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17th International Congress of Myriapodology

23-26 July 2017
Maritime Park & Spa Resort
Krabi, Thailand

Abstract


ANIMAL
SYSTEMATICS
RESEARCH
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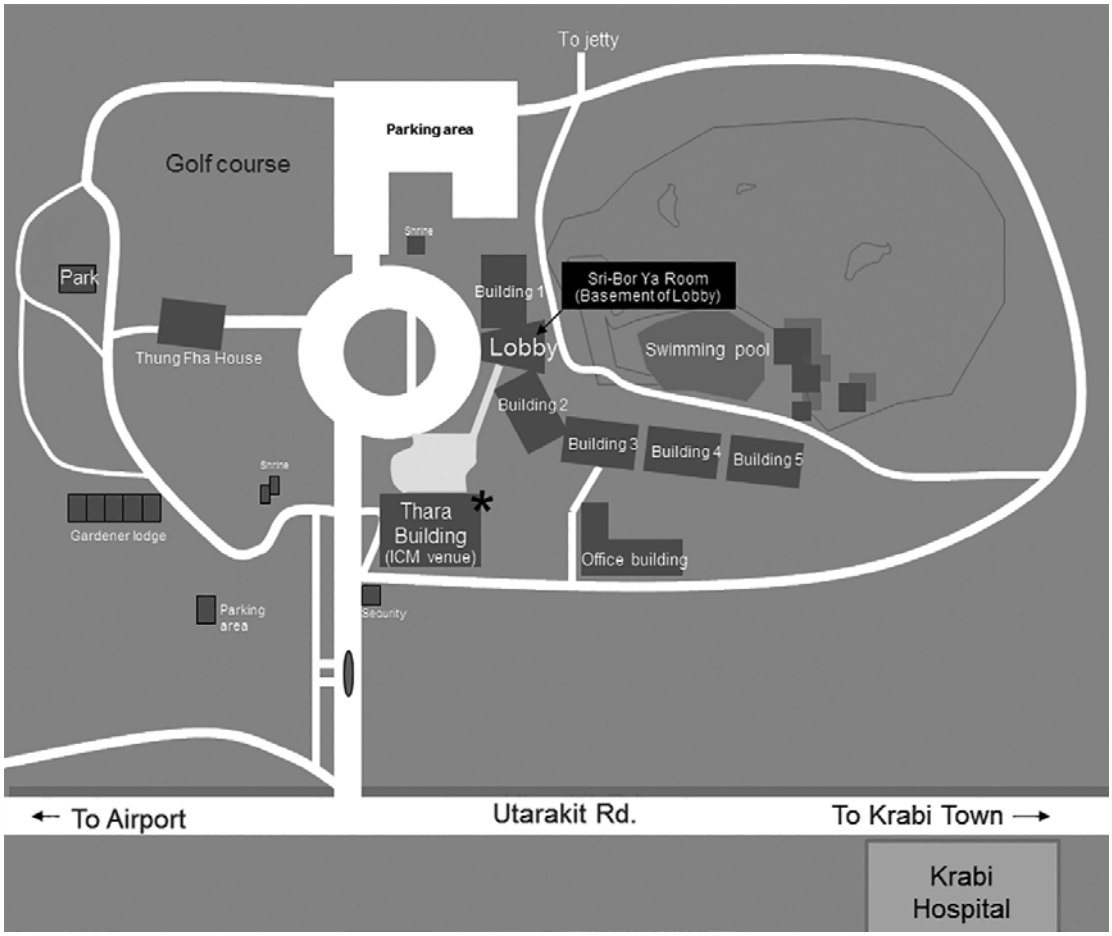
INTRODUCTION TO ICM

The International Congress of Myriapodology (ICM) aims at the interpretation of scientific knowledge about Myriapoda and Onychophora, which include diplopods, pauropods, symphylans, chilopods and onychophorans. Participants are not limited to experts and specialists but also include researchers from other relevant fields as well as amateurs from several communities who are interested in these spectacular animals. Diverse topics of presentation and discussion are encouraged, exploring the latest findings on myriapods and onychophorans at both global and regional scales. The goal is to build on research connections across the scientific community that has been forged since the first ICM in Paris in 1968. Up to date, the previous congresses have been regularly attended by participants from more than 30 countries around the world.

CONFERENCE VENUE

Maritime Park & Spa Resort, Krabi



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CONFERENCE PROGRAM

Saturday, 22 July

Registration starts from 16.00 to 19.00. The welcome party will take place in the Sri-Bor Ya Room starting from 18.00 – 22.00.

Sunday, 23 July

Registration starts from 8.00 to 9.00. The opening ceremony and plenary lectures start from 9.00 to 17.00 at the conference venue, Thara Room. Poster setup will be 17.00 to 18.00 at the conference venue, Thara Room.

Monday, 24 July

The plenary lectures start from 8.30 to 16.20, and the poster session starts from 16.20 to 18.00 at the conference venue, Thara Room.

Tuesday, 25 July

Excursion for participants who have made bookings with Krabi Maritime Resort Agency.

Wednesday, 26 July

The plenary lectures, CIM general assembly and closing ceremony of the 17th ICM Congress start from 8.30 to 17.00, and the farewell dinner starts from 19.00 – 22.00 at the conference venue, Thara Room.

Note: Lunch will be served in the Sri-Bor Ya Room.

CONFERENCE SCHEDULE

International Congress of Myriapodology
Maritime Park & Spa Resort, Krabi, THAILAND, 23-26 July 2017

Date and Time	Activities	Venue
Saturday, 22 July 2017		
16.00 – 19.00	Registration desk opening (Round 1)	Sri-Bor Ya Room
18.00 – 22.00	Welcome party	
Sunday, 23 July 2017		
08.00 – 09.00	Registration desk opening (Round 2)	Thara Room
09.00 – 09.40	Opening ceremony and Introduction	
09.40 – 10.30	Ten Years of Fascinating Myriapodology Research…Our Continuing Insight into the Great Biodiversity	
10.30 – 10.50	Coffee break	
10.50 – 12.10	Plenary lecture 1	
12.10 – 13.00	Lunch	Sri-Bor Ya Room
13.00 – 15.00	Plenary lecture 2	Thara Room
15.00 – 15.20	Coffee break	
15.20 – 17.00	Plenary lecture 3	
17.00 – 18.00	Poster setup	
Monday, 24 July 2017		
08.30 – 10.10	Plenary lecture 4	Thara Room
10.10 – 10.30	Coffee break	
10.30 – 12.10	Plenary lecture 5	
12.10 – 13.00	Lunch	Sri-Bor Ya Room
13.00 – 14.40	Plenary lecture 6	Thara Room
14.40 – 15.00	Coffee break	
15.00 – 16.20	Plenary lecture 7	
16.20 – 18.00	Poster session	
Tuesday, 25 July 2017		
08.00 – 16.00	Excursion	
Wednesday, 26 July 2017		
08.30 – 10.30	Plenary lecture 8	Thara Room
10.30 – 10.50	Coffee break	
10.50 – 11.50	Plenary lecture 9	
11.50 – 13.00	Lunch	Sri-Bor Ya Room
13.00 – 15.00	Plenary lecture 10	Thara Room
15.00 – 15.20	Coffee break	
15.20 – 17.00	General Assembly & Closing Ceremony	
19.00 – 22.00	Farewell dinner	

ORAL PRESENTATION & ACTIVITY PROGRAMS

SATURDAY 22 JULY 2017 (Sri-Bor Ya Room)

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16.00 – 19.00	**Registration round 1** (front desk at Sri-Bor Ya Room)	
18.00 – 22.00	**Welcome party**	

SUNDAY 23 JULY 2017 (Thara Room)

08.00 – 09.00	**Registration round 2**	
09.00 – 09.30	**Opening ceremony**	
09.30 – 09.40	Introduction **Somsak Panha**	
09.40 – 10.30	Ten Years of Fascinating Myriapodology Research…Our Continuing Insight into the Great Biodiversity **Somsak Panha, Piyatida Pimvichai, Natdanai Likhitrakarn and Warut Siriwut** …….…….	**1**
10.30 – 10.50	**Coffee/Tea**	
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11.30 – 11.50	Who Profits from Global Warming? Effect of Increased Temperature on Behaviour of Millipedes **Ivan Hadrián Tuf and Jana Smolová** ……..…..…	**4**
11.50 – 12.10	Does Colouration Matter? Taxonomical Comparison of *Xystodesmus* and *Riukiaria* Millipede Species (Diplopoda: Xystodesmidae) **Zoltán Korsós** ……..…..……	**5**
12.10 – 13.00	**Lunch**	
13.00 – 13.20	Three *Lophoturus* Species (Lophoproctidae, Diplopoda) Were Found in Far North Queensland, Australia; Should They Be Identified As Cryptic or Be Considered As Different Species Based on the Definition of Genus *Lophoturus*? **Cuong Huynh and Anneke Veenstra** ……..……..	**6**
13.20 – 13.40	Pacific Island Polyxenida **Megan Short** ……..…….	**7**

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14.00 – 14.20	An Updated Checklist of the Myriapods (Myriapoda) Recorded in Mainland France, Corsica and Monaco	
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14.20 – 14.40	Review of the Holarctic Family Anthroleucosomatidae (Diplopoda, Chordeumatida)	
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	Note: Not included in registration fee

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ORAL SESSION

Ten Years of Fascinating Myriapodology Research…Our Continuing Insight into the Great Biodiversity

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Since Malacology became our research specialty in 1987, over these past 30 years our research on their biodiversity in Thailand has resulted in more than 500 land snail species being identified with 121 newly described species, together with five new genera and one new family. The RIO Summit on biodiversity, and the birth of the Convention on Biological Diversity in 1993 awakened people, including governmental instances, all over the world to start becoming involved with biodiversity conservation and sharing its benefits. The Biodiversity Research and Training Program was established in Thailand in 1995 and originally started funding fundamental research, especially on the taxonomy of all kinds of plants, animals and micro-organisms in Thailand. Thousands of papers were published, even larger numbers of voucher specimens have been deposited and hundreds of young scientists were trained. Since then biodiversity has inspired Thai people, and especially our team, to expand fundamental research in various groups of terrestrial invertebrates such as, earthworms, millipedes, and centipedes. Amazingly, in the 10 years of Myriapodology since 2007 up to now, the Top Ten Awards of Species Exploration have twice been awarded to new species described by our team from Thailand: to "the shocking pink millipede, *Desmoxytes purpurosea* Enghoff, Sutcharit & Panha, 2007" in 2008, and to "the waterfall centipede, *Scolopendra cataracta* Siriwut, Edgecombe & Panha, 2016" in 2017. This is in no small part due to the great three myriapodologists, Professors Henrik Enghoff (Copenhagen), Sergei I. Golovatch (Moscow) and Gregory D. Edgecombe (London), who have devoted so much of their time and inspired young Thai scientists to advance this field of science in Thailand. So far, 193 millipede species have been identified with 76 species new to science (mainly from the orders Glomerida, Polydesmida and Spirostreptida). In contrast, of the 47 centipede species recorded in Thailand, only three appeared to be new to science (order Scolopendromorpha). These results are based on a combination of detailed morphological studies and up to date molecular phylogenetic analyses, published in more than 30 research papers. Moreover, relying on our in depth systematic knowledge, a multidisciplinary research on the venoms of centipedes, involving experts in chemistry, biochemistry and pharmacology, has been launched with the aim to improve current insights in the phylogeny and evolution of the venoms so that this information can eventually lead to various biomedical applications.

KEYWORDS: Southeast Asia, Myriapoda, biodiversity, new species

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From Six Legs to Almost a Thousand – The Postembryonic Development of Millipedes

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A review is given of anamorphosis, the process by which millipedes develop from (mostly) hexapod first stadium juveniles to multi-legged adults (and even beyond). The talk is based on a previous review paper (Enghoff, H., Dohle, W. & Blower, J.G. 1993. Anamorphosis in millipedes [Diplopoda] – the present state of knowledge with some developmental and phylogenetic considerations. – Zoological Journal of the Linnean Society 109: 103-234). The distinction between euanamorphosis, hemianamorphosis, and teloanamorphosis is explained, as well as the enigmatic phenomenon of periodomorphosis – the return to an "immature" stadium following full maturity. Special emphasis is placed on new insights gained during the almost 25 years since the previous review paper, including the "rule-breaking" genus *Dobrodesmus* Shear et al., 2016, the significance of trans-segmental colour patterns, as well as a recently discovered pattern of missing defense glands and its bearing on anamorphosis.

KEYWORDS: Diplopoda, anamorphosis, periodomorphosis, phylogeny

Evolution of Bioluminescence in Sierra Luminous Millipedes (Polydesmida, Xystodesmidae)

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Bioluminescence in the order Polydesmida is a novelty limited to the genus *Motyxia* Chamberlin, 1941. These millipedes emit a blue-green light that can be seen in darkness. The luminescence functions as an aposematic (warning) signal, alerting nocturnal predators of the millipede's noxious chemical defenses. While the light is known to be generated by a photoprotein, the identity and homology of the protein is uncertain. Light has a single evolutionary origin in the common ancestor of *Motyxia*; however, the circumstances of this evolutionary innovation are unknown. Why nocturnal aposematism evolved in *Motyxia* and not in Appalachian xystodesmid species is uncertain but may be a result of different predator assemblages. Here I show that both instances of aposematism (diurnal and nocturnal) are accompanied by similar phenotypic changes, including larger cyanide defense glands and greater overall conspicuousness. These results demonstrate how nocturnal aposematism evolved in *Motyxia*, and differs from the previous knowledge that luminescence is not associated with predator warning. Aposematism in Xystodesmidae is a useful system to study the evolution of warning coloration because it represents two replicated origins of the same function.

KEYWORDS: millipede, *Motyxia*, phylogeny, bioluminescence, aposematic

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Who Profits from Global Warming? Effect of Increased Temperature on Behaviour of Millipedes

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It is very difficult to predict changes in communities caused by global warming, because reaction of different species can be species-specific. This study is aimed to effect of increased temperature on behavior of two species of millipedes. We compared behavioural response of native forest species *Leptoiulus proximus* (Němec, 1896) and invasive non-native species *Cylindroiulus caeruleocinctus* (Wood, 1864), which is now common in urban ecosystems. During 10-days laboratory investigations at start of summer (June) and its end (August) we registered behavioural acts and activity of both species at natural temperature and artificialy increased temperature. The temperature was grossed up about 2–4°C compared to mean of control temperature 16–18°C. Behaviour of both species was affected by increased temperature. At general, *L. proximus* was less active at end of summer, but on its start increased temperature decreased its activity. By contrast, behaviour of *C. caeruleocinctus* was not affected by increased temperature in June, but only in August. Despite less active millipedes, increased temperature did not caused increased mortality during those 10-days experiments. Better surviving of invasive *C. caeruleocinctus* and its infiltration into natural ecosystems in near future seems to be presumable.

KEYWORDS: Diplopoda, Julidae, *Cylindroiulus caeruleocinctus*, *Leptoiulus proximus*, activity, climate changes

Does Colouration Matter? Taxonomical Comparison of *Xystodesmus* and *Riukiaria* Millipede Species (Diplopoda: Xystodesmidae)

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The colour pattern of the millipede body, especially in the case of the blind polydesmidans, is usually not regarded by taxonomists as a primary distinguishing character. In this respect, the family Xystodesmidae seems to present an exception: there are many colourful species, and their taxonomy, with special emphasis on North American species, has been extensively investigated and illustrated.

Xystodesmid millipedes are also widespread in East Asia and, with a few exceptions, little attention was paid to their colourful appearance. During my three years study on the millipede fauna of the Ryukyu Archipelago, I have collected myriapods on more than 50 islands. Here I focus on two genera: *Xystodesmus* and *Riukiaria* which have a rather similar morphology in classic gonopodal traits.

Fifteen species of *Xystodesmus* (nine new) and 33 species of *Riukiaria* are compared, both in terms of male gonopod structure and live colouration where fresh samples could be collected. As opposed to the simple, bifurcated, forceps-like gonopod scheme observed in most species of *Riukiaria*, *Xystodesmus* species usually have a slightly more complicated gonopod with additional branches and appendages. In addition, there is a tendency in body size difference between the two genera, as well as some other morphological differences, like presence or absence of metatergal tubercles, and rounded or acute posterolateral corners of paranota. However, variability is high in the two closely related genera, and assignment of alcohol specimens to the appropriate genus based purely on these traits is often remarkably difficult.

With the experience of field observations of hundreds of live specimens of these xystodesmids, I have noted a small set of colour characters which are quite stable and seem to correspond to the generic assignment. These are: uniform brownish, greyish or yellowish tergal colouration with lighter paranota, always with bright orange, pale yellow or whitish spots on paranota, white legs and antennae in *Xystodesmus*; whereas bright orange, yellow or dark metallic, greenish tergal colouration often with dark spots or transversal bands, coloured or dark legs and antennae, and never with orange paranotal spots in *Riukiaria*.

In order to support the stability of these colour patterns to the two genera, we carried out a preliminary DNA-analysis as well, and with two, yet unexplained exceptions the maximum likelihood tree corresponds well to the observations. In conclusion, I strongly recommend to record and carefully describe the live colour pattern of East Asian xystodesmid species before assigning them to the appropriate genera.

KEYWORDS: colour pattern, Xystodesmidae, East Asia, Ryukyu Archipelago

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Three *Lophoturus* Species (Lophoproctidae, Diplopoda) Were Found in Far North Queensland, Australia; Should They Be Identified As Cryptic or Be Considered As Different Species Based on the Definition of Genus *Lophoturus*?

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Genus *Lophoturus* Brölemann, 1931 (Lophoproctidae, Diplopoda) is defined by the following characteristics: 0 to 4 pairs of linguiform processes on each side of median cleft of labrum and antennal article VI with 3 thick sensilla. *Lophoturus queenslandicus* Verhoeff, 1924 was the first eyeless penicillate millipede collected from a tropical region - Cairns, Australia that was formally described. Specimens from this region had similar taxonomically important morphological characters. However, their body form and length, as well as dorsal colour and patterning proved to be different, suggesting the presence of more than one *Lophoturus* species. This assertion was supported by results of a phylogenetic analysis of DNA extracted and sequenced using 18S and COI regions from the three species. Specimens of *Lophoturus* preserved in ethanol can prove difficult to confidently identify to species level because their colour gradually fades. Examination of live specimens with their body colour visible, together with morphological characters and DNA analysis is the most reliable way of correctly distinguishing between these three species. *Lophoturus queenslandicus* Verhoeff, 1924 is used as the reference species from Cairns region of Australia, and two new species are described.

KEYWORDS: morphological characters, body length, colour, phylogenetic analysis.

Pacific Island Polyxenida

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The Pacific Ocean is scattered with islands of volcanic origin. Millipedes from two families in the sub-class Penicillata, order Polyxenida have been identified from a number of these islands. The pattern of distribution of species is examined with a view to considering how the species arrived on the islands.

KEYWORDS: bristly millipedes, biogeography

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Taxonomic Synthesis of the North American Millipede Genus *Pseudopolydesmus* Attems, 1898 (Diplopoda: Polydesmida: Polydesmidae)

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The millipede genus *Pseudopolydesmus* Attems, 1898 is found throughout eastern North America, and can be separated from other polydesmid genera based on the following: body tan-brown to pink with 20 segments, 16 to 35 mm long, gonopods falcate, acropodite with triangular processes on lateral and medial sides, with a large pulvillus, and lacking an endomere and solenomere branch. The genus has 12 species that are poorly diagnosed, creating confusion for species identification. To remedy this problem, *Pseudopolydesmus* type specimens were examined, museum specimens georeferenced, and newly-collected specimens were studied to resolve geographic ranges and intraspecific morphological variation. Genetic data was extracted from five genes, three mitochondrial (12S, 16S, COI) and two nuclear (28S, EF1α), to examine genetic variation among species. We then estimated a molecular phylogeny of *Pseudopolydesmus* to infer evolutionary history of the genus and to provide a systematic context for the description of new species. We discovered three new species and recognize two species groups: the *serratus* and *canadensis* groups. We propose an ontology of anatomical terms describing the gonopods of the family Polydesmidae to allow easier comparison between genera in future taxonomic and evolutionary studies of this Holarctic family.

KEYWORDS: millipede, *Pseudopolydesmus*, gonopod

An Updated Checklist of the Myriapods (Myriapoda) Recorded in Mainland France, Corsica and Monaco

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The present work and checklist summarise information and knowledge on all the myriapod species (centipedes, millipedes, pauropods and symphylans) recorded in France - including mainland metropolitan France (FR-FRA), Corsica island (FR-COR) and the Principality of Monaco (MC) - three geographical units formally recognised in Fauna Europaea database. The previous lists, catalogues and maps are updated by incorporating published, revised and field data obtained about the myriapod fauna of France s.l., up to the early 2017. Some species of diplopods not previously reported in the literature or databases are also listed with details of records. Altogether, the checklists of myriapods include 150 Chilopoda species, 303 Diplopoda species, 68 Pauropoda species and 18 Symphyla species. Special considerations and discussions related to several species of diplopods are added. This work is a step toward future taxonomic and geographical atlases for Myriapoda in France [INAMYFRA project] as well a contribution to Fauna Europaea.

KEYWORDS: atlas, checklist, Chilopoda, Diplopoda, Pauropoda, Symphyla, France, Corsica, Monaco

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Review of the Holarctic Family Anthroleucosomatidae (Diplopoda, Chordeumatida)

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The Holarctic family Anthroleucosomatidae is one of the most heterogeneous and problematical of families within the class Diplopoda. It is referred to as a "nightmare" in many publications and has served as a "wastebasket" for chordeumatid taxa that could not be relegated to some better defined families. For this reason, the present study is focused on the resolution of complex systematic and biogeographical relationships among representatives of this family. A rearrangement of 35 genera of anthroleucosomatids with a total of 84 species into 12 complexes of the genera is carried out on the basis of features of the anterior and posterior gonopods and biogeographical characteristics. The genera *Bulgardicus*, *Camptogona* and *Ghilarovia* are excluded from the family Anthroleucosomatidae. This group has a broad disjunct distribution in the Holarctic Region, with centres of genesis and diversification on the Balkan Peninsula and in Caucasia. Of the total of 12 complexes of genera, even as many as 10 are characteristic of the aforementioned territories. The *Alloiopus*, *Caucaseuma*, *Dentatosoma*, *Enghoffiella*, *Flagellophorella*, *Herculina*, *Ratcheuma* and *Vegrandosoma* complexes are endemic to the territory of Caucasia, while the *Anthroleucosoma* and *Bulgarosoma* complexes are endemites of the Balkan Peninsula. The monotypic *Leschius* complex is the only complex of anthroleucosomatids known from the Nearctic Region. The complex with the widest distribution is the North-Mediterranean *Anamastigona* complex, which includes representatives native to the Apennine and Balkan Peninsulas, many of the Greek islands, Cyprus and the Middle East, with one representative having been spread by man in western regions of Europe as well.

KEYWORDS: Anthroleucosomatidae, complexes, Balkan Peninsula, Caucasia, systematics, biogeography

A Taxonomic Review of Genus *Harpolithobius* Verhoeff, 1904 (Lithobiomorpha: Lithobiidae)

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Genus *Harpolithobius* was erected by K.W. Verhoeff in 1904 with *Lithobius anodus* Latzel, 1880 as a type species. The genus is distinguished from all other lithobiid genera by the following set of characters: small coxosternal teeth, generally 2+2, a pair of stout porodonts, forcipular coxosternite with almost straight, medially not incised edge, first pair of legs without or with a reduced number of spines, tibia and femur swollen; all legs with numerous tegumentary irregular blue-violaceous pigmented spots. Male tibiae 14 and 15 often modified. The genus comprises approximately 25-30 known (sub-)species distributed in the Balkan and Apennine peninsulas, the Carpathians, Crimea, Caucasus, and Anatolia. With the exception of *H. anodus*, which is widely distributed in Central and SE Europe, most species have rather restricted ranges. Three species: *H. oltenicus* Negrea, 1962 (Romania), *H. birsteini* Zalesskaja, 1972 (Abkhazia, Georgia), *H. vignatagliantii* Zapparoli, 1989 (southeastern Anatolia) are obligate cave-dwellers. Here we report two new soil-dwelling species found in Northeast Bulgaria and one new cave species found in Serekas Mts, Greece. Furthermore, we discuss the taxonomic position of the monotypic genus *Anodonthobius* (with *A. osellai* Matic, 1983) described from Northeast Anatolia. The genus is morphologically close to *Harpolithobius*, and a study of new material revealed that some of the diagnostic characters used to justify it are in fact erroneously interpreted. Thus, the validity of *Anodonthobius* remains controversial as the only characters that seem to distinguish it from *Harpolithobius* at present are the slightly swollen 1st tibia and the more setose coxosternum.

KEYWORDS: *Harpolithobius*, *Anodonthobius*, new species

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Current Known Distribution of Centipedes (Chilopoda) in Romania: Faunistic and Ecological Records

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The Romanian centipede fauna has been studied for over a century and a half. During this period, 112 valid species were identified but the faunistic and ecological records resulted from studies conducted on limited territories or specific habitats. The purpose of our study is to assess the currently known pattern of distribution for centipede species taking into account the bias of sampling efforts within Romania. A database with 2623 locations for every recorded species was generated and subsequently processed in a geographic information system (GIS) using the 10 x 10 km grid resolution recommended by EEA with 2550 grid cells corresponding to Romanian territory and just 450 of them with data, mostly (76,44%) with records for less the 6 species.

The spatial statistical analysis validated the supposition of a strongly biased sampling for Romania and highlighted the hotspots of increased sampling efforts. Most of the hotspots are concentrated in the western half of the country and in Dobrogea, overlapping with the karst areas in Romania, while the greatest part of the eastern half is less investigated. The grid cells with the highest Z scores, between 6.4 and 12.13 (p value is < 0.05 when Z scores take values between 2.01 and 12.13), are all located in Southeastern Romania, corresponding to three ecoregions, the Banat Mountains, Banat Hills and south-eastern extremity of the Southern Carpathians.

Our results are relevant for some future projects like targeted investigations, to generate distribution models and for assessment of the conservation status for some endangered centipede species.

KEYWORDS: centipede, distribution pattern, hotspots, Romania

Millipede and Centipede Assemblages on the Northern and Southern Slopes of the Lowland Altais, Southwestern Siberia, Russia (Diplopoda, Chilopoda)

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The present study is based on fresh samples collected in the lowlands of the Charysh District, Altai Province, SW Siberia (N 51˚21′, E 83˚37′) from June to August 2016. Two types of habitat were sampled, two times each: (1) rocky xeromorphic bushes with *Caragana arborescens*, *Lonicera tatarica* and *Spiraea chamaedryfolia* located on the southern slope at 480–530 m a.s.l. and (2) rocky forested sites with *Betula pendula* and *Pinus sylvestris* on the northern slope at 620–630 m a.s.l. The material was collected using the standard soil fauna sampling techniques used in Russia (Ghilarov, 1987). The species richness in the millipede assemblages is found to be very low and similar on both slopes (I_J=0.86). Thus, only 5 diplopod species are known to occur on the southern slope (*Megaphyllum sjaelandicum* (Meinert, 1868), *Sibiriulus latisupremus* Mikhaljova, Nefediev et Nefedieva, 2014, *Orinisobates sibiricus* (Gulička, 1963), *Schizoturanius clavatipes* (Stuxberg, 1876) and *Altajosoma* sp.), whereas 6 species inhabit the northern slope (all above reported from the southern slope, plus *Leptoiulus tigirek* Mikhaljova, Nefediev, Nefedieva et Dyachkov, 2015). The record of the julid *S. latisupremus* is new and the westernmost for the species. The julid *L. tigirek*, which has recently been included in the Red Data Book of the Altai Province, has been collected outside its terra typica for the first time, thus also clarifying the eastern range limit of the species. The julid *M. sjaelandicum* considerably predominates on the dry S slope (44–60 % of the total millipede abundance), whereas *S. latisupremus* tends to dominate on the more humid N slope (44–70 % of the total diplopod abundance). The seasonal dynamics of diplopod numbers ranges from 21±4.4 to 48±10.8 ind./m² on the southern slope, and from 9±1.2 to 22±13.6 ind./m² on the northern one, gradually declining from June to August in both habitat types.

The total species richness in the centipede assemblages is twice as high compared to the millipede ones, with 10 and 11 species recorded on the S and N slope, respectively. Most Chilopoda species are common to both slopes, namely, *Lithobius* (*Ezembius*) *ostiacorum* Stuxberg, 1876, *L.* (*E.*) *proximus* Sseliwanoff, 1880, *L.* (*E.*) *sibiricus* Gerstfeldt, 1858, *L.* (*Monotarsobius*) *insolens* Dányi et Tuf, 2012, *L.* (*M.*) *curtipes* C.L. Koch, 1847, *Escaryus retusidens* Attems, 1904, *E. koreanus* Takakuwa, 1937 and *Arctogeophilus macrocephalus* Folkmanová et Dobroruka, 1960. However, the similarity in species composition between the study slopes is weak (I_J=0.62). Thus, two species are recorded only on the southern slope (*L.* (*M.*) *vagabundus* Stuxberg, 1876 and *Strigamia* sp.) while three species dwell only on the northern slope (*L.* (*M.*) *nordenskioldii* Stuxberg, 1876, *L.* (*M.*) sp. and *Strigamia pusilla* (Sseliwanoff, 1884)). On S slope, two species predominate, in particular, *L.* (*M.*) *insolens* (32–67 % of the total chilopod abundance) and *E. retusidens* (43 % of the total centipede abundance in June). Five dominant or subdominant species (*E. retusidens*, *E. koreanus*, *L. sibiricus*, *L. curtipes* and *L. insolens*) inhabit the northern slope. The seasonal dynamics of Chilopoda density ranges from 20±6.8 to 27±19.6 ind./m² on the southern slope, and from 31±0.0 to 47±11.6 ind./m² on the northern one, the highest being in June and August and the lowest in July in both habitat types.

KEYWORDS: millipede, centipede, ecology, distribution, lowland, Altais

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Molecular Phylogeny of the Dragon Millipede Genus *Desmoxytes* Chamberlin, 1923 in Thailand and Neighboring Countries

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Millipedes of the genus *Desmoxytes* Chamberlin, 1923 are also known as "dragon millipedes" because of their colorful bodies and often conspicuous lateral body processes known as "paraterga". These animals are usually found in limestone or cave habitats as endemism. Currently, 47 species of *Desmoxytes* have been recorded from South China through Southeast Asia. During 2014 to 2016, we surveyed *Desmoxytes* in the "Biodiversity Hotspots" of mainland Southeast Asia (Thailand, Myanmar, Laos and Malaysia) and discovered several peculiar, unknown species. Their complicated morphological characters present a challenge to research on the species diversity and evolutionary relationships of *Desmoxytes*. Therefore, we investigated the morphological characters together with a phylogenetic analysis, based on the DNA sequences of three gene fragments (COI, 16S rDNA, 28S rDNA), for 60 operational taxonomic units. The three genes revealed high genetic distances between congeners, and the mean interspecific distances of COI, 16S and 28S were 17.0%, 15.4% and 2.4%, respectively. The phylogenetic tree indicated a strong congruence with the morphological characters. Additionally, the tree showed that *Desmoxytes* is non-monophyletic with five separate lineages. The first group showed mainly wing-shaped paraterga and a strongly condensed gonopod, while the other four groups exhibited differences in their paraterga and gonopod characters. Moreover, the genetic structures of *Desmoxytes* seem to be related to their geographical distribution. The phylogenetic analysis of *Desmoxytes* strongly contributes to understanding the rich species diversity and the great evolutionary adaptation of this animal group through time in this region.

KEYWORDS: *Desmoxytes*, dragon millipede, endemism, species diversity, phylogeny, Thailand

Effects of N-Deposition on Millipede Survival and Growth

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Millipedes are generally known to play an important role in ecosystem function. However, ecology of millipedes is understudied, with the role of many species of millipedes being entirely unknown. This is especially true for nutrient cycling, decomposition, and other ecosystem-scale processes, where the effect of millipedes has rarely been documented. Quantification of millipedes' ecological roles is important in the context of global change, which will change the way ecosystems function and is already creating novel systems. Nitrogen cycling is one aspect of global change where changes are conspicuous: terrestrial ecosystems are receiving increased nitrogen from fossil fuel combustion and nitrogenous fertilizers. Available nitrogen is likely limiting to millipede populations and communities, and millipedes certainly affect N-mineralization by increasing decomposition rates and preferentially selecting litter and soil sources of variable quality. However, neither the effects of changing nitrogen concentrations on millipedes nor the effects of millipedes on nitrogen transformations are well understood or quantified. We will present the first experiment in a series intended to explore the effects of global change on millipede ecology. *Ptyoiulus impressus* (Julida: Parajulidae) were collected from a mixed forest in central Georgia, USA, and exposed to either ambient or increased nitrogen. Experimental mesocosms were 10 cm diameter, 15 cm tall plastic cylinders with 5 cm deep soil and 5 g fragmented maple (*Acer* sp.) leaf litter. Soil nitrogen as nitrate was increased from ambient by 10 kg/ha by the addition of $NaNO_3$. Nitrate was monitored weekly during the experiment. Millipede biomass and survival were also monitored.

KEYWORDS: ecology, *Ptyoiulus*, nitrogen, survival

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Synergy of Temporal and Spatial Differentiation Leads to Fine-Scale Niche Separation in Tropical Millipede Community

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Mechanisms of ecological niches separation among coexisting species in saprotrophic communities are still far from being solved. In species-rich tropical millipede communities both trophic and spatial mechanisms of niche separation are realized, but usually it appears as distinct guilds joined several species with close ecology. Sharing common resources among several species can be also achieved by temporal separation of activity at different scales. We investigated millipede community in monsoon tropical forest in Cat Tien National Park (southern Vietnam) focusing on the seasonal and diurnal changes in species' activity. We found seasonal complexes of species that have peaks of abundance in different period. Most of species are expectedly timed to rainy season (*Enghoffosoma anchoriforme, E. digitatum*) but others are abundant in the dry period (*Nedyopus dawydoffiae*). Some of species have prolonged period of abundance (*Thyropygus carli*), whereas other appears for very short time (about one month) with extremely high density (*E. retrorsum*). Patterns of diurnal activity also differ among species. Most species forage at nights when humidity is relatively higher and temperature is lower. There are also species that are active round the clock. Temporal differentiation corroborates closely with spatial differentiation. In most species preferred habitats change with time both at the diurnal and seasonal scales. Many aspects of temporal and spatial patterns of millipede activity might be explained by maintaining the water balance. We conclude that spatial and temporal differentiations of coexisting millipede species are strongly interrelated and form a principal mechanism promoting niche separation in tropical millipede communities.

KEYWORDS: Diplopoda, tropical forest, niche separation, spatial structure, life history

Distribution, Diversity Patterns and Faunogenesis of the Millipedes (Diplopoda) of the Himalayas

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The Himalayas support a highly rich, diverse, multi-layered, mostly endemic diplopod fauna which presently contains >270 species, 53 genera, 23 families and 13 orders. This is the result of mixing the ancient, apparently Tertiary and younger, Plio-Pleistocene elements of various origins, as well as the most recent anthropochore introductions. At the species and, partly, generic levels, the fauna is largely autochthonous and sylvicolous, formed through abounding *in situ* radiation and vicariance events. In general, the species from large genera and families tend to occupy a wide range of altitudes, but nearly each of the constituent species shows a distribution highly localized both horizontally and altitudinally, yet quite often with sympatry or even syntopy involved. The bulk of the fauna is Indo-Malayan in origin, with individual genera or families shared with those of SE Asia (mostly) and/or S India (few). Sino-Himalayan and, especially, Palaearctic components are subordinate, but also clearly distinguishable.

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Müllerian Mimicry in Japanese Xystodesmid Millipedes

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The convergence of warning signals in unpalatable species known as Müllerian mimicry is a straightforward example of evolution by natural selection. However, ecological and evolutionary factors structuring Müllerian mimicry rings remain unclear. Two cyanide-generating xystodesmid millipede groups distributed in the middle part of Japan, the *Parafontaria* species complex and *Riukiaria* species, show similar gray body color. We hypothesize Müllerian mimicry as the responsible mechanism for the color similarity between the two groups. Interestingly, our phylogenetic analyses showed that some lineages of the *P. tonominea* species complex diverged from the gray mimicry rings to the ancestral orange morph or intermediate morphs between gray and orange. We also found that two parasitoid fly species may tend to lay eggs on gray morphs more than orange and intermediate morphs in the *P. tonominea* species complexes and its related species. The gray morph may be protected from other predators such as birds, through the benefits of the gray mimicry rings. Reversals to the ancestral orange morph in the *P. tonominea* species complex is geographically restricted in the Kansai District, central part of Japan, where multiple speciation events occurred through diversification of genital and body sizes in the species complex, suggesting species diversification may facilitate the transitions of the color morphs. We discuss that different predators and speciation may have roles in structuring Müllerian mimicry rings in these millipedes.

KEYWORDS: millipede, mimicry, *Parafontaria*, *Riukiaria*, Xystodesmidae

Large Sequences for Tiny Myriapods, Big Data-Analyses Including All Living Myriapoda Classes

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Traditionally, four groups are united in Myriapoda: Chilopoda (centipedes) and Diplopoda (millipedes), containing the vast majority of species, as well as Pauropoda and Symphyla. Morphological support for the monophyly of Myriapoda is scarce, but was never questioned in recent phylogenetic studies. However, phylogenomic data from Pauropoda is still missing, leaving relationships among the major lineages uncertain. Morphological data largely favours a sister group relationship of Diplopoda and Pauropoda (Dignatha-hypothesis), within monophyletic Progoneata (Chilopoda as sister to all remaining groups). Monophyletic Progoneata were likewise supported from multi-gene studies with full coverage among myriapod subgroups. However, Symphyla resulted as sister group of Pauropoda in a taxon coined Edafopoda. Still support for this hypothesis is based on a restricted data set, especially regarding Pauropoda.

We firstly present analyses with transcriptomic data from the pauropod *Acopauropus ornatus*. All analyses support monophyly of Myriapoda, as well as each of its main groups (Pauropoda were represented by a single species). All analyses likewise strongly support Edafopoda and a closer relationship between Diplopoda and Chilopoda.

Results will be presented along with explanations on the analysis pipeline. All results were tested with a Four-Cluster-Likelihood-Mapping approach. Comments will be given on (i) the position of myriapods within the Euarthropoda, and (ii) on relationships within both Chilopoda and Diplopoda.

KEYWORDS: Pauropoda, Symphyla, Edafopoda, Progoneata, phylogenomics, monophyly of Myriapoda

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Millipedes from the Age of the Dinosaurs: Burmese Amber Fossils from the Late Cretaceous Reveal an Unusual Fauna (Myriapoda, Diplopoda)

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Both the first land arthropods and the largest known land arthropod fossil were millipedes. From the Palaeozoic a rich millipede fauna is known, especially from carboniferous coal deposits. Most of these millipedes belong to now extinct orders. A huge faunal shift must have occurred during the Mesozoic, a time period for which the fossil record of the Diplopoda is quite scarce. Recently, we were provided access to some of the largest private collections of millipedes preserved in Burmese amber, dating to the late Cretaceous, 100 million years ago. Previously, only some Polyxenida, still attributable to recent families or even genera, were known from this time period. Our study of more than 100 specimens revealed a rich and diverse fauna, encompassing different genera, species and families of the orders Polyxenida, Glomeridesmida, Glomerida, Siphoniulida, Polyzoniida, Platydesmida, Siphonophorida, Stemmiulida, Callipodida, Chordeumatida, Spirobolida and Spirostreptida. While so far all species can be placed in recent orders, some species might be representatives of now extinct families. The advent of micro-CT technology allows for the previously impossible study and digital reconstruction of the gonopods and telopods of the amber preserved specimens. Some groups show a surprisingly conserved morphology, while others show massive changes. The similarities and differences of the Late Cretaceous millipede fauna to recent millipedes is discussed and elaborated.

KEYWORDS: Diplopoda, fossil, Mesozoic, Cretaceous, Burmese amber, micro CT, Glomeridesmida, Glomerida, Polyzoniida, Siphonophorida, Siphonorhinidae, Spirobolida, Cambalidea, Stemmiulida, Callipodida, Chordeumatida, Heterochordeumatidae, Polydesmida, Haplodesmidae

Comparative Analysis of the Centipede Nervous System – Past, Present and Future in Arthropod Neuroanatomical Research

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Myriapods are chronically understudied with respect to their anatomy and morphology. This is, however, astonishing as their phylogenetic position within arthropods has been controversially discussed and a consensus is still in debate. As independent data are needed to supplement knowledge based on traditional external morphology and modern molecular sequence information, a promising approach embraces the comparison of structure and development of the nervous system. For the past 10 years centipedes, and especially *Scutigera coleoptrata*, were intensively studied with respect to their nervous systems and sensory organs. Detailed and comparative analyses revealed results that had an impact on general arthropod anatomy and phylogenetic implications. As examples, the organization of single ommatidia or deutocerebral processing neuropils strongly gave support to the Mandibulata hypotheses and a sistergroup relationship to Tetraconata. In-depth investigations showed that the organization of visual neuropils contradicts previous transformation scenarios and roots the possession of only two visual neuropils including a visual chiasm in the last common ancestor of mandibulate arthropods. This talk will focus on recent investigations on centipedes and light up new questions to be answered in future research projects.

KEYWORDS: centipedes, nervous system, evolution, morphology

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Sensing from Both Ends? Transformation of Locomotory into Multifunctional Appendages in Chilopoda (Myriapoda)

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The arthropodium can be regarded as one, if not *the* eponymous key innovation of arthropods. In taking on a sheer plethora of functions (ranging from locomotion, food handling and ingestion, copulation, respiration, and chemo/mechano-sensation), arthropodia are one of the most versatile, most specialized and hence, likely one of the most widely modified features known. This specialization is particularly evident considering the appendages of the head, commonly and in many cases independently transformed into a series of mouthparts. Comparable modifications comprise the convergent transformation of the anterior-most thoracic arthropodia which brought forth additional mouthparts, often of autapomorphic characteristic and taxonomic importance. Body appendages are thus a predestined subject for investigating adaptive evolutionary transformation processes and a key aspect to address issues of functional morphology constraints. In addition to the forcipules and despite its taxonomic significance, centipedes possess another largely unregarded example of arthropodial transformations: the terminal (or ultimate) legs that are characterized by distinct and at times quite extraordinary, morphological variations. We will show that these transformations are by no means restricted to its outer morphology, but that this particular centipede character was subjected to a whole cascade of adaptations in terms of neuroanatomy, variability, posture and behavioral adaptations as well as sensillar and glandular organization.

KEYWORDS: terminal legs, evolutionary morphology, arthropodial transformations

A New Group of Cambalidea (Diplopoda: Spirostreptida) from Burmese Amber: Exploring Ancient Cretaceous Diversity Using Modern Micro-CT-Technology

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Diplopods were some of the first terrestrial animals, playing a major role in terrestrial ecosystems. Representatives of an extant order of Juliformia are not known before the Carboniferous, with a fossil of a possible species of the Spirobolida. Although their calcified cuticle favors fossilization, the fossil record of the Diplopoda remains scarce during the Mesozoic. We describe the oldest known clearly assignable representatives of the juliform order Spirostreptida and the only record of the order for the Mesozoic, from Cretaceous Burmese amber, dating back to the Albian-Cenomanian border ca. 99 mya. For the description and non-invasive exploration of morphological details we utilize modern micro-CT technology as well as classical microscopy. This group of Spirostreptida, with a legless 4th body-ring, belongs to the suborder Cambalidea and has well-developed anterior and posterior gonopods on body-ring 7. We describe 10 specimens, two of them adult males, belonging to several species. These Cretaceous Cambalidea show a unique morphology and cannot be assigned to any extant family. Therefore we suggest placing them in a separate family. In contrast to extant Cambalidea, the third leg pair is located at the anterior margin of body-ring 3, resulting in a large gap between leg pair 3 and 4. Setae are present on the posterior margin of the Metazonites, a character otherwise confined to the order Julida. The phylogenetic position of this new group within the Cambalidea remains uncertain, especially since the position and monophyly of the different Cambalidea families is under constant debate.

KEYWORDS: Burmese amber, Diplopoda, Spirostreptida, Cretaceous, Cambalidea, micro-CT

The Relationship Between Autophagy and Apoptosis in the Midgut Epithelium of Myriapoda

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In multicellular organisms the processes of programmed cell death (PCD) are combined with physiological and morphological changes of cells that cause their deletion from tissues and organs. Therefore, it plays an important role in maintaining tissue homeostasis. Among the types of PCD, apoptosis and autophagy have been distinguished as processes caused by many factors (e.g., xenobiotics, pathogens, starvation, irradiation, etc.). Autophagy and apoptosis have been precisely described in the cytoplasm of the digestive cells in the midgut epithelium of centipedes (e.g. *Lithobius forficatus, Scolopendra cingulata*) and millipedes (e.g. *Archispirostreptus gigas, Epibolus pulchripes, Strongylosoma stigmatosum, Polydesmus angustus, Julus scandinavius*). Autophagy can be activated in order to degrade toxins and pathogens and/or exploit the reserve material, enabling thus the cell survival. However, when the cell cannot cope with strong stressors, the apoptosis is involved. During this process, long-lived proteins and organelles are delivered to autophagosomes and digested inside autolysosomes. Using the light, confocal and transmission electron microscopy, as well as the histochemical and immunohistochemical methods, we could described precisely these processes, their activation according to different stressors and finally, the relationship between them in the midgut epithelium of above mentioned myriapods. In conclusion, autophagy and apoptosis fulfill important role in the proper functioning of the midgut epithelium in both, the millipedes and centipedes.

KEYWORDS: millipedes, centipedes, midgut ultrastructure, autophagy, apoptosis

The Virtual Microscope Slide Collection VIRMISCO — Digitalisation of Microscopic Collection Objects

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Digitalisation allows science rapid access to research objects while conserving the originals. For transparent to semi-transparent three-dimensional microscopic objects, such as microinvertebrates or microscopic pieces of organisms, the definition of standards and available databases are scarce. The transfer and presentation of large data volumes which rapidly arise by z-stacks in high quality via the internet is also a challenge. The Virtual Microscope Slide Collection – VIRMISCO – is a project working on standards and recommendations for taking microscopic image stacks of 3D objects and presenting such z-stacks on an online platform. The core of VIRMISCO is the online viewer, which enables the user to focus online through the object as if using a real microscope. Additionally, the VIRMISCO viewer offers features such as rotating, zooming, and measuring, changing brightness or contrast as well as downloading complete z-stacks as jpeg files or video file. The benefits of VIRMISCO: 1) Virtual access to collections for taxonomic studies, like type material. 2) New way for taxonomic publishing. 3) Education and taxonomic training since it constitutes a virtual reference collection.

KEYWORDS: collection, taxonomy, voucher, database, website

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Identification of Archipolypoda (Diplopoda) from the Classic Carboniferous Site of Joggins, Nova Scotia, Canada

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Millipede body fossils found inside trunks of *Sigillaria* at Joggins, a UNESCO World Heritage site along the Bay of Fundy in Nova Scotia, Canada, were first described by J.W. Dawson in the mid-1800s, and later revised by Samuel Scudder and others. The most commonly cited (although not always correctly) of these is *Xyloiulus sigillariae* (Dawson). Dawson also described large fossil trackways at Joggins that have been subsequently interpreted as having been made by the diplopod *Arthropleura*. Exposures at Joggins are Carboniferous (lower Westphalian; Langsettian).

We report the presence of archipolypods, which had been notably absent from the Joggins biota, although relatively common at a number of other classic Carboniferous sites with a similar biota. The largest of several specimens, about 11 cm long, and consisting of about 17 preserved segments, is mostly flattened and only moderately well preserved. Portions of the dorsal and ventral sides of the millipede are exposed. Details of the dorsal side are hard to discern. One sternite, however, bears a pair of preserved excertile-sac pits (ventral pits) located medial to stout coxal segments and oriented as those of euphoberiids, approaching each other anteriad. There are indications of transversely elongate spiracles lateral to the legs, and the overall shape and configuration of the sternites is like that of euphoberiid archipolypods. Additional specimens, preserved in dorsal aspect, have depressed prozonites and raised metazonites like those seen on "*Euphoberia" brownii* from Lancashire, England, and on an unnamed genus of archipolypod from Kansas, USA, but lack more definitive characters.

KEYWORDS: millipede, Joggins, Archipolypoda

Phylogenomics and Biogeography of Onychophora Across Former Gondwana

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Velvet worms (phylum Onychophora) are an ancient, globally distributed group of soil invertebrates found in dark, humid environments such as leaf litter and rotting logs. The phylum is composed of two families: Peripatidae, which is predominantly found in the Neotropics but contains relictual lineages in West Africa and Southeast Asia; and Peripatopsidae, found in the former temperate Gondwanan landmasses of Chile, South Africa, Australia, New Guinea, and New Zealand. In order to assess how closely their biogeographic patterns match the breakup of Gondwana, we sequenced and assembled *de novo* 28 transcriptomes and three genomes from representatives of both families, covering their known geographic range. We then analyzed these data using concatenation and species tree phylogenetic methods, allowing for different levels of missing data, and performed a molecular clock dating analysis. We confirm the monophyly of both families and discuss our findings regarding the timing and order of cladogenetic events as they relate to the breakup of Gondwana.

KEYWORDS: phylogeny, transcriptomics, velvet worms, Peripatidae, Peripatopsidae

Phylogeography of the Velvet Worm Species Complex *Peripatoides* spp. (Onychophora, Peripatopsidae) Across New Zealand

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The ovoviviparous velvet worm genus *Peripatoides* Pocock, 1894 (Onychophora: Peripatopsidae) is found across both the North and South islands of New Zealand, from Cape Reinga to Catlins Forest Park. Early molecular work using allozyme electrophoresis suggested large genetic divergences within the genus, and especially those identified as *Peripatoides novaezealandiae* (Hutton, 1876), despite being extremely morphologically conserved. From the six available names, four new species were erected diagnosed exclusively on allozyme data, as no distinguishing morphological characters were apparent. Because of this, other authors have suggested treating these species as *nomina dubia*. In order to determine the number of species within *Peripatoides* and its biogeographic patterns in the context of New Zealand's turbulent geologic history, we sequenced the mitochondrial gene cytochrome *c* oxidase subunit I (COI) and performed double digest restriction site-associated DNA sequencing (ddRADseq) on 102 *Peripatoides* specimens, spanning the known geographic range, and compared the resulting population groupings. We find at least 5 genetically distinct clades that show geographic structuring, and look for morphological characters to corroborate and diagnose these genetic species.

KEYWORDS: RADseq, velvet worms, New Zealand, phylogeography, taxonomy

Discovery of Two Monophyletic Clades Within the Appalachian Millipede Genus *Nannaria* Chamberlin, 1918 (Diplopoda: Polydesmida: Xystodesmidae)

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Currently the eastern North American millipede genus *Nannaria* Chamberlin, 1918 comprises 23 species, but may in fact represent the most species-rich genus in the family Xystodesmidae, with an estimated 200 undescribed species. Somatic characters are fairly uniform in the genus, however gonopod morphology can vary significantly—even among closely related species. Some species occupy highly restricted geographic ranges (< 10 km^2), while others appear to inhabit ranges of over 3000 km^2 with little to no morphological variation. Use of genetic information will shed light upon the species diversity and evolutionary history of this poorly understood genus. Here we use three genes, COI, 28S and EF1a, as well as morphological characters, to disentangle the evolutionary relationships among a subset of 43 species (including 32 novel species). We found two monophyletic clades within *Nannaria*, the *minor* and *wilsoni* groups, which are distinct both genetically and morphologically. We discuss the systematics of these two groups, gonopodal evolution, and microendemism in the U.S. Appalachian Mountains.

KEYWORDS: millipede, Xystodesmidae, *Nannaria*, gonopod, endemic, species

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Myriapoda Threatened Brazilian Species (Chilopoda and Diplopoda) and Implications for the Conservation of Its Biodiversity in Brazil

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The biodiversity crisis we live in requires well-planned conservation efforts. To overcome this issue, red lists of threatened species are recognized as the main approach for evaluating the conservation status of species. Here, we focused on the Brazil Red Book of Threatened Species of Fauna, published in 2016 by Brazilian Environment Ministry. The list was elaborated throughout workshops with specialists, which evaluated 223 millipede species and 9 centipede species, representing 33% of all myriapods known for Brazil. The list identified 15 myriapod species in some degree of extinction risk. All of them are considered endemic for Brazil and 11 are only known for subterranean habitats. Despite of 5 of them being recorded in protected areas, mineral extraction and intense and unregulated ecotourism represent great threats. Five species were considered as critically endangered, 4 as endangered, and 6 as vulnerable species. The great number of data deficient myriapod species (97) states the need of investing in ecology and taxonomy studies about the group. This list of threatened myriapods is a warning for those involved with subterranean fauna conservation, due to the high level of endemism and the fragility of those habitats worldwide. The presence of myriapods in the list brings attention to the group, which usually receives little or none attention in conservation programs. We provide an historical analysis of red lists, and discuss the implications of red lists for biodiversity conservation, the effectiveness of protected areas system in conserving the group and the role of ecotourism in subterranean habitats conservation.

KEYWORDS: red list, IUCN, extinction risk, protected areas, ecotourism, subterranean habitats, centipede, millipede

Evidence of Multiple Divergent Mitochondrial Lineages Within the Southern African Diplopod Genus *Bicoxidens* Attems, 1928 (Spirostreptida)

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Two recent studies have suggested that divergent mitochondrial lineages may be present in a southern African millipede, *Bicoxidens* Attems, 1928. *Bicoxidens* like many other endemic soil invertebrates exhibits low dispersal capabilities and strict habitat preferences which often lead to geographic isolation. Given that geographic isolation is the foundation for genetic divergence and possibly speciation, there was good reason to suspect that *Bicoxidens* consists of several distinct lineages. On this basis the mitochondrial *cytochrome c oxidase* subunit 1 (COI) was used to test the monophyly of *Bicoxidens* and reveal divergent lineages within the genus. Maximum likelihood and Bayesian inference analyses recovered a paraphyletic *Bicoxidens* with divergent lineages present in three species, *B. friendi*, *B. flavicollis* and *B. brincki*, suggesting high genetic diversity within the genus. Bayesian genetic cluster analyses results suggested the presence of multiple distinct mitochondrial lineages within the genus with four identified in *B. flavicollis* alone. As such, the divergent lineages observed among *Bicoxidens* populations suggest the presence of several hidden species.

KEYWORDS: hidden species, afrotropical, endemic, genitalia, phylogeny, mitochondrial lineages

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The Evaluation of Characters Suitable for Generic Determination in the Order Siphonophorida

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A large collection of Siphonophorids from Brazil has been evaluated in detail. Previously (Read & Enghoff 2009) we looked at characters that were suitable for distinguishing between species. Here we concentrate on the generic level. Two genera can be identified within the Brazilian collection and the characteristics used to separate them are described. Specimens from other parts of the world held in the Natural History Museum in London are then examined to evaluate the usefulness of these characters more generally.

KEYWORDS: millipede, Siphonophorida, Brazil, generic characters

Millipede Assemblages along Altitudinal and Vegetation Gradient in the Alpine Zone in the West Tatra Mountains: Spatial and Temporal Variations in the Conditions of a Changing Climate

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Extensive monitoring of epigeic activity of millipedes has been undertaken since the nineties of the past century on a series of plots in the alpine zone in the West Tatra Mountains, Slovakia. The repeated pitfall trapping in 1992–1993, 1997–1998, 2007–2008 and 2014–2015 involved stands on granite and limestone bedrocks, differing in altitude, exposition and vegetation. The given twenty-year period involves the time of parallel effects of recovery from atmospheric acidification and increasing air temperature. Although any comparable data about millipede assemblages from the previous acidification period are not available, analysis of sampling exhibited significant temporal changes in the presence of Carpathian endemic and cold tolerant species, as well as the eurytopic species of millipedes, but differently on granite and limestone stands. Generally, on granite bedrock the alpine grasslands were characterized by significant increase of millipede abundances, with the predominating chordeumatid species *Chelogona carpathicum*, *Hylebainosoma tatranum* and *Mastigona bosniensis*. Different species spectrum represented mainly by juliform millipedes and decrease in total activity characterized alpine grasslands on limestone. The portion of Carpathian endemic species, *Leptoiulus tussilaginis*, *Leptoiulus liptauensis*, *Polydesmus tatranus* and *Chelogona carpathicum*, subsequently decreased, but abundance of eurytopic *Leptoiulus trilobatus* increased. The measured environmental parameters at individual plots (soil chemistry and temperature, exposition, altitude) in consequences with confirmed warming of given habitats and acidification recovery were used and discussed in evaluation of the whole data set. The synergic effects of all factors allowed only a partial explanation of the changes in assemblages of millipedes.

KEYWORDS: millipedes, epigeic activity, alpine habitats, climate changes

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Natural History of the Millipede *Brachycybe lecontii* Wood, 1864 (Platydesmida, Andrognathidae)

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The millipede *Brachycybe lecontii* Wood, 1864 is a social millipede known for paternal care of eggs and congregating in pinwheel-shaped groups. Endemic to the eastern U.S., molecular data has shown its closest relative resides in East Asia. Despite its unique biological features and novel subsocial behavior, the taxon is understudied compared to other social arthropods. We provide a natural history of the species including anatomical details, identity of its fungal food, and updated description utilizing light and scanning electron micrographs. We provide illustrations of a comb-like structure on the tarsi of the three anterior leg pairs and characterization of the species chemical defense anatomy.

KEYWORDS: millipede, Diplopoda, *Brachycybe lecontii*

The Giant Pill-Millipede Genus *Zephronia* Gray, 1943 in Northern Thailand (Diplopoda, Sphaerotheriida, Zephroniidae)

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The giant pill-millipede family Zephroniidae is restricted in its distribution to Southeast Asia. Most of zephroniids belong to the genus *Zephronia*, *Z. siamensis* Hirst, 1907 being yet the only species of this genus recorded from Thailand. However, members of *Zephronia* actually occur throughout Thailand, especially in forest habitats. In this study, giant pill-millipedes were collected from and observed in various places in northern Thailand during the rainy season of 2016. The morphology and molecular analyses of these specimens reveal several species of *Zephronia* that are likely to be new and endemic to Thailand.

KEYWORDS: Diplopoda, Zephroniidae, phylogeny, taxonomy

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Trends in Centipede Systematics

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The injection of molecular data has transformed many aspects of centipede systematics, from the species level to inter-ordinal relationships. Transcriptome-based analyses of hundreds or thousands of genes have provided a well supported framework for family-level relationships across Chilopoda, the most surprising result from the perspective of morphological phylogenies being the exclusion of *Craterostigmus* from a putative clade named Amalpighiata. Species-level taxonomy is being enhanced by phylogenetic analyses of traditional targeted-sequenced genes, examples including the European barcode initiative and multi-locus phylogenies of genera such as *Scolopendra*, *Rhysida*, *Digitipes* and *Strigamia* on a regional or global scale. Such phylogenies have permitted traditional morphological characters to be mapped phylogenetically as well as allowing divergence time estimates that can be interpreted biogeographically. Recent years have seen the discovery of fresh samples for several systematically intriguing taxa described from few specimens in the "classical" era of myriapod taxonomy, such as *Sterropristes*, *Edentistoma*, *Alluropus* and *Plutonium*, all of which have been incorporated into molecular phylogenies. A number of biogeographically rich regions of the world, such as China, Thailand, India and Mexico, have had novel and revisionary taxonomic work conducted using new collections that fill prior gaps in distributional data.

KEYWORDS: phylogeny, taxonomy, molecular systematics, biogeography

Molecular Phylogeny of the Centipede Genera *Rhysida* Wood, 1862 and *Alluropus* Silvestri, 1912 in Southeast Asia

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Tropical centipedes in the genera *Rhysida* Wood, 1862, and *Alluropus* Silvestri, 1912, were comprehensively revised based on broad-scale taxonomic sampling that integrates new field and historical collections from mainland Southeast Asia. Traditional identification was emended using morphological surveys and molecular study. The phylogenetic results from three partial genes (COI, 16S and 28S rRNA) confirm the validity of seven described *Rhysida* species in Southeast Asia/Australia: *R. lithobioides* (Newport, 1845), *R. longipes* (Newport, 1845), *R. immarginata* (Porat, 1876), *R. nuda* (Newport, 1845), *R. carinulata* (Haase, 1887), *R. singaporensis* Verhoeff, 1937, and *R. polyacantha* Koch, 1985. The two nominal Southeast Asian species *R. leviventer* Attems, 1953, and *R. marginata* Attems, 1953, are placed in junior subjective synonymy with congeneric species and within another revised genus *Alluropus*, respectively. *Alluropus* nests either with Indian-Sino or Indo-Australian *Rhysida* species depending on phylogenetic construction method. Two morphologically distinct populations of *A. calcarata* were found to be distributed allopatrically in the Indochina sub-region. In the case of Otostigminae, relationships among members of this subfamily remain quite ambiguous but at least the data from morphology and/or distribution may show some taxonomic signal for species group recognition i.e. *Rhysida+Alluropus*, *Digitipes+Otostigmus* and *Ethmostigmus+Sterropristes*.

KEYWORDS: Otostigminae phylogeny, *Rhysida*, *Alluropus*, Southeast Asia

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Evolution of Parental Care in Centipedes (Chilopoda)

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Centipedes (Chilopoda) are subsocial arthropods that exhibit diverse forms of female-only parental care, ranging from provisioning of gametes, via nest building and burrowing, to egg and offspring attendance. Chilopoda consists of Notostigmophora (=Scutigeromorpha) and Pleurostigmophora (the remaining four orders). After fertilization, females of Scutigeromorpha and Lithobiomorpha lay a number of eggs, one by one, without additional care for eggs after they have covered with a secretion that cements the soil particles together. Even this simplest form of care may increase offspring survival by concealing eggs from predators and parasitoids, or by buffering them against environmental hazards, such as extreme temperatures and desiccation. Evolutionary transitions towards more complex behaviours include egg and offspring attendance in *Craterostigmus* and the two orders of Epimorpha (Scolopendromorpha and Geophilomorpha). These centipedes lay all their eggs in a single clutch, within a brood cavity. The females then spend weeks in guarding, grooming and moistening clutches of eggs, hatchlings and juveniles until they reach a sufficiently advanced stage of development to fend for themselves. This form of parental behaviour serves to protect the offspring and increases their fitness by neutralizing specific hazards that might threaten survival or growth, including predators, cannibalistic conspecifics, parasites, pathogens and desiccation. Assuming that Amalpighiata is monophyletic (i.e., *Craterostigmus* is a sister group of all other pleurostigmophoran centipedes, as retrieved in molecular phylogenetic analyses), we can assert that egg and offspring attendance either is a general feature of all Pleurostigmophora that has been secondarily modified in Lithobiomorpha, or else it is a homoplastic trait that has been convergently acquired by *Craterostigmus* and Epimorpha.

KEYWORDS: parental care, evolution, centipedes, Chilopoda

Significant Genetic Diversity in *Scolopendra morsitans* Linn. (Chilopoda: Scolopendromorpha: Scolopendridae)

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Scolopendra morsitans Linnaeus, 1758 is an Old World centipede species with a wide tropical and subtropical distribution. Morphologically diverse, *S. morsitans* has long been suspected to be a species complex consisting of several hitherto unrecognized species. However attempts to determine putative species boundaries inside *S. morsitans* based on morphological characters have been unsuccessful. The objective of the present study was to study the genetic diversity of *S. morsitans* covering its natural habitat and to determine whether it represents a valid species or a species complex. Data consisted of DNA sequences of mitochondrial COI and 16S rRNA and nuclear 28S rRNA. Phylogenies representing the evolutionary history of the species were constructed using methods based on parsimony (TNT) and maximum likelihood (RAxML). The results obtained from these analyses were somewhat incongruent, especially regarding the ordering of the deep nodes. Unsurprisingly, the nodal supports were low in these nodes in both trees. *S. morsitans* was found to be polyphyletic in both phylogenies. Bayesian Poisson Tree Process (bPTP) species delimitation was applied to study putative species boundaries. In addition pairwise distances (DNA barcode comparison) were calculated for each marker region in order to determine the extent of genetic diversity. Pairwise distances up to over 20 percent were observed in each marker region. Pairwise distances between individuals were correlated with geographical distance. Significant genetic diversity strongly implies that *S. morsitans* is indeed a species complex and is in need of revision.

KEYWORDS: centipede, *Scolopendra*, species complex, phylogeny, DNA barcoding

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Exploring the Peristomatic Structures As a Source of Potential Phylogenetic Characters for the Highly Diverse Genus *Lithobius* (Lithobiidae, Lithobiomorpha)

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The phylogeny of *Lithobius*, the largest centipede genus (> 500 spp.), is not resolved. Traditional taxonomic characters like number and arrangement of ocelli, number of antennal articles or tergite projections are insufficient to draw an overview of the species inter-relationship within the genus. Previous microanatomical studies show that peristomatic structures may differ between species of different 'subgenera' of the genus *Lithobius*. In the present study, we further investigate the epi- and hypopharynx of 29 *Lithobius* species of the three 'subgenera' *Lithobius* (23 spp.), *Monotarsobius* (3 spp.) and *Sigibius* (3 spp.) with scanning electron microscopy. As preliminary results, we compare peristomatic characters between the species, adjust character descriptions based on the existing character matrix and describe new characters. These findings pave the way for further phylogenetic analyses of the genus *Lithobius* based on peristomatic structures in combination with a first µCT-investigation of internal structures of the cephalic capsule in the genus.

KEYWORDS: *Lithobius* sp., epipharynx, hypopharynx, phylogeny, microanatomy, SEM

Current Status of the Taxonomy and Biogeography of Giant Centipedes (Chilopoda: Scolopendromorpha) from Cuba

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The last comprehensive study on Cuban centipedes dates back to 1977. 40 years ago, 4 orders, 8 families, 17 genera and 43 species were listed, from which the order Scolopendromorpha was the best represented with 2 families, 4 subfamilies, 6 genera and 21 species. Aiming to provide a basis for future advances, a preliminary update on the taxonomy and species diversity of Cuban scolopendromorphs was published in 2014, including a list comprising 3 families, 5 subfamilies, 6 genera and 21 species. After that list, two more species were reported to occur in the country, summing to 23 species in total. In the present work, the species diversity of Cuban scolopendromorphs is again updated, based on the revision of all specimens deposited in national institutional collections, as well as on material deposited in foreign collections from the USA, Romania, Bulgaria, Germany, France and Switzerland. As result, 1 genus and 3 species are reported as new to Cuba, and 3 species are deleted. The new list comprises 3 families, 5 subfamilies, 7 genera and 23 species. The distribution of the taxa is also updated, based on both examined specimens and published records, making this dataset the most complete to date.

KEYWORDS: Scolopendromorpha, Caribbean, Cuba, list, maps

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Comparative Morphology and Evolutionary Transformation of Venom Glands in Chilopoda

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Forcipules with venom glands are shared by all centipedes and are therefore considered the most important apomorphy defining them. Venom glands consist of two major components, (1) the more or less extended glandular sac, which releases secretion into (2) a strongly cuticularized duct at its distal tip projecting towards the tarsungulum where it opens through a subterminal pore. The glandular sac is surrounded by musculature and shows a modular composition. Each module represents an enormously stretched glandular unit and consists of at least one canal cell, one intermediary cell and two secretory cells of unequal size. One secretory cell is very small and contains typical secretory granules, hence called the granulated type-1 cell. In contrast, the other is very elongated and, along with adjoined ones, may even reach back to the trochanteroprefemur in some taxa. This non-granulated type-2 secretory cell surrounds a tubular reservoir filled with main portion of venom maturing while being mixed up with sc-1 secretion and moving up the partly cuticularized conducting canal established by the intermediary and canal cells. The cellular anatomy of venom gland modules and common duct system is similar across all five centipede subgroups. However, slight differences are also discernible on ultrastructural level which can be used for reconstructing the evolution of venom glands in Chilopoda. Being the morphology-focused branch of a comprehensive, multidisciplinary study on chilopod venom gland evolution, this contribution integrates data obtained by classic, invasive analytical methods, such as (immuno-) histochemistry and electron microscopy, and by non-invasive approaches like µ-CT.

KEYWORDS: epidermal glands, secretion, evolutionary morphology

When Sex Matters: Dramatic Sexual Dimorphism in the Venom and Venom System of the Centipede *Scolopendra hardwickei*

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Sexual dimorphism of venoms is well known in spiders and certain snake species. However, it remains poorly documented among most venomous animals. This is particularly the case for species where there are in many cases no obvious differences in the appearances of males and females. Using a combination of gas-chromatography mass spectrometry, proteomics, transcriptomics, electrophysiology, and magnetic resonance imaging we describe the venom and venom system of the striking, aposematic centipede *Scolopendra hardwickei*. We also provide the first insight into the venom proteome of any *single* centipede specimen, as well as the first detailed characterisation of the low-molecular weight non-peptidic components of any centipede venom. Despite no obvious differences in non-reproductive behaviour or morphology between captive males and females, our results demonstrate dramatic sexual dimorphisms in venom composition, pharmacology, and venom gland morphology. We show that there are substantial differences in the relative abundance and expression levels of high *versus* low molecular weight components, and that males and females appear to employ very different venom strategies. Although we can only speculate as to the differences in function of male and female *S. hardwickei* venom, our results highlight the important role that sex-specific natural selection can play in the evolution of centipede venoms.

KEYWORDS: centipede, *Scolopendra*, venom

Stable Isotope Composition ($\delta^{13}C$ and $\delta^{15}N$ values) and Trophic Position of *Lithobius (Monotarsobius) curtipes* C.L. Koch, 1847 from the Kola Peninsula

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The centipede species *Lithobius curtipes* (Chilopoda, Lithobiidae) is a widespread and functionally important predatory soil invertebrate of the Kola Peninsula (66-67°N). Trophic relationships might be among the key factors determining the most northern distribution of *L. curtipes* compared to other myriapod species and its successful existence in the Subarctic ecosystems of various types. In this study we aimed at: 1 – identification of the range of prey used by *L. curtipes* and assessing its specificity in different subarctic habitats; 2 – detection of the main sources of energy fueling populations of *L. curtipes* and other top-level predatory invertebrates; 3 – analysis of seasonal, ontogenetic and biotopic variations in the trophic niche of *L. curtipes* at the northern periphery of its geographical range; 4 – experimental evaluation of the contribution of *L. curtipes* to the regulation of organic matter decomposition in subarctic ecosystems via a trophic cascade mechanism. The isotopic composition of C and N ($\delta^{13}C$ and $\delta^{15}N$ values) of the tissues of adult centipedes collected from the pine forest confirmed the trophic position of *L. curtipes* as a predator obtaining energy primarily via detrital food chains from decomposing plant litter, but not from the humified organic matter of plant roots. No clear evidence was found for age-related or for sex-related differences in the trophic niches of this centipede.

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KEYWORDS: centipede, *Lithobius curtipes*, northern periphery of the area, trophic position, stable isotopes

The Diversity and Distribution of Pauropoda in China

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Pauropoda were not recognized from China until 1988, when Chongzhou Zhang and Zhongping Chen reported seven species in eastern Zhejiang Province and southern Tibet, including four new species and three new records from Pauropodidae, Eurpauropodidae and Sphaeropauropodidae. However, there were no further studies on Chinese pauropods for the next two decades. In the past 10 years, we have conducted field investigations and specimen collections for Pauropoda in 18 provinces (27 sampling sites), and found one new genus, 22 new species and 9 new recorded species. Brachypauropodidae was found in China for the first time. So far, 39 species of 11 genera in four families have been reported in China, and we have provided a key of the Chinese Pauropoda in this research. Of the four families, Pauropodidae is the most widely distributed and species-rich family in China, with six genera and 33 species in almost all climatic regions. The families Eurypauropodidae, Brachypauropodidae and Sphaeropauropodidae are distributed sporadically, with only one or two species currently known from China. However, many places in China have not been investigated, and a large number of unknown species remain to be further studied.

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KEYWORDS: Pauropoda, taxonomy, distribution, China

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Five New Species of the Genus *Nedyopus* Attems, 1914 (Diplopoda: Polydesmida: Paradoxosomatidae: Nedyopodini) from Japan, Taiwan and Hong Kong

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The East and Southeast Asian millipede tribe Nedyopodini Jeekel, 1968, which originally contained four genera, has since been revised and shown to be monogeneric, comprising the single large genus *Nedyopus* Attems, 1914. Five new species of *Nedyopus* are described: two from Japan, two from Taiwan and one from Hong Kong. We provide a key to all known species of *Nedyopus*, with their distributions mapped both generally and in Taiwan in particular. Most of the *Nedyopus* species occur in Taiwan and Japan. The ratio of species number to area shows that Taiwan supports the highest species diversity. Similarly high rates of species diversity are also observed in most other millipede genera in Taiwan. At present, 72% of the 93 diplopod species known from Taiwan are endemic to the island.

KEYWORDS: millipedes, Nedyopodini, *Nedyopus*, Taiwan, diversity

Philippine Platyrhacidae (Diplopoda: Polydesmida) and New Island Records for *Derodesmus dorsalis* (Peters, 1864)

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The Philippine fauna of Platyrhacidae which was erected by Pocock in 1895 is reviewed. Collections from the Field Museum of Natural History, California Academy of Sciences, Museum of Natural History – University of the Philippines Los Baños and the National Museum of the Filipino People were reexamined. Results show ten species of certain status and two in uncertain positions in the Philippine fauna. *Platyrhacus petealviolai* San Juan & Lit, 2010 is transferred to genus *Ilodesmus* Cook, 1896 on the basis of gonopodal characteristics. *Derodesmus dorsalis* (Peters, 1864), except for its known distribution in Negros and Luzon Islands, is recorded for the first time in Leyte, Samar and Sibuyan Islands, Philippines. Descriptions of new species, possibly of Genus *Mastigorhacus* Jeekel 2007, are withheld until further collection is made to supplement singular samples.

KEYWORDS: Platyrhacidae, *Derodesmus*, Philippines

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A Review of the Millipede Genus *Desmoxytes* Chamberlin, 1923 in the Fauna of Vietnam (Diplopoda, Polydesmida, Paradoxosomatidae), with Descriptions of Three New Species

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The large, basically Chinese to Malayan genus *Desmoxytes* Chamberlin, 1923 contains 13 species in the fauna of Vietnam alone, including three described as new: one from the Xuan Son National Park, Phu Tho Province, one from the Cuc Phuong National Park, Ninh Binh Province, and the other one from the Vinh Phuc and Ha Giang provinces. Among three new species, the first is distinguished by the gonopodal solenophore showing a rounded lobuliform lamina medialis, coupled with a well-developed lamina lateralis which supports a densely setose area, and a tuberculiform gonopod tip; the second differs from congeners by the gonopodal femorite being short, parallel-sided, more or less constricted near the middle, and gonopod tip rounded; the third is diagnosed by the gonopodal femorite being long and enlarged distally, the postfemoral region short and with a bilobate tip. The relationships between *Desmoxytes* species from Vietnam were analyzed using a fragment of the 16S rRNA mitochondrial gene. The genus *Desmoxytes* is shown to be paraphyletic. More *Desmoxytes* species are to be added to the analysis in order to clarify the phylogeny of the genus.

KEYWORDS: dragon millipedes, *Desmoxytes*, new species, phylogeny, Vietnam

Integrative Taxonomy of the Millipede Family Pachybolidae in Continental SE Asia

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Currently the millipede family Pachybolidae in continental SE Asia includes six genera, viz., *Aulacobolus*, *Litostrophus*, *Tonkinbolus*, *Apeuthes*, *Decelus*, *Trigoniulus*, plus the "tramp" species *Leptogoniulus sororn*us. For identification, until now mainly gonopodal characters have been used. However, with relatively simple, homogeneous gonopods such as those of *Litostrophus* and *Tonkinbolus*, DNA data provides important information. Therefore we present here the very first mtDNA sequence data of SE Asian Pachybolidae. As a result *Tonkinbolus* (type species *T. scaber*) is synonymized under *Litostrophus*. The genus *Atopochetus* (type species *A. rubropunctatus*), hitherto considered a dubious synonym of *Aulacobolus*, is re-instated for several species until now placed in *Tonkinbolus*. The combination of morphological characters and mtDNA sequences (partial COI and 16S rRNA fragments) strongly support monophyly of the genera *Litostrophus* and *Atopochetus*. Nine new species of both genera are being described. The mtDNA sequence data also suggest treating the Trigoniulidae as a subfamily of the Pachybolidae. Moreover, several new species of other pachybolid genera are described, as well as several species of Pseudospirobolellidae that are included to improve phylogenetic inferences.

KEYWORDS: mitochondrial DNA, phylogeny, Southeast Asia, species delineation

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Morphology and Molecular Genetics of the Giant Pill-Millipede Genus *Sphaerobelum* in Northern Thailand

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Only five species of the giant pill-millipedes in the genus *Sphaerobelum* have been known from Southeast Asia. Among these, *Sphaerobelum truncatum* was the only species reported in the north of Thailand. However, previous collections were focused on only a small area of the region. There are many areas with similar habitat type, where more *Sphaerobelum* species were expected to be found. Therefore, in this study, specimens of *Sphaerobelum* were randomly collected throughout Northern Thailand. Each specimen was collected by direct observation during the rainy season of 2016 and 2017. The morphological data were compared with *S. truncatum* and the mitochondrial COI gene sequences were used to analyze evolutionary relationships. The results are discussed.

KEYWORDS: Myriapoda, Diplopoda, Sphaerotheriida

POSTER SESSION

The Millipede Genus *Julus* Linnaeus, 1758 in the Caucasus (Diplopoda: Julida: Julidae)

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At present, the genus *Julus* includes six species already described from the Caucasus: *J. colchicus* Lohmander, 1936; *J. jedryczkowskii* Golovatch, 1981; *J. kubanus* Verhoeff, 1921; *J. lignaui* Verhoeff, 1910; *J. lindholmi* Lohmander, 1936; and *J. subalpinus* Lohmander, 1936. In addition, three new species are revealed, one each from the Republic of Dagestan, the Krasnodar Province and the Republic of Karachaevo-Cherkessia, all in Russia. The new species are named and described, all nine species illustrated, diagnosed and keyed, their morphological variations refined, and distributions mapped, based on the literature data and abundant new samples. The differences between species, their zoogeographic and altitudinal distribution patterns are discussed.

KEYWORDS: millipede, fauna, *Julus*, Diplopoda, Caucasus

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Redescription of the Centipede *Newportia amazonica* Brölemann, 1903, and Taxonomic Notes of Some Brazilian Species of *Newportia*

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Newportia is one of the most diverse genus of scolopendromorph centipedes worldwide. In the last twenty years many studies on systematic and taxonomy focused on the genus, therefore, it is one of the well-known groups of Scolopendromorpha. The genus is subdivided in three subgenera with circa of 60 species in the Neotropical region. For Brazil 21 species and two subspecies are known for the subgenera *Newportia* (17 spp and two sspp) and *Tidops* (four spp). Seven species belonging to the subgenera *Newportia* are exclusive from Brazil. This study aims to review some barely known species of the subgenera *Newportia,* and redescribe and illustrate *Newportia amazonica*. Type material and fresh material from four myriapodological collections were examined. *Newportia paraensis*, *N. brevipes*, *N. maxima*, *N. diagrama aureana* and *N. ernst fossulata* are morphologically close to each other. *Newportia paraensis* and *N. diagrama aureana* share some characters with *N. brevipes*: cephalic plate, tergite 1, and ultimate legs. *Newportia ernsti fossulata* had its status changed to species level. *Newportia maxima* is also close to *N. brevipes*, *N. paraensis*, and *N. diagrama aureana*, but differs from this taxa for the absence of paramedian sutures in tergite 1. *Newportia amazonica*, *N. unguifer*, and two other species from Venezuela: *N. tetraspinae* and *N. guaiaquinimensis* are the only species of *Newportia* with tarsus 1 ending in a claw. Both Venezuelan species are morphologically similar to *N. amazonica*, therefore, they are considered synonymous. *Newportia bahiensis* is considered *nomen nudum.*

KEYWORDS: Chilopoda, Scolopendromorpha, taxonomy, Newportiinae

Asymmetry in Geophilomorpha (Myriapoda, Chilopoda) Centipedes from Brazil

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Geophilomorpha is one of the most diverse terrestrial group within the class Chilopoda. This order has about 1,250 species belonging to 13 families distributed throughout the world, seven occurring in Brazil (Geophilidae, Ballophilidae, Oryidae, Mecistocephalidae, Macronicophilidae, Aphilodontidae and Schendylidae). Geophilomorpha centipedes are diagnosed by the presence of 14 antennomers in antenna, as well as a fixed number of segments in the last pair of legs-bearing according to families and genera. In the present study, specimens were collected in six Brazilian states, especially of the family Schendylidae and studied in relation to the external morphology. We observed an asymmetry in conservative characters in 24 percent of specimens collected, which, for the most part, has variation in the number and size of the antennomers, and a small portion has variation in the size and number of segments of the last pairs of legs-bearing. Both asymmetries were never recorded in the literature. These variations may be related to several reasons, among them, random mutations, neutral mutations or low frequency of some alleles in the population being maintained by selection of heterozygotes. Another probable explanation would be Floating Asymmetry (FA), characterized by small random and non-directional deviations between the planes of symmetry of individuals during ontogenetic development, caused by environmental stress in a population. However, more population and ontogenetic studies would be needed to identify the real cause of these frequently encountered variations.

KEYWORDS: Chilopoda, variability, morphology, Neotropical region

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Investigation of the Mandibular Structures and Evaluation of Their Phylogenetic Significance in the Genus *Lithobius* (Lithobiomorpha: Lithobiidae)

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The mandibles form a pair of complex and functionally important mouthparts in centipedes and other mandibulate arthropods, displaying an array of specialized microstructures. These were hitherto appraised in the lithobiomorph centipede family Henicopidae and proved to be a source of useful characters to differentiate genera and subgenera. Here, we apply the same approach to the family Lithobiidae, particularly the genus *Lithobius*, which encompasses about half the species in the family. Inspection of the subgenera *Lithobius* (11 spp.), *Monotarsobius* (4 spp.), *Sigibius* (3 spp.) and *Ezembius* (1 sp.) uses scanning electron microscopy to investigate the structure of the mandibular aciculae, the accessory denticles, the branching bristles fringing the mandibular teeth, and branching bristles on the Haarpolster to test whether they deliver phylogenetically useful information.

KEYWORDS: *Lithobius* sp., mandible, phylogeny, microanatomy, SEM

Notes on the Post-Embryonic Development of *Cryptops parisi* Brölemann, 1920 (Chilopoda: Scolopendromorpha: Cryptopidae)

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Scolopendromorpha are epimorphic centipedes, i.e., juveniles hatch with the full complement of segments and legs. However, there is very little information about the number of free-living instars in this order. We here analyse characteristics of the post-embryonic development of the European species *Cryptops parisi* from the time when the young animals leave the brood. The population of *C. parisi* in the vicinity of Novi Pazar (southwestern Serbia, the Balkan Peninsula) was sampled at least once a week from March to November of 2012. In total, we examined 958 specimens (370 males and 588 females). On the basis of measurements of head length, head width, length of cephalic paramedian sutures, number of prelabral setae, number of coxal pores of the ultimate legs, number of setae within the coxal pore-field, and number of setae on the anterior border of the coxopleuron, we were able to distinguish seven pre-adult and adult instars. The most useful character for doing this was the number of coxal pores of the ultimate legs in both sexes.

KEYWORDS: *Cryptops parisi*, post-embryonic development, coxal pores, Serbia

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Ultrastructure and Phylogenetic Evaluation of the Tömösváry Organ in *Craterostigmus tasmanianus* Pocock, 1902 (Myriapoda: Chilopoda)

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Centipedes share cuticular sensilla of various morphologies and functions. However, more complex sense organs are only present on the head and associated appendages of some centipede subgroups. For instance, postantennal organs, termed Tömösváry organs in Myriapoda, were only known from Scutigeromorpha and Lithobiomorpha in which they are located in small excavations of the cuticle at either side of the head, posterior to the antennal base and, if present, anterioventrally to the eye. Tömösváry organs were assumed to be present in Craterostigmomorpha but sound anatomical evidence was missing. Present contribution documents the existence of Tömösvary organ in *Craterostigmus tasmanianus* for the first time, based on light and electron microscopy. TEM reveals two distinct groups of altogether 8–12 biciliated receptor cells nested in a cup-shaped epithelium containing hundreds of sheath cells surrounding a huge sensillum lymph space. Each receptor cell projects two elongated, partly convoluted cilia, that pass through a pore canal in the cuticle, then branch and finally attach to the sensory plate lining the pore canal from above with a very thin cuticle. Axons of receptor cells project into the nervus tömösváryi innervating the lateral protocerebrum. Homology of Tömösváry organs in Chilopoda is further strengthened by a set of ultrastructural characters, i.e. receptor cells each projecting two cilia that branch apically. However, some ultrastructures deviate from Tömösvary organs of Scutigeromorpha/Lithobiomorpha, i.e. the absence of a cuticular excavation or the asymmetric distribution pattern of receptor cells and their cilia. Consequently, these characters would have to be considered further apomorphies of Craterostigmomorpha.

KEYWORDS: evolutionary morphology, sense organ, ciliary receptors

Chemical Composition and Taxonomic Significance of Defensive Secretions of Some Members of the Families Blaniulidae and Nemasomatidae (Diplopoda, Julida)

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The majority of millipede species are chemically defended against predators. Millipede defensive semiochemicals are mostly volatile and in some cases strongly odorous and repellent to both vertebrates and invertebrates. The families Blaniulidae and Nemasomatidae belong to the order Julida and include generally slender and small species. To date, only five species of the family Blaniulidae and no member of the family Nemasomatidae have been chemically investigated. In order to obtain additional information on the semiochemistry of defensive systems in juliform millipedes, we analysed the chemoprofiles of eight species of blaniulids (*Acipes* sp., *Archiboreoiulus pallidus*, *Boreoiulus tenuis*, *Blaniulus dollfusi*, *B. guttulatus*, *Choneiulus palmatus*, *Nopoiulus kochii*, *Proteroiulus fuscus*), as well as one nemasomatid species (*Nemasoma varicorne*). For collection of defensive secretions, individuals of each species were soaked in 2 ml of methylene chloride or hexane. Gas chromatography-mass spectrometry revealed the presence of a great variety of both quinones and non-quinones. We identified 30 different benzoquinones, hydroquinones and naphthoquinones in the defensive fluids of blaniulids, and bezoquinones and hydroquinones in the nemasomatids. The compounds of highest relative abundance in all analysed species were 2-methyl-1,4-benzoquinone and 2-methoxy-3-methyl-1,4-benzoquinone. Small amounts of p-cresol were registered in *C. palmatus*, *P. fuscus* and *N. varicorne*, its presence probably representing a plesiomorphic feature. Naphthoquinones were registered only in the genera *Acipes*, *Nopoiulus* and *Proteroiulus*. More than 20 esters were identified in the defensive cocktails. Their relative abundance in total extracts varied from 8% (in *C. palmatus*) to almost 40% (in *B. guttulatus*). Additional studies need to be conducted in order to clarify their possible roles. The results of this study indicate that both blaniulids and nemasomatids are "quinone millipedes".

KEYWORDS: Julida, Blaniulidae, Nemasomatidae, chemoprofile, quinones, non-quinones

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One for a Thousand? – The Evolution of the Musculo-Skeletal System of the Diplopod Head

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The Myriapoda, comprising round 17.000 described species, are the smallest and most enigmatic group of extant arthropods. Among the myriapods, the millipedes (Diplopoda) are the dominating group in terms of species-richness and abundance. The scientific interest in this group has increased during the last decades and today's research on diplopods is focused on biogeography, genetics, taxonomy and the external morphology. However, studies on the internal anatomy are scarce and limit our understanding of the evolutionary history of this group. Especially the musculo-skeletal system, which has been proven to contribute key information about the evolution and phylogeny in other arthropod groups, is chronically understudied. The aim of this study is to investigate the morphology of the musculo-skeletal system of the head and anterior trunk segments in representatives of major diplopod taxa (Polyxenida, Pentazonia, Polyzoniida, Chordeumatida and Polydesmida). Using state of the art techniques like micro-computed tomography and confocal laser scanning microscopy in combination with classical histology we want to describe the musculo-skeletal anatomy of the heads of these groups for the first time. This will test the potential of this character system to contribute answers to major questions about the evolutionary history of this group, like the morphological changes connected to the transformation from a biting to sucking feeding mode in polyzoniid diplopods.

KEYWORDS: Diplopoda, head, musculo-skeletal morphology, evolution

Working with Databases – Assessing the Practical Usability of the Soil-Zoological Data Warehouse Edaphobase with Myriapod Data

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The basal function of Edaphobase is to collect and mobilize worldwide distributed data on soil-fauna ecology and taxonomy, including diplopods and chilopods. Furthermore, a newly implemented tool, Edaphostat, enables statistical analyses of appropriate data stored in the database. In a Nationwide Field Monitoring study, various groups of soil invertebrate organisms were sampled on 36 sites from 12 different habitat types (coniferous and deciduous forest, grassland and arable land) in four regions of Germany. One aim of this project is to evaluate the usability of Edaphobase and Edaphostat, i.e., for nature protection issues as expressed by regional authorities. Furthermore, data for habitat types so far underrepresented in the database were generated. The myriapod assemblages (Diplopoda, Chilopoda) were systematically surveyed using pitfall traps and soil-core samples. Additional environmental data includes, among others, pH value, soil texture, C/N ratio, and soil water content. Detailed vegetation surveys allow a classification of habitat types according to EUNIS and the 'German Red Data Book' on endangered habitats. All data were imported into Edaphobase with an import wizard. In the 36 sites, 35 Diplopoda species and 25 Chilopoda species were recorded. Non-metric multidimensional scaling ordinations based on chilopod and diplopod data show similarity of sites of the same habitat type in most of the cases. Tools from Edaphostat reveal characteristic diplopod communities typical for the studied habitat types.

KEYWORDS: database, communities, meta-site analysis, distribution patterns

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Lithobius (*Monotarsobius*) sp., a New Species of Centipede from High Altitude Forest in Central Taiwan

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Three species of *Lithobius* (*Monotarsobius*), *Monotarsobius crassipes holstii* (Pocock, 1895), *Monotarsobius obtusus* Takakuwa, 1941, and *Monotarsobius ramulosus* Takakuwa, 1941, were recorded from Taiwan by Takakuwa (1941) and Wang (1955-1963). However, Takakuwa's specimens were destroyed in an air attack during the war in 1945, and we could not locate Wang's specimens in Taiwan. We studied specimens of centipedes collected from Taiwan and deposited at the National Museum of Natural Science. Herewith we describe a new lithobiid centipede using a stereo-microscope and SEM. The new species is characterised by a secondary sexual character on leg 15 of the male, a very large ventral swelling occupying almost 50% of the ventral surface of the femur; the gently curved apical region bears about 20 short setae and numerous very small pores (0.8-1.0μm) of epidermal glands; antennae composed of 19 articles; 6 ocelli [1 posterior + 3 dorsal, 2 ventral] on each side; Tömösváry's organ moderately small, slightly bigger than adjacent ocelli; 2+2 coxosternal teeth, the inner slightly larger than the outer tooth; coxal pores round, 3,3,3,3 in male, 4,4,4,4 in female; female gonopods with 2+2 sharp coniform spurs; legs 14-15 with numerous large pores (9.1-11.1μm) of telopodal glands concentrated on the inner side of the femur, tibia and tarsus except the surface of the femoral swelling. The new *Lithobius* (*Monotarsobius*) sp. occurs in high altitude forest (ca. 2135m) in central Taiwan. This secondary sexual character is described for the first time in the genus *Lithobius*.

KEYWORDS: *Lithobius*, *Lithobius* (*Monotarsobius*), new species, Taiwan, taxonomy

Functional and Transcriptomic Analysis of Leaf Litter Digestion by Millipedes: Role of Microorganisms and Digestive Enzymes. An Introduction of a Starting Project.

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Millipedes represent important group of saprophagous soil macrofauna in temperate and tropical ecosystems. They play important role in decomposition of dead plant matter. The degradation of cellulosic compounds in digestive tract depends on synergistic action of digestive enzymes of invertebrates and microorganisms. The project focused on decomposition of cellulose in digestive tract deals with representatives of European millipede orders, additionally the studies involves several tropical species showing differences in intestinal conditions. Feeding experiments with measurement of metabolism, cellulose assimilation and manipulative experiments enable us to assess real contribution of cellulose digestion for energy budget of millipedes and releasing of CO_2 and CH_4. Measurements of chemical and physical conditions, presence of gases and other fermentation products and activity of digestive enzymes in combination with metatranscriptomic analysis of individual gut sections provide information for structural and functional description of the digestive process. The study is focussed on explanation of mechanisms of organic matter transformation in millipede intestines, and assessment the role of animal digestive apparatus, intestinal microorganisms and their interactions. The project includes the following aims: (a) To describe the distribution of intestinal enzymes digesting consumed leaf litter, (b) To compare microbial communities and microbial or invertebrate enzymes in main gut sections of model species to deduce compartmentalisation of main intestinal microbial and digestive processes, (c) To assess the real nutritive and ecological importance of cellulose degradation by millipedes and (d) To assess relation between intestinal cellulose degradation and methane releasing from millipedes.

KEYWORDS: millipedes, digestive enzymes, gut microbial communities, cellulose degradation, methane release

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Seasonality and Life Cycles of Chordeumatid Millipedes in Montane Central European Spruce Forests

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Two contrasting spruce mountain forest sites were monthly sampled during the two subsequent years 2015 – 2016 for analysis of dynamics and life history of two representatives of the family Haaseidae, *Haasea germanica* (Verhoeff, 1901) and *Haasea flavescens* (Latzel, 1884), and one representative of the family Chordeumatidae, *Mycogona germanica* (Verhoeff, 1892). Simultaneously, soil temperature and humidity were continually measured. All these three species form characteristic and permanent millipede community in the given types of mountain stands. Combination of soil sampling and pitfall trapping allowed us to define the basic morphological characters of the postembryonic stadia, and to describe in detail life history and seasonal dynamics of the given species. For both species of *Haasea*, there was not possible to distinguish the stadia III – VI, therefore they were evaluated together. The males and females of *Haasea germanica* reached maturity and occurred only in the period June – December and those of *Haasea flavescens* in August – December. Analyses of the structure of their populations indicate one reproducing period with subsequent postembryonic development during at least twenty following months including the cold winter period. Continual occurrence of adults of the millipede *Mycogona germanica* during the whole year and less unambiguous course of postembryonic development suggest a longer survival of adult males and females as well as possible repeated hatching periods during the year. In evaluation of obtained data, possible modification of life history of studied species due to the changes of soil microclimatic and different habitat conditions has been taken in consideration.

KEYWORDS: millipedes, *Haasea*, *Mycogona germanica*, life cycle, seasonal dynamics

The Taxonomic Value of the Vulvae in Millipedes of the Family Julidae (Diplopoda)

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The Diplopoda exhibit an overwhelming diversity of reproductive strategies associated with specialized copulatory organs. Most males of this group possess modified walking legs, so-called gonopods, as secondary copulatory structures additionally to their primary copulatory organs (penes). Since Latzel (1884), the morphology of these gonopods has gained exceptional importance in regard to diplopod taxonomy and systematics. However, females do not possess such secondary copulatory structures, and their primary sexual organs, the vulvae or cyphopods, have been vastly neglected in modern taxonomy and phylogeny. Only a handful of studies emphasise vulva structure as an additional character for modern diplopod classification. Our aim is to extend the knowledge of vulvae morphology and re-examine their value for the determination of diplopod taxa of the family Julidae. Using µCT, SEM and CLSM in combination with dissections we tried to find easily accessible characters suitable for identification on species-level. First results indicate the external morphology of vulvae to be highly variable and species-specific, showing no phylogenetic signal. Therefore it is not a useful character for the classification even on the genus level. On the other hand, this variation pattern allows discrimination between morphologically similar females of closely related species. We therefore recommend to always include descriptions of the female vulvae in species descriptions of julid diplopods.

KEYWORDS: Diplopoda, Julidae, taxonomy, vulvae

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The Postembryonic Development of *Telodeinopus aoutii* (Demange, 1971) (Diplopoda: Spirostreptida: Spirostreptidae)

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The development of 101 individuals from *T. aoutii* has been studied more than four years captured in culture under defined conditions. A weekly control of the individuals guaranteed the acquisition of all moultings (in total 378). The number of apodal and podal body rings (incl. collum), number of ommatidia, body length and wide as well as live mass were measured each week. The curves of growth of body length, wide and mass in both sexes are linear, even after reaching maturity. Stages were determined on the basis of the body rings in combination with mass, body length and wide. This a posteriore classification was verified with a Multi-response Permutation Procedure ($A = 0.69$, $p < .001$). The eyerowed method was tested and can be used for the classification of younger stages only. The postembryonic development of this spirostreptid species runs according to the laws of anamorphosis. Maturity is reached in males and females in stage (XIII)-XV. Post maturational moultings occur, but without increase of body rings. Premature males occur from stage XI to XIV.

KEYWORDS: anamorphosis, body measurements, stage classification

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The Tentorium of the Arthrosphaeridae (Diplopoda: Sphaerotheriida)

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One of the few autapomorphies supporting the monophyly of the Myriapoda is the 'swinging tentorium', the inner skeleton of the head. Nevertheless, studies of the tentorium in Diplopoda are scarce and there are, if present at all, only descriptions of single representatives of the different orders. These studies already show a certain degree of variation between different orders, however, the variation within the different millipede groups remains uncertain. Here we study for the first time since Verhoeff 1932 the tentorium of the Arthrosphaeridae, a family of giant pill-millipedes (Sphaerotheriida) endemic to Madagascar and India. We use modern micro-CT imaging techniques to compare the tentorium of two endemic Malagasy genera, *Sphaeromimus* and *Zoosphaerium*. The general structure of the arthrosphaerid tentorium corresponds to the state described for the Sri Lankan *Arthrosphaera dentigera* by Verhoeff. Like in the Zephroniidae, described by Silvestri 1903, there is no direct connection to the lateral head capsule in the Arthrosphaeridae. The posterior process is plate-like and the long, rod-like hypopharyngeal bar is articulated to a plate-like Nebententorium. While the basic structure of the tentorium is conservative in the Arthrosphaeridae, the shape of its components varies within the family. This is especially true for the epipharyngeal bar in *Sphaeromimus* and *Zoosphaerium*. The tentorium is a potential source of morphological characters for phylogenetic analysis inside the different orders of millipedes. Therefore, more studies are needed to explore intraspecific variation and variation between higher ranking taxa to infer informative characters. This study is a first step into this direction.

KEYWORDS: tentorium, Diplopoda, Sphaerotheriida, Arthrosphaeridae, micro-CT

Fine Structures of the Hepatic Cells in Millipedes

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The hepatic cells ("liver cells", "hepatic tissue") in millipedes form a continuous layer of cells that adhere to the visceral muscles and surround the midgut epithelium. To determine the differences in the structure and ultrastructure of hepatic cells in different millipede taxa, we studied the following species which inhabit different environments and use different food resources: *Julus scandinavius* (order Julida), *Polydesmus angustus* and *Strongylosoma stigmatosum* (order Polydesmida; the families Polydesmidae and Paradoxosomatidae, respectively), *Epibolus pulchripes* (order Spirobolida; the family Pachybolidae) and *Archispirostreptus gigas* (order Spirostreptida). The studies were conducted with the use of the light and transmission electron microscopy, together with histochemical methods. The hepatic cells show distinct mesenchymal shape and each of them possesses own non-cellular basal lamina. In all examined species, the ultrastructure of hepatic cells presents numerous similarities suggesting that the main role of them is the accumulation of the polysaccharides, which are not accumulated in the digestive cells of the midgut epithelium. In addition, we can state that in millipedes that feed on algae, the accumulation of proteins occurs in the midgut epithelial cells, causing the absence of these chemical compounds in the hepatic cells. When there is the lack of the hepatic cells, the reserve material storage must be taken over the midgut epithelium. In in saprophagous millipedes the hepatic cells play the main role in accumulation of reserve material.

KEYWORDS: millipedes, ultrastructure, hepatic cells, reserve material

A Checklist of the Millipedes (Diplopoda) of Georgia, Caucasus

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The diplopod fauna of Georgia is very rich given the country's relatively small territory, presently comprising 98 species from 43 genera, 12 families and seven orders. The number of species and, to a lesser degree, genera is about twice as high as quoted in the latest checklists available for Azerbaijan and Iran, and ca 2/3 as diverse as the fauna of the very much larger Turkey. Most of the Diplopoda known from Georgia are subendemics (40 species, or 39%), shared with one or more neighbouring countries, but another 33 species (33%) are strict endemics, nearly all highly localized, including 12 presumed troglobites. Several genera are likewise endemic to Georgia, including a few troglobionts. The proportions of the remaining, more widely distributed species are rather modest, represented by Mediterranean, Euro-Mediterranean, eastern Mediterranean, eastern European or ubiquitous elements, but even among the latter the subcosmopolitan *Nopoiulus kochii* (Gervais, 1847) may have originated in the Caucasus, because the remaining congeners (from all subgenera) seem to be endemic to the Caucasus region. Within Georgia, the fauna of the western part (= Colchis) is particularly rich and diverse, the faunas of the central and eastern parts of the country growing increasingly depauperate inland and apparently following a rather gradual climatic aridization gradient from west (the Black Sea coast) to east (until Armenia and Azerbaijan). Much more work, to include alpine and cave environments as well, is required in order to reveal and refine the real diversity of Georgia's Diplopoda.

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Species Diversity of Millipedes (Diplopoda) in Myanmar

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The Republic of the Union of Myanmar, formerly known as Burma, is a globally recognized biodiversity hotspot, because it supports a very high number of species, many of which are unique to the region and of global importance. At present, the millipede fauna of Myanmar comprises 92 species from 34 genera, 13 families and 8 orders. Most of the diversity, including 66 new species and further 4 new records, were described in 1889–1896 by Pocock. That material was mainly collected by Leonardo Fea during his several trips across Myanmar (1885), as well as Eugene William Oates, who was a civil servant in the Public Works Department in India and Myanmar from 1867–1899. The bulk of millipede diversity in Myanmar belongs to the order Polydesmida which includes 4 families, 17 genera and 45 species (48.9%), followed by Spirostreptida with 2 families, 7 genera and 19 species (20.6%); Sphaerotheriida with 1 family, 3 genera and 12 species (13%) and Spirobolida with 2 families, 2 genera and 10 species (10.9%). The family Paradoxosomatidae (Polydesmida) contains the greatest proportion of species (37), followed by Harpagophoridae (Spirostreptida) (14) and Zephroniidae (Sphaerotheriida) (12). The four most species-rich genera are *Zephronia* (10 species), *Orthomorpha* (8), *Antheromorpha* (6) and *Gonoplectus* (5), which combined represent 31.5% of the indigenous species diversity. Most of the known species (70 of 92) have only been recorded in Myanmar and for the time being are to be regarded as endemic. Four of 34 genera present in Myanmar are also endemic: *Ctenorangoon*, *Tuberogonus*, *Alogolykus* and *Cryptodesmoides* (although the latter genus is still dubious). There are five widespread, synanthropic, anthropochore species, as well as 13 shared between Myanmar and Thailand such as, e.g., *Zephronia viridescens*, *Tonkinbolus caudulanus*, *Eudasypeltis setosus*, *Orthomorpha insularis*, *O. karschi* or *Tylopus doriae*. Because the mountain ranges lying at the border between the northern and central parts of Thailand and Myanmar are relatively low, they seem to be especially rich in millipedes compared to the other parts of the countries, but this increased diversity may also be accounted for in part by the relative accessibility of those mountains for collection. Altogether, there are 57 collecting localities in Myanmar, mostly those visited by Fea, together with the neighboring rivers or islands. The localities that support most of the species recorded in Myanmar are Yangon with 14 species (11 type localites), followed by Palon in Pegu with 13 species (9 type localites) and Malewoon with 12 species (5 type localites). The number of the places in Myanmar whence Diplopoda have been taken is quite low because of the limited exploration of the country, coupled with no local research in this group. Thus, the Animal Systematics Research Unit (ASRU) actively surveyed and collected millipedes in several areas of Myanmar. As a result, there are about a dozen new species to be described in the near future. Provisionally, the Recent millipede fauna of Myanmar as described above, although clearly Oriental in origins, appears to have surprisingly little in common even at the family level with the fossil diplopod record of the country known from the early Cretaceous Burmite amber (about 99–100 Mya). This research is actively underway as well.

KEYWORDS: millipedes, species diversity, Myanmar

Redescription of the Poorly Known Cave Millipede *Skleroprotopus membranipedalis* Zhang, 1985 (Diplopoda: Julida: Mongoliulidae)

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The julidan family Mongoliulidae Pocock, 1903 is distributed in the temperate areas of East Asia. At present, it comprises 6 genera and approximately 30 species. Genus *Skleroprotopus* Attems, 1901 contains 19 species distributed in the Asian part of Russia (Primorsky Province), Korea, North China and Japan. In China, the genus is known with four species – the genotype *Skleroprotopus confucius* Attems, 1901 (Zhang-Jia-Kou City, Hebei Province), *S. laticoxalis* Takakuwa 1942 (Shen-Yang City, Liaoning Province), *S. serratus* Takakuwa & Takashima 1949 (Yan-tou village, Shanxi Province), and *S. membranipedalis* Zhang, 1985, described from Shihua Dong (Stone Buddha Cave), Fangshan County, Beijing. The original description of *S. membranipedalis* Zhang, 1985 is in Chinese, and the illustrations are rather poor that is why we provide here a new, emended description of the species based on freshly collected topotypic material. The redescription includes the first SEM micrographs and the first detailed observations of the species' female characters. A brief review of genus *Skleroprotopus* is made, and an identification key to its species is presented. Unlike most members of the genus, *S. membranipedalis* Zhang, 1985 seems to be a troglomorphic species. It is hitherto known only from two caves - Shihua Dong and Cloud Water Cave (new record) in Fangshan County. Its type specimens are kept in the Myriapoda collection of the Institute of Zoology, Chinese Academy of Sciences (IZCAS), Beijing (curator Kaibaryer Meng).

KEYWORDS: troglobite, taxonomy, amended description, vulvae, China

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Two Cases of Incongruencies Between Phylogenetics and Morphology in Australian Millipedes (Diplopoda, Polydesmida, Paradoxosomatidae)

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Incongruencies between morphology and phylogenetics were observed in two species of Southern Australian millipedes in the family Paradoxosomatidae using morphology and molecular phylogenetic analysis (partial mt COI rDNA, mt 16 rRNA, nc 28S rRNA). In *Somethus castaneus* (Attems, 1944) from two localities at Mt Osmond, Adelaide, South Australia, in the center of species distribution, three of eight sequenced specimens branch between *S. castaneus* with lowest genetic distances to both *S. lancearius* and *S. castaneus*. In contrast, all specimens morphologically and in 28S resembling unambiguously *S. castaneus*. In specimens of the genus *Pogonosternum* at one locality near Dargo in Central Gippsland, Victoria, within the supposed area of the potential (overlapping) distribution border of *P. nigrovirgatum* (Carl, 1912) and *P. jeekeli* Decker, 2017, specimens morphologically closely resemble *P. nirgovirgatum*, but showing local divergence in number of male tarsal and tibial brushes of legs, but phylogenetically (COI, 16S) clustering within *P. jeekeli*. Both cases are discussed in terms of assumptions, such as aberrant morphology, distant genetic lineages or past introgressive hybridization events.

KEYWORDS: introgression, hybridisation, aberration

Millipedes (Diplopoda) in Hoffer's Collection in the National Museum in Prague (Czech Republic)

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Augustin Hoffer (20.IV.1910–21.X.1981) was a significant Czech entomologist. He focused not only to fauna of the Czech Republic, but he was also studying insects of all Palearctic area. During his excursions, he was collecting Invertebrates also for his colleagues. Therefore, millipedes from the Czech Republic, Slovakia and Montenegro are present in his collection. The millipede collection contains 185 specimens preserved in 80% ethanol, representing 20 species from the orders Polydesmida, Glomerida, Chordeumatida, Julida and Polydesmida. The material was collected in 1932–1936, in Moravia (eastern part of the Czech Republic, at the surroundings of the towns Brno, Tišnov, Adamov and Rajhrad), Zádielska dolina Valley (Slovakia) and Crkvice (Montenegro). The collection is valuable because it brings important faunistic data from the period before the Second World War.

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KEYWORDS: millipedes, historical collection, faunistics

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New Rare Millipede (Diplopoda) Species for the Czech Republic Found After 2000

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Recently, 77 millipede species are known from the Czech Republic. They belong to orders Polyxenida, Glomerida, Polyzoniida, Julida, Chordeumatida and Polydesmida. After the year 2000, eleven new species for the Czech Republic were found. They occur at various types of habitats. The majority of new species appear at places influenced by human activities, e.g. in parks, botanical gardens, zoos, gardenings, greenhouses etc. (*Amphitomeus attemsi, Cylindroiulus vulnerarius, Haplogona oculodistincta, Melogona gallica* and *Propolydesmus germanicus*). Others species were discovered in natural habitats, e.g. forests and their ecotones. These species are often rare, relict and stenoec, occurring in small populations only (*Hungarosoma bokori, Hylebainosoma tatranum* and *Melogona transsylvanica*). The third group is represented by species exhibiting specific requirements of subterranean habitats; their populations are very small. Their presence in the Czech Republic was revealed by special pitfall traps modified for collecting deep-living Inbvertebrates, and by research in caves (*Brachychaeteuma bradeae, Macrosternodesmus palicola* and *Geoglomeris subterranea*). Of these eleven species, nine are categorized in the Red List of Threatened Invertebrates in the Czech Republic.

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KEYWORDS: millipedes, faunistics, endangered species

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IUCN Red List Assessment of the Giant Millipedes from Madagascar

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Recent extensive studies on the millipedes of Madagascar revealed a rich endemic biodiversity with the majority of the species being highly dependent on forest habitats. Due to the ongoing deforestation in large parts of Madagascar, the unique millipede fauna was therefore suspected to be highly threatened by extinction. In this study, a comprehensive assessment of the extinction risk of two of the most striking orders of Malagasy millipedes, Sphaerotheriida and Spirobolida, was conducted and the knowledge gaps regarding the conservation status were identified.

For this purpose, the available data on the distribution, ecology, habitat trends and threats for the 145 described endemic species was compiled. The extinction risk of each species was assessed in accordance with the criteria of the IUCN Red List of Threatened Species. The overall extinction risk as well as the spatial distribution of species-richness, threatened species and Data Deficient species were analysed.

The study shows that almost a third of the examined species are threatened by extinction, most of them even qualifying for the Critically Endangered category. Thirteen species are microendemic to a single forest fragment of less than 10 km^2 and thus highly threatened. Additionally, 26% of the species have been assessed Near Threatened, while 19% of the species are listed as Data Deficient. The major threats to the species are slash-and-burn agriculture (tavy) and logging activities within the remaining forests, followed by mining activities. Littoral forests were identified as the most endangered habitat type, with over 70% of the inhabiting species being threatened.

KEYWORDS: Diplopoda, Sphaerotheriida, Spirobolida, Madagascar, conservation, IUCN Red List of Threatened Species

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Phylogeography and Intraspecific Variation of the Millipede Model Organism, the Black Pill Millipede *Glomeris marginata* (Villers, 1789) (Diplopoda, Glomerida, Glomeridae)

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The Black Pill Millipede (*Glomeris marginata*) is morphologically the best studied species of the group Diplopoda. The studies reach from the muscle, tracheal, tubul sensoral, or glands systems to defensive secretions, mating behaviour, pheromones, gene expressions covering even the embryonic development. As the most widely distributed species of the Glomerida it is ideally suited as a model species for further studies. Several colour forms are known covering the Central European distribution range. Here we want to test if *G. marginata* and its different colour variants form a monophyletic taxon, or if several cryptic species might hide under the name. For this test we analyzed barcoding mDNA COI-data. We also want to find out the phylogeographic relationship of its different populations as well as the possible origin of the species. The 97 sampled specimens of *G. marginata* yielded 47 different haplotypes. Analyses (CHAO1) show that 404 haplotypes can be expected. In order to cover all haplotypes of *G. marginata*, up to 6,000 specimens would have been to be sampled. The analysis shows that there is a high genetic diversity within the western part of middle Germany and also in the Pyrenees. There are five major haplotype lineages over Europe. There is evidence that origin of the species lays at the Mediterranean coast, the distant-most haplotypes are found in SE France. While intraspecific genetic variation is high, distinct genetic lineages could not be linked to colour forms or geographical areas. Morphologically similar species such as *G. annulata* and *G. maerens* whose limited areas of distribution lie inside the range of *G. marginata* are clearly distinct from the latter.

KEYWORDS: millipede, Diplopoda, Glomerida, Glomeridae, barcoding, biogeography

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The Millipede and Centipede Faunal Composition of an Asian Rainforest Using the Example of the Halimun-Salak National Park on Java, Indonesia

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The Halimun-Salak National Park, located in West Java, Indonesia, possesses one of the last remaining primary rainforest areas on the densily populated island of Java. Human influences like deforestation, logging and plantations reduce the species diversity and density. To assess this effect on the Myriapoda community, samples of Myriapoda were collected during the dry season from the 9th September till the 7th October 2015 in three different areas of the park, ranging from natural to damaged rainforests. The first area, Mt. Salak and Sukamantri, had little natural vegetation, a lot of logging and plantations (bananas). The second habitat, Cidahu, was semi natural, former deforested now regenerating forest with some alien species in the floral composition, like *Casuarina* Linnaeus. The third area, Cikaniki, was covered with primary rainforest with only selective logging being undertaken. Altogether, more than 1000 specimens were collected by hand. The majority of the centipede specimens belonged to the order Scolopendromorpha, but the highest diversity of morphospecies was observed in the Geophilomorpha. Nine Diplopoda (millipedes) orders were found: Chordeumatida, Glomerida, Glomeridesmida, Polydesmida, Polyxenida, Siphonophorida, Sphaerotheriida, Spirobolida and Spirostreptida. The most dominant order for both the diversity of species and the quantity of specimens (47% of all collected samples) were the Polydesmida. Habitat 3, Cikaniki, had the highest species and genera density. This has been the first known study about the Myriapoda faunal composition of a tropical SE Asian rainforest.

KEYWORDS: faunal composition, Java, Indonesia, centipede, millipede, Halimun-Salak, tropical Asia, Scutigeromorpha, Lithobiomorpha, Scolopendromorpha, Geophilomorpha, Chordeumatida, Glomerida, Glomeridesmida, Polydesmida, Polyxenida, Siphonophorida, Sphaerotheriida, Spirobolida, Spirostreptida

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First Fossils of the Order Siphoniulida (Myriapoda, Diplopoda)

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With only two described recent species worldwide, Siphoniulida represents the rarest of the 16 extant orders of millipedes (Diplopoda). Additionally, there is no fossil record of this order yet. While millipedes, in general, constitute an important fossil group, there is a gap in the Mesozoic with only about a dozen described species. Thus, the finding of two Siphoniulida specimens in Burmese amber dating from the Cretaceous presented the challenge of comprehensively describing this ancient treasure in a non-destructive way. Both specimens measured less than six millimeters in total length, were partly curled and important characters were obscured by debris, amber cracks or not visible from the outside at all. Hence, we utilized µCT technology to describe the first two fossil representatives of the order Siphoniulida, doubling the number of known species of this enigmatic order. The three-dimensional reconstruction the specimens of *Siphoniulida muelleri* sp. nov. and *S. preciosus* from µCT scans revealed not only important external characters, but also previously unstudied internal characters of this order. For example, the shape of the internal tracheal apodemes and details of the head like the gnathochilarium or the incisura lateralis could be visualized and studied in the digital 3D-models. Our analysis shows a strikingly similar morphology between the two recent and our newly described 100 Myo year old species. However, the investigation of previously unknown morphological characters through µCT deepened our insights into the order Siphoniulida, and might lead to hints towards the still unresolved phylogenetic placement of this whole order within the millipedes.

KEYWORDS: millipede, Diplopoda, Siphoniulida, fossil, Mesozoic, Cretaceous, Burmese amber, micro CT

Four New Species of the Millipede Genus *Glyphiulus* Gervais, 1847 from Caves in Southern China (Diplopoda, Spirostreptida, Cambalopsidae)

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Four new species of the millipede genus *Glyphiulus* Gervais, 1847 are described from caves in southern China: *G. foetidus* from Guangxi Zhuang Autonomous Region and Yunnan Province, *G. ge* and *G. impletus* from Guangxi Zhuang Autonomous Region, *G. guangnan* from Yunnan Province. According to the structure of the first male leg pair, these new species belong to the *javanicus*-group. Due to the absence of any troglomorphic traits, they are supposed to be troglophilic. Detailed descriptions and a distribution map of these new species are provided.

KEYWORDS: diplopods, *Glyphiulus*, cave, new species, taxonomy, China

Rearrangement of Mitochondrial Genes in Myriapods

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The typical myriapod mitochondrial genome contains a single chromosome with 13 protein-coding regions, 22 tRNA, two rRNA genes and a AT-rich region. Rearrangements of mitochondrial genes have been found in four classes (Diplopoda, Chilopoda, Symphyla and Pauropoda). In this study, we sequenced the complete mt genomes of six species from three myriapod classes (Diplopoda, Chilopoda and Pauropoda). The gene arrangement of *Prionobelum* sp. (Diplopoda) and *Scolopendra subspinipes* (Chilopoda) is identical to that of *Limulus polyphemus,* which is assumed to represent the myriapod ground pattern and shared by myriapod–chelicerate clade. Gene order in *Pauropus longiramus* (Pauropoda) mtDNA is basically identical to that of ancestral arthropod mtDNA found in *Limulus* and *Prionobelum* sp., with the exception of translocations of two tRNAs (*trnT*, *trnY*). The overall arrangement of the genes around the *Asiomorpha coarctata* (Diplopoda) and *Xystodesmus* sp. (Diplopoda) mt genomes is unique compared to other myriapod species. All coding regions are on a single strand in *A. coarctata* and *Xystodesmus* sp. which has been reported in the mt genome of the millipede *Appalachioria falcifera* with an entire side of the genome inverted. Inversion of the entire side of a genome (*trnF-nad5-trnH-nad4-nad4L, trnP, nad1-trnL2-trnL1-rrnL-trnV-rrnS, trnQ, trnC* and *trnY*) could constitute a common event in the order Polydesmida. In contrast to the inferred ancestral gene arrangement of myriapods, at least 8 genes and gene blocks (*nad3*; *nad6-cob*; *trnM-nad2-trnW*; *trnT*; *trnN*; *trnY*; *trnL1*; *trnI*) in mt genome of *Mecistocephalus marmoratus* (Chilopoda) have rearranged. The mechanisms of mitochondrial gene rearrangements can provide valuable information for studying problems of mitochondrial genome evolution. To better understand the evolutionary implications of gene arrangements in the Myriapoda, mt genome research with broader taxon sampling will be required.

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