacts and being suitable for experiments in agricultural fields. During the first period of the project in 2017 we established rain exclusion experiments on plots with different long-term fertilization schemes in the DOK trial in Switzerland. Here, I present first results of the combined effect of reduced soil moisture and organic carbon content on epigeic and endogeic collembola communities in winter wheat fields.

Keywords: Collembola, agricultural fields, drought, climate change, rainout, shelter, soil carbon content.

Geographic variation in interactions between Collembola and the insecticidal mushroom *Strobilurus ohshimae* in Japan

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Ecological interactions often vary geographically. Fungus-fungivorous Collembola interactions are ubiquitous in terrestrial ecosystems. Certain species of Collembola feed on macrofungal sporocarps in huge numbers. The basidiomycete *Strobilurus ohshimae*, which fruits exclusively on fallen twigs of *Cryptomeria japonica*, has sporocarps covered with secretory projecting cells that can kill Collembola on contact, but certain species of Collembola feed on its sporocarps. The geographical variability in the interactions between macrofungi and fungivores are, however, poorly understood. We investigated the geographic distribution of Collembola species feeding on *S. ohshimae* sporocarps in native *C. japonica* forests in Japan. The presence of potential sporocarp feeders was surveyed using bait-traps containing Shiitake mushrooms. The preference for *S. ohshimae* was evaluated by determining the density of *S. ohshimae* per sporocarp mass relative to that for Shiitake mushrooms. The presence, species, and mode of feeding of Collembola preferring *S. ohshimae* varied with the site, and geographic variation in preferences for *S. ohshimae* was observed in one Collembola species. In Akita, *Ceratophysella* sp. 1 fed mainly on the gills of *S. ohshimae*, while *Ceratophysella* sp. 2 fed mainly on the interior parts of the stipes. In Yamanashi, Kyoto, Wakayama, Oki Is., Shimane,

and Kochi, *Ceratophysella pilosa* or closely related taxa preferred *S. ohshimae* and fed mainly on the interior parts of caps. In Miyagi and Yakushima Is., no Collembola showed preference for *S. ohshimae*. *Ceratophysella denisana*, which is distributed widely, and *Ceratophysella cf. horrida* never showed preferences for *S. ohshimae*. *Morulina alata* fed on *S. ohshimae* in Akita, Sado Is., Toyama, and Oki Is., but did not show strong preferences. *Ceratophysella* sp. 3 preferred *S. ohshimae* in Shizuoka and Wakayama, but not in Kochi. These results suggest that the strength and mode of impact of Collembola grazing on *S. ohshimae* varied geographically.

Keywords: *Ceratophysella*, ecological interaction, feeding preference, fungivorous Collembola.

Diversity of Collembola along an altitudinal gradient in montane forests of Southern Far East of Russia: litter vs rotten wood

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Collembolan communities in the litter and rotten wood were investigated in two elevation belts of three mountains of Sikhote-Alin' Range (the Far East of Russia). Two forest belts were represented by mixed forest (MF) with predominating *Pinus koraiensis* (500-600 m alt.) and pure coniferous forest (CF) with *Abies nephrolepis* and *Picea jezoensis* (1000-1300 m alt.). The slopes of Olkhovaya (N 43.32, E 133.66), Oblachnaya (N 43.65 E 134.20), and Ko (N 47.08, E 136.40) mountains were sampled. Five replicate litter and wood samples were taken with a soil corer (D 5.5 cm) from each of six plots. A total of 8,521 Collembola specimens were collected, distributed among 126 species. The species richness of one site was, on the average, 44 (from 36 to 50) in the litter and 34 (from 26 to 43) in the rotten wood. 16 saproxylobiotic species living exclusively in rotten wood were found. Some of them were sporadically very abundant (e.g. *Folsomia najtae* Pot. et al., *Desoria* sp.n.). Other 8 saproxylobiotic species were represented in the litter by only 1-2 individuals in all material under study. 42 species were recorded only in litter and were absent in rotten wood. Spatially organized communities of saproxylobionts were more diversified in samples of wood than in litter-dwellers. Considering the particular species, widely distributed saproxylobiotic and saproxylophilous species (*Proisotoma minima* Abs., *Friesea* complex *claviseta* Axel.) keep a preference to wood in the Far East of Russia. The species of subfamily Neanurinae were not abundant but prefer the rotten wood as common for the most species of this taxon. Differences in species richness (SR) between these two altitudinal belts were not significant for litter, while SR was always higher in MF (lower belt) than in CF (37 vs. 30, on the average) in rotten wood. This study representing three mountain profiles indicate an essential role of rotten wood in the formation of highly diverse collembolan communities in the forests of South Far East of Russia, especially considering mixed forests at lower altitudes. The study was supported by funds of the Chinese-Russian Research Cooperative Program of RFBR (No. 18-54-53032 GFEN).

Keywords: Biodiversity, spatial scale, elevation, East Asia, microsite.

Longitudinal invasions of Collembola within the Palearctic: new data on non-indigenous species

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In the South Hemisphere invasive Collembola has been well documented, especially in more isolated and vulnerable regions (such as sub-Antarctic islands), where native species are thought to be outcompeted by the invasive species. However, predicting the possible invasions within the Holarctic is less well understood. The movement of invasive species between the Palearctic and Nearctic received some attention, while the movement of invasive species at smaller scales between the eastern and western parts of the Palearctic has been weakly documented. Considering the expansion of primarily European species, we recently recorded *Orchesella cincta* in Kamchatka (Far East of Russia, Elizovo, coll. L. Lobkova, new rec.). It is the first record of the species and the genus in the Eastern Asia. *Orchesella cincta* was already claimed to be an introduced species in North America, although the origin of the population from Kamchatka remains questioned. The threat of the expansion of Asiatic species to Europe exists and is possibly much higher than previously thought, as mentioned in an old statement "Siberia in Europe". For example, *Vertagopus asiaticus*, a highly common corticolous species in Eastern Asia, previously unrecorded in Europe, was recently collected by us under loose bark of willow in Losinoostrovsky Park Moscow, Russia. Another possible species with a high risk of a similar invasion is *Parisotoma trichaetosa*, which was already recorded from compost in Finland and pasture near the Moscow region and under single trees along a street in Moscow (coll. N. Kuznetsova, new rec.). *Parisotoma trichaetosa* is a common species in different natural sites of Siberia and Northern Far East. Our new records of these three expansive species and other cases, documented already in the literature on Collembola in Europe and Asia, call for investigation and draw attention to the problem of alien expansions in the Palearctic. The study was supported by funds of the South African-Russian Research Cooperative Program of RFBR (No. 19-516-60002).

Keywords: exotic species, risk assessment, expansion.

Soil Collembola communities along a microclimatic gradient at the entrance of Dobšinská Ice Cave, Slovakia

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The study on soil Collembola was carried out in front of Dobšinská Ice Cave at altitude 969 m a.s.l., Slovak Paradise National Park, in autumn 2016 and spring 2017. Soil samples were taken at three sites along the karst scree slope in 17.3 m transect representing a small-scale microclimatic gradient. The annual mean soil temperature (October 2016 - October 2017) ranged from -0.5 to +4.1°C, from the cave entrance along the transect line up the slope. There was a increase trend in soil moisture and organic carbon content from cold cave entrance to a for-

est site. The vegetation changed from moss on rocks at the cave entrance to the upper forest part of slope (*Fageto-Piceetum*) with herbal cover. The effect of microclimatic gradient and soil-chemical parameters on abundance and diversity pattern of soil collembolan communities was assessed. During both seasons, species numbers and diversity indices of Collembola communities were lowest at cold site near ice cave entrance with lithosol. In spring, relatively similar mean abundances of individuals were recorded at sites along gardient. In autumn, the highest community abundance was observed at the slope site in the middle part of the gradient with well developed organic profile. Cluster analysis (the group average method and the Sörensen (Bray-Curtis)) indicated differences in the structure of Collembola communities, i.e. marked difference was showed between communities at cold site (1) and other two sites (2-3) in both periods, which was related to the different soil microclimate and edaphic conditions. A total of 18 montane species were recorded along the small-scale gradient with a high number and low mean abundance in micro-climatically favourable forest section of the gradient. Among the occupants of this microclimatic gradient, four were Carpathian or Western-Carpathian endemics. Their occurrence highlights the conservation biology value of the cave entrances representing "natural karst gradients". The study was supported by a grant from the Slovak Scientific Grant Agenecy VEGA 1/0346/18 and the Slovak Research and Development Agency APVV-17-0477.

Keywords: Collembola, diversity, cave entrance, karst gradient, soil microclimate.

The role of chemical communication in interactions between collembolan species

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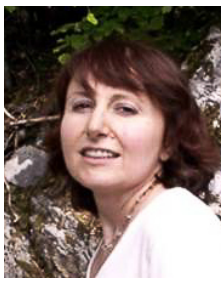

A great diversity of organisms live in the soil and contribute to shaping aboveground biodiversity and to the functioning of terrestrial ecosystems [1]. Interactions between soil organisms are based on the emission and perception of substances that are as diverse as those already well-studied in surface-dwelling organisms. The study of chemical communication between soil organisms needs to be better explored in order to determine the mechanisms that govern the assembly of communities and to understand ecosystem functioning as a whole. Chemical communication in soil invertebrates occurs in a variety of functions, including the clustering of individuals of the same species and of both sexes in a favorable habitat. The molecules inducing this clustering are aggregation pheromones and have already been observed in more than 300 arthropod species belonging to 11 different orders. Although the role of pheromones is devoted to intra-specific interactions, cross-species attractions have been observed, too. Different hypotheses on the evolution of pheromones confront each other to explain these observations: 1) pheromones evolve in a progressive Darwinian fashion, species accumulating small changes in the proportions and structures of chemical components as they diverge 2) the evolution of pheromones occurs by major abrupt changes ("saltatory changes") While the composition of aggregation pheromones is well-known in many insect orders, it is almost unknown in Collembola, which are one of the most abundant soil arthropod groups (20,000 to 400,000 ind./m²). The presence of aggregation pheromones has been previously demonstrated in 16 species belonging to 3 out of 4 orders of Collembola and only one case of cross-attraction has been observed. Using attraction experiment to a substrate conditioned by Collembola, we observed two new cross-species attractions and one repulsion (between the more distant species), the five other tested interactions being neutral. A distance phylogenetic tree was created including the abovementioned species (among others). Our first results support the

hypothesis that the sensitivity to pheromone aggregation of other species decreases gradually with molecular phylogenetic distance in Collembola. However, these results will have to be consolidated by testing interactions between more species, allowing the construction of a distance matrix. Our exploratory work allowed us to develop for the first time a protocol allowing to collect volatile molecules emitted in the environment by Collembola. This protocol allowed us to approach the identification by mass spectrometry of one molecule released by the collembolan *Heteromurus nitidus*, supposed to be a component of the aggregation pheromone. The role of this molecule as aggregation pheromone remains to be tested.

Keywords: Aggregation, pheromones, Collembola, chemical communication, phylogeny.

Assessment of Protura response to soil contamination within urban environment

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Urban areas by increasing of habitat fragments modified by human activities and changing biochemical properties of urban soils threatens biodiversity of soil microarthropods. Soil contamination, including heavy metal concentration, has impact on their distribution pattern and community structure. Nonetheless, soil proturans, the poorly know taxonomic group of soil invertebrates, have generally been neglected and did not explored in urban environment. We assessed Protura communities within urban patches in the city centre of Warsaw, Poland which were classified to four types of urban patches: forests, park lawns with tree, street lawns with tree and street lawns without tree. Twenty five locations during two years were examined across urban area. Our research hypothesis was that soil contamination and type of urban patches could modify Protura communities. The main objectives of the study were 1) evaluate influence of the environmental factors such as soil pH, moisture, fertility and heavy metals concentration on the diversity and distribution pattern of Protura communities; 2) whether urban habitat type determined Protura community composition. Our results showed that urban habitat type identify a predictable and explainable percentage of variation in species composition of Protura communities in urban environment. Protura did not react significantly to varying environmental soil conditions, including heavy metal concentration. However, species-specific response to soil conditions changes, such as soil pH, moisture, total carbon, nutrients content and heavy metals concentration were observed. We conclude that differences among urban patches, not soil contamination, are of much higher importance in structuring Protura communities in urban environment.

Keywords: Protura, soil microarthropods, heavy metal pollution, biodiversity.

Phylogeny, Phyloecology, Phylogenomics

Phylogeny of Neotropical Seirinae (Collembola, Entomobryidae) based on mitochondrial genomes

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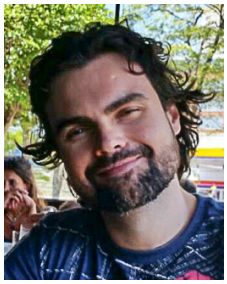

Seirinae Yosii (sensu Zhang & Deharveng) comprises about 220 nominal species in two genera, *Seira* s.l. and *Tyrannoseira*. Even though it is one of the largest subfamilies of Collembola and presents widespread distribution, until now no internal phylogeny of Seirinae was proposed, what leads to difficulties in understanding the evolutionary patterns of its species among themselves and with other Entomobryidae. This study aims to clarify the phylogenetic relationships of Neotropical Seirinae, testing the validity of the subfamily, the status of genera and subgenera and which morphological features hold phylogenetic signal within *Seira* s.s. We used 28 samples of different species of Entomobryoidea, from the following genera and subgenera: *Seira* (*Seira* s.s.) – 11, *Seira* (*Lepidocyrtinus*) – 8, *Tyrannoseira* – 3, *Lepidosira* – 1, *Lepidocyrtoides* – 2, *Entomobrya* – 1, *Lepidocyrtus* – 1 and *Trogolaphysa* – 1. Samples were processed and DNA libraries were built and sequenced using Illumina HiSeq 2000. Whole mitochondrial genomes were reconstructed using MitoZ and MIRA/MITOBim tools. Bayesian phylogenetic analysis was performed using BEAST. Phylogenetic character mapping was studied to *Seira* s.s. species in Mesquite. The final phylogeny was proposed using all 13 mitochondrial protein coding genes. Our results confirm: *Lepidosira*-group, represented in this study by *Lepidosira* and *Lepidocyrtoides*, belongs to Entomobryinae, not *Seirinae*; and the monophyly of Seirinae was recovered and its internal relationships were *Lepidocyrtinus* + (*Tyrannoseira* + *Seira* s.s.). Concluding, we also verify the macrochaetae formula of the first abdominal segment in *Seira* s.s. holds high phylogenetic signal and it is reassured as an important diagnostic character within the group.

Keywords: Entomobryoidea, evolution, *Lepidosira*, group, Next Generation Sequencing, *Seira*, *Tyrannoseira*.

Colour patterns and genetic distances within *Morulina gilvipunctata* (Collembola: Neanuridae)

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Morulina gilvipunctata (Collembola: Neanuridae) features yellowish dots or bands on a dark blue dorsum. Three subspecies (*M. gilvipunctata gilvipunctata*, *M. gilvipunctatapricipalis*, and *M. gilvipunctata irrorata*) have been previously described from Japan, based on differences in colour patterns. The diagnostic validity of colour pattern in the Collembola has been challenged, but this has not been examined in *Morulina*. Here, we report four addition-

al *M. gilvipunctatacolour* patterns, and explore whether such patterns are diagnostic of *M. gilvipunctatasubspecies*. Specimens of *M. gilvipunctatawere* obtained from Niigata, Tokyo, Shizuoka, and Nagano (four sites in Japan). Specimens of *M. gilvipunctata gilvipunctata*, *M. gilvipunctatapricipalis*, and *M. gilvipunctata irroratawere* collected from the type localities. We evaluated the associations between colour patterns and molecular variations in the mitochondrial cytochrome coxidase I gene and mitochondrial 16S ribosomal RNA gene. We recognised a total of seven colour patterns. Only one form was evident at each locality. Genetic distances were closer within the same patterns than among different patterns. Therefore, we suggest that each colour pattern reflects genetic differentiation and can be used to diagnose M.gilvipunctatasubspecies.

Keywords: Collembola, colour pattern, *Morulina*, Neanuridae.

Phylogenetic relationships within the Subfamily Neanurinae (Collembola: Neanuridae) with emphasis on the tribe Sensillanurini

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The Sensillanurini tribe is structured by five genera including *Americanura* with 24 species, *Palmanura* with 22 species, *Sensillanura* with 7 species, *Tabasconura* and *Honduranura* both monotypic. The quetotaxia in collembola is very particular since each seta has a specific place along the body. Also, these setae can be ordinary, sensilas, scales, trichobotrias or even present a very diverse morphology. All of them have been used for diverse phylogenetic analyzes in the different orders. The results show that collembolans are particularly diversified in the Poduromorpha order; this quetotaxia is reduced and varies according to the structure in which they are found. For example, in the Sensillanurini tribe, antennal chaetotaxy is one of the most important feature since the distribution of these setae, as well as their number, play an important role for the location of the Sensillanurini tribe within the subfamily. The main goal of this study is to locate the Sensillanurini tribe within the subfamily, as well as comfirm its monophyly, several species from the different tribes that make it up were included, as well as all the species that make up the tribe. In this analysis, also several species that are part of the Neanuridae family were taken into account as external groups. We used 148 morphological characters for the data matrix, inferred from external morphological structures belonging to 77 taxa, where 14 of them are binary characters and the rest 134 are multi-state characters. Based on the obtained evidence and the taxa used in this work, there is no support to recognize the tribes as they are defined. This means that it is difficult to establish which of them are the evolutionary closer to Sensillanurini, which in turn, is not solved either as monophyletic. Paranurini, Neanurini, Morulodini and Lobellini, are included in a closer clade which contains most of the genera of Sensillanurini that is supported by a combination of characters that could finally be interpreted as synapomorphies such as the cephalic seta "C", the form of the macroseta present in the tubercle Sc and the number and shape of the microsetae in the Dorso lateral tubercles of the abdomen IV. Paleonurini tribe and most of the species of the *Sensillanura* genus the further evolutionarily, except for the *S. austriaca* species, which is located in a clade closer to Sensillanurini. We also suggest that the *Tabasconura* genus could be a morphological variant of *Americanura*. *A. prima* could be a species that presents plesiomorphic characters. This result tentatively could establish a different genus that also belongs to the Sensillanurini tribe.

Keywords: Sensillanurini, phylogeny, morphology.

Signal through the noise? Phylogeny of the tribe Neanurini (Neanurinae).

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The Neanurini represents one of the most diverse lineages in the subfamily Neanurinae. The tribe consists of 23 genera and more than 200 described species, mainly distributed in the northern hemisphere, and one of them, Neanura muscorum Templeton, 1836, has a cosmopolitan distribution. Despite their broad distribution and diversity, the phylogeny of this tribe remains poorly known.

Here, we present the quantitative phylogenetic analysis of the tribe based on morphological data. The goals of our work were to: (i) evaluate the monophyly of currently recognized genera; and (ii) assess the strength of the phylogenetic signal of morphology in defining major Neanurini clades and their relationships, despite the great degree of morphological homoplasy in the tribe.

Cladistic analyses were conducted using 78 morphological characters scored for 39 species belonging to all genera. All characters were analyzed as unordered and equally weighted. External groups were represented by five taxa (*Bilobella carpatica*, *Oregonanura cascadensis*, *Morulodes serratus*, *Sensillanura austriaca*, *Paralobella breviseta*) belonging to the remaining Neanurinae tribes. The parsimony analyses were conducted in TNT using both equal and implied weighting. Heuristic searches resulted in single most parsimonious tree arranged in a three main clades. The phylogeny supports the following main conclusions:

(i) The genera *Caucasanura*, *Catalanura*, *Kalanura*, *Protanura* and *Pumilinura* were recovered as para- or polyphyletic groups. Their position and relationships change depending on the analysis (equal and implied weighting under different k-values), but they do not form monophyletic groups on any of the cladograms obtained.

(ii) The genera *Cryptonura* and *Endonura* were discovered as poorly defined. The members of these two genera are never clustered together. In the analysis under equal weights, *Cryptonura* is positioned on the basis of the cladogram, while in the analysis under implied weights it forms a sister group for *Persanura* within the clade B.

(iii) Although the main aim of the study was not to analyze the monophyly of the tribe because of the insufficient representation of external groups, it should be noted that the tribe Neanurini was not recovered in our study as monophyletic, because three out of five taxa used as external groups were nested within the representatives of Neanurini.

Keywords: Neanurini, phylogeny, morphology.

Phylogenomics of Collembola from low-coverage whole-genome sequencing

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Collembola (springtails), having unique morphological characteristics, is widely distributed in terrestrial ecosystems. It is one of the key groups in understanding the evolution of arthropods and the origin of hexapods, and is of important systematic values. The current four-order classification system is still controversial, with the monophyly and systematic status of several important groups unclear. Molecular studies based on multiple genes did not give a fully resolved phylogeny. Small body size of collembolans also impedes the application of popular phylogenomic next-generation sequencing (NGS) techniques. The study plans to extract a large number of phylogenomic markers from low-coverage whole-genome sequencing, to reconstruct the phylogeny of Collembola using multiple types of molecular markers, i.e. mitogenomes, single-copy nuclear genes and ultraconserved elements (UCEs). Our preliminary result has recovered the phylogeny of Collembola as Neelipleona + (Poduromorpha + (Entomobryomorpha + Symphypleona)) and most previous disputed nodes are resolved here.

Keywords: genomic data, revision, taxonomy, Collembola.

Taxonomy, Faunistics

MSS Collembola of the Sierra de Guadarrama National Park (Spain)

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An intensive sampling in the Colluvial Milieu Souterrain Superficiel (Mesovoid Shallow Substratum, or MSS) (Juberthie et al., 1980) of the Sierra de Guadarrama using Subterranean Sampling Devices (SSD) (Ortuño et al., 2013) was developed as part of a research project supported by the Spanish Ministry of Agriculture, Food and Environment-National Parks Autonomous Agency (http://www.mapama.gob.es/es/parques-nacionales-oapn/), SPIP2014 01143. The sampling was done in the eastern half of the Central System (Iberian Peninsula) in the mountainous subunit called Sierra de Guadarrama, within the limits of the protection area (33 960 hectares), declared as national park a few years ago (BOE, 2013). The lower altitudinal limit for the sampling was 1375m a. s. l. (above sea level), and the highest limit was located at the 2301m altitude, near the summit of Peñalara. The geology of the area is characterized by rocks of different origins, but the lithological substrate is mostly comprised of gneiss metamorphic rocks with a certain tendency to fracture and form morrenic and colluvial deposits

(glacial and peri-glacial events), forming most of the scree-talus of the area in which up to 33 traps (SSD) were placed. The data were obtained from the first extraction of the traps between May and October of 2015. During a study of the Collembola taxon, 31 genera and 55 species (12 new species) were identified. The highest representative genus presence in almost all traps was *Orchesella*, with two new species (Baquero et al., 2017). This study has demonstrated that the Colluvial MSS has a particular Collembola species composition, supporting that it should not be considered as a mere ecotone between the surface and the deep subterranean ecosystems, but as a properly differentiated habitat.

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Keywords: Collembola, MSS, differentiated habitat, subterranean ecosystem.

Two new species of *Temeritas* (Collembola, Sminthuridae) from Brazil, with comments on the genus

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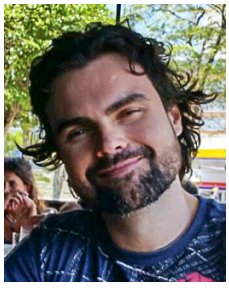

Temeritas Richards (Sminthuridae) currently holds about 40 species described mostly from tropical regions, 10 of them from the neotropics. The genus is characterized mostly by species with very long antennae, subequal or longer than body length, with fourth antennal segment highly subdivided, usually with more than 20 segments. Here we present two new species of the genus from Brazilian northeastern region: *Temeritas* sp. 1, similar to other neotropical taxa such *T. amazonensis* Arlé & Oliveira and *T. caatingae* Arlé & Oliveira in having long chaetae over body, clypeal area of head and second and third antennal segments; and *Temeritas* sp. 2, the sole species of the genus with fourth antennal segment subdivided in 18–19 segments, absence of long chaetae on head and antennae, and lacking mucronal chaeta. The study of detailed morphology of both species let us to divide neotropical Temeritas in two groups: macroceros-group or *Temeritas* stricto sensu holding more typical species of the genus as *Temeritas* sp. 1; and *ormondae*-group with *T. ormondae* Arlé & Oliveira and *Temeritas* sp. 2, both more similar to *Pararrhopalites* Bonet & Tellez. Our observations suggest *Temeritas* maybe a para or polyphyletic group of Sminthurinae.

Keywords: Brazilian springtails, detailed chaetotaxy, *Pararrhopalites* Bonet & Tellez, Sminthurinae, Symphypleona, taxonomy.

Diversity and distribution of Romanian Carpathian springtail fauna

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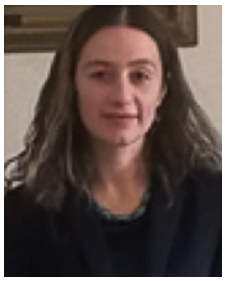

In recent years there has been increasing recognition of the importance of the Carpathians in the evolution of the biota within the European Alpine System. The Carpathian Mountains form the largest European mountain range and pass through Austria, Czech Republic, Slovakia, Poland, Hungary, Ukraine, Romania, and Serbia. Their geographical position, extent, isolation, landscape heterogeneity, well-preserved environment, and relatively low impact of Quaternary glaciations make them an important region for studies on European biodiversity and biogeography. Our study will have a considerable contribution to the advances in the distribution patterns and species richness including endemism of Collembola group. Analyses of endemism and the identification of so-called 'biodiversity hotspots' (endemism and threat) have an importance for conservation. These can be conceptually identified either because they have a high number of endemic species with restricted distributions (areas of micro-endemism) (Carrara & Flores, 2013), or because they have high species richness (hereafter, hotspots) (Pascual et al., 2011). Springtails are among the most abundant soil-dwelling arthropods with densities up to several hundred thousand individuals per square metre in forest soils. Studies on springtail ranges size for invertebrate taxa are still scarce. Our recent studies on the range size of Colembola across Europe (Fiera et al., 2017) and the fact that previous studies showed how collembolan distribution can be determined both by broad zoogeographical factors and local ecological conditions (Ávila-Jiménez & Coulson, 2011) make them an ideal candidate group for studies on range sizes. Romanian Carpathians host a unique variety of soil and cave Collembola, many of which are rare, vulnerable or threatened. More than 430 species have been described from Romania and more than 300 of these species occur in Romanian Carpathians. Species of restricted range size are of ecological interest. Improved understanding of the factors that restrict range sizes and sufficiently precise models to foresee changes in the spatial distribution of rare species are therefore indispensable tools in biodiversity forecasting and conservation management. The current geographical distribution of Collembola species reflects not only the ability of a given species to survive specific environmental conditions but also the ability to have successfully colonized a habitat once the appropriate niche became available (Ávila-Jiménez & Coulson, 2011).

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Keywords: biogeography, species distribution, Collembola, Romanian Carpathian Mountains, endemic species.

Biogeographical and ecological insights from Australasian faunas: the megadiverse collembolan genus, *Entomobrya* (Entomobryidae)

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Australian Collembola belonging to the genus *Entomobrya* are common and widespread but have not been studied for 80 years. We are describing 38 new species all of which have been found anywhere else making the genus the most species rich of any collembolan genus in Australia and highly endemic. Some species are only found on mountain tops and others in saline habitats that are at risk from climate change and rising sea levels respectively. None are found arid and semi-arid regions nor on subantarctic islands. The five introduced exotic species are only found in pastures and on arable land and may be of economic significance. The ecological contribution these species make to ecosystem integrity is through their contribution to decomposition of plant residues and so recycling nutrients through the soil and leaf litter systems.

Keywords: New species, redescriptions, chaetotaxy, colour patterns, phylogeny.

New records of Entomobryomorpha (Collembola: Hexapoda) for Iranian fauna

(poster cancelled)

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The results of Collembola fauna are much poorer in Lorestan Provinces (west of Iran). In this study 13 different habitat types and 37 sampling areas of Lorestan province (Western Iran) were selected for studding on Collembolan's fauna during 2016-2017. Totally, 24 species of springtails from 18 genera and 8 families were recorded in this study. The species *Ceratophysella cf. borealis*, *Desoria neglecta*, and *Dicyrtoma grinbergsi* are new record for the Iranian fauna. Also three genera; *Pseudachorutes*, *Xenylla* and *Anurophorus* with the species *Anurophorus coiffaiti*, *Ceratophysella gibosa*, *Sphaeridia pumilis* and *Dicyrtoma ghilarovi* are new for the west part of Iran.

Keywords: Lorestan province, Collembola, *Ceratophysella cf. borealis*, *Desoria neglecta*, *Dicyrtoma grinbergsi*.

Preliminary report of Protura from Northern India

(poster cancelled)

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Protura are very rare entomofauna for entomologist and zoologist because of their deep dwelling habits in the pedoecosystems. Therefore, this group is always neglected and poorly searched by the entomologist and zoologist in the northern region of the country. They are very fragile, white coloured, eyeless, cylindrical, lack of antennae and primarily wingless group of Hexapod having anamorphosis with 12 segmented abdomens. It is very least studied group from India. Hence, an attempt was made to search this group of fauna from different pedoecosystem viz. bamboo grove, mango orchard and natural ecosystem of teak plantation from the Varanasi, India during 2007 and 2008 and fauna were explored by modified Tullgren's funnel technique and identified as Protura of Acerentomidae family. The fauna were photographed with the help of Leica MZ16 microscope mounted with Leica DFC 290 camera. The result reveals that bamboo grove and mango orchard soil harboured the proturans fauna comparatively higher to lower relative abundance respectively. Literatures are justified that this is the first coloured photographic report from India instead of Lucida drawing. Present information focusing on the distribution of fauna in the different pedoecosystems which need more research on its threats to diversity and functional role.

Keywords: India, Acerentomidae, pedoecosystem, Varanasi, Protura.

The fauna of springtails (Collembola) from the forest ecosystems of Iran.

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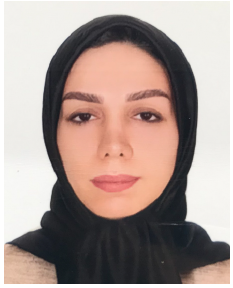

Collembola (Hexapoda) fauna of parts of Hyrcanian forest in North of Iran, Mazandaran povince was studied during 2016. Sampling was done from soil and leaf litter. Then springtails were extracted by Berlese funnel. Totally, 18 genera and 2 species belonging to 10 families were collected which 14 species were identified. Of them the genus *Pogonognathellus* (Tullberg, 1871) and two species *Pogonognathellus* sp. cf. *flavescens* (Tullberg, 1871) and *Arrhopalites* sp. gr. *principalis* (Stach, 1945) are recorded for the first time from Iran. Also four new species are recorded for the first tine from Mazandaran including: *Entomobrya cf. schoetti* Stach, 1922, *Entomobrya corticalis* (Nicolet, 1841), *Entomobrya nigrocincta* Denis, 1923 and *Arrhopalites* sp. gr. *caecus* (Tullberg, 1871).

Keywords: Hyrcanian forest, Iran, Collembola.

Review

Historical & global scale catalogue of Collembologists (1722 - 2017) - I & II

Jean-Marc Thibaud (1)

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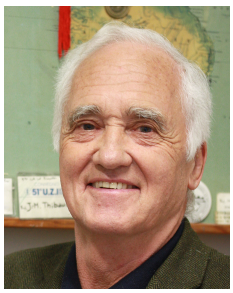

From 1722 to 2017, we have counted and taken into consideration, 14 253 publications on Collembola (springtails), including collaborations, published by 1 351 authors from 68 different countries. We can give an estimation, collaborations not included, of 7 500 to 8 000 publications by these authors.

Keywords: Collembola, bibliography, history.

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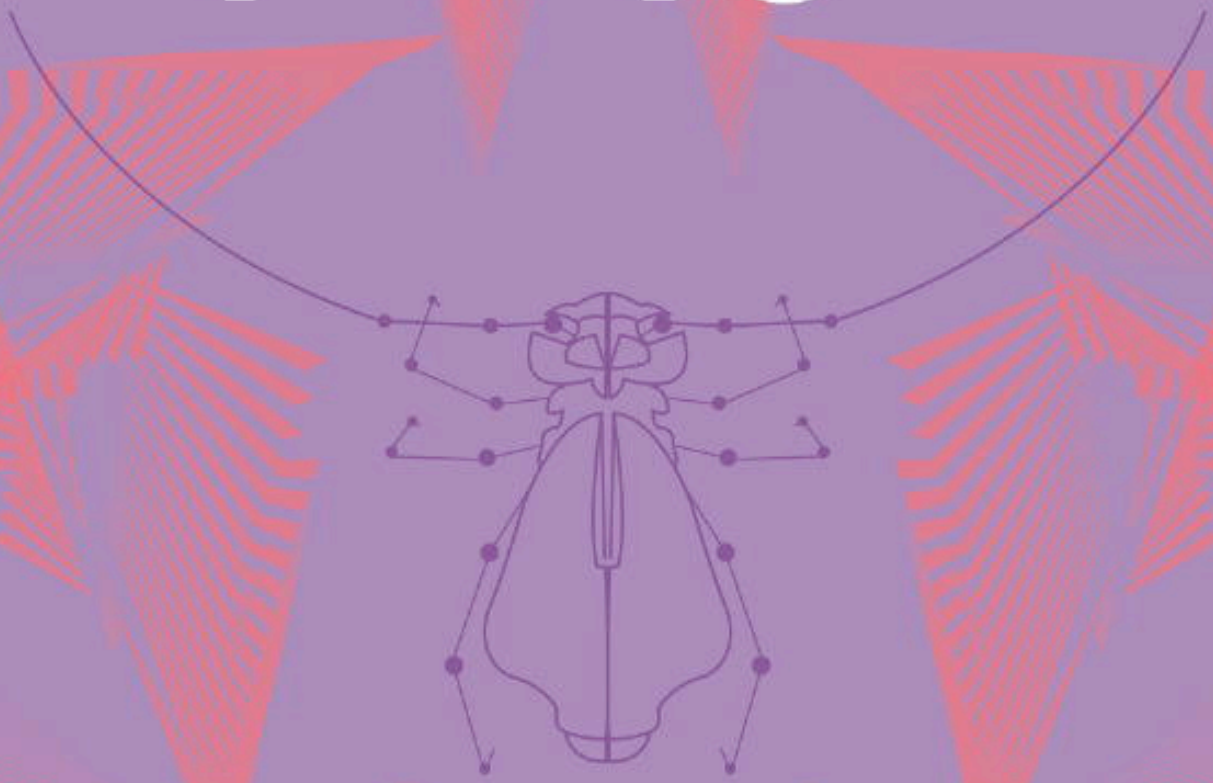

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